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The water upwelling in Oued Righ Valley: Inventory and Caracterization.

F. Zahi, A. Drouichee, N. Bouchahm, W. Hamzaoui, W. Chaib, L. Djabri
Center of Scientific and Technical Research on Arid Regions (CRSTRA)
Adresse : Campus universitaire 07000 Biskra -Algérie-

E-mail : zahi_faouzi@yahoo.fr

Abstract
This work is part of a research program of the division « water and soil » in the center of scientific and technical research on arid regions (CRSTRA). It focuses on the upwelling water problem in the valley of Oued Righ (South- east Algeria). Increased demand for water in the oases of Algerian Sahara has led to an important augmentation in the exploitation of groundwater [1]. Moreover, the geomorphologies of the area, insufficient disposal of drainage water and the decontamination have caused, in recent years, the increase of water upwelling's areas. This has harmful effects on human and his environment. Besides, the studied region is one of the oldest cultivated lands in Algerian Sahara.
A collector channel of drainage and wastewater has been realized in 1925 to drain the overage water from oases. Currently, with increasing water demand (population and development), the question of water upwelling becomes more acute. Thus, a census operation about affected areas by this phenomenon has identified twenty sites; the determination of water's physicochemical parameters of identified sites gives salinity values oscillating between 6 and 70 g / l. the latter vary depending on the nature and feeding mode of these areas.

Keywords: Upwelling waters, groundwater, Oued Righ, Low Sahara, salinity.

1. Introduction

Low Sahara is characterized by the phenomenon of water upwelling. This has negative effects on environment and health. Water upwelling is generated by combined effects of the extensive growth of discharge flow used for irrigation, mainly associated with excessive use of water resources, has induced to significant waste, showing important amounts of water overage severely disrupted the natural balance in urban Saharian environment [2]. The phenomenon of water upwelling is very old in the Oued Righ area, already known in colonial era, that is to say, the second half of the 19th century, in fact over 2000 wells were identified in the early 60 years, over a third of borings were abandoned involving hence the rise of artesian water which reach the phreatic aquifer and causing the phenomenon of upwelling [2].

2. Characteristics of the studied area
The valley of Oued Righ is a geographical entity situated in South-eastern of Algeria between latitude 32° 54' and longitude 34 ° 09' (Figure 1). The bottom of the region is a long depression (150km length, 20km wide), it is in fact a kind of guttering very flat, oriented North-South, the general slope is about 1 ‰, the altitude increases gradually from 100 m in upstream El Goug (the highest coast) to - 27 m downstream Chott

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Merouane [3]. The latter being located in a hyper-arid climate and crossed by a main channel (channel of Oued Righ), it plays a very important role in the valley because it ensures the disposal of excess irrigation water, and decontamination of the urban areas on an estimated length of 150 km.

The groundwater resources in the region are depicted by two major aquifer systems that are: Terminal Complex (TC) and Intercalary Continental (IC), both overcome by the phreatic aquifer identified in all oases. On an aggregate capacity of over 30 000 $.10^9$ m^3 [4]. The region of Chott Merouane and Chott Melghir is the natural outlet of these hydraulic complexes:

- The Quaternary aquifer (phreatic aquifer): is essentially sand, at the base clay layers and semipermeable evaporates which separates it from the upper Pliocene. This layer is supplied mainly by water seepage from wadis and especially by surplus water percolation during irrigation periods.
- Terminal Complex aquifer**:** is the superposition of three aquifer units which are from top to bottom:

A first aquifer, from sands; is actually a network of small interconnecting layers, it is placed in the sand with clay of Pliocene.

A second aquifer was incorporated in the Pontian sands of the Upper Miocene, much more continuous and permeable than the previous ones.

The limestone aquifer located in crack and karstic limestone of carbonate Senonian and Eocene inferior. This aquifer system has at a depth between 100 and 500 m.

- Intercalary Continental aquifer: Often called "Albian water", consists mainly of post-Paleozoic sediments ranging from Triassic to the Albian and represented by alternating of sandstone and clay layers or permeable levels are dominant with a thickness of above 250 and sometimes reaching over 1000 m.

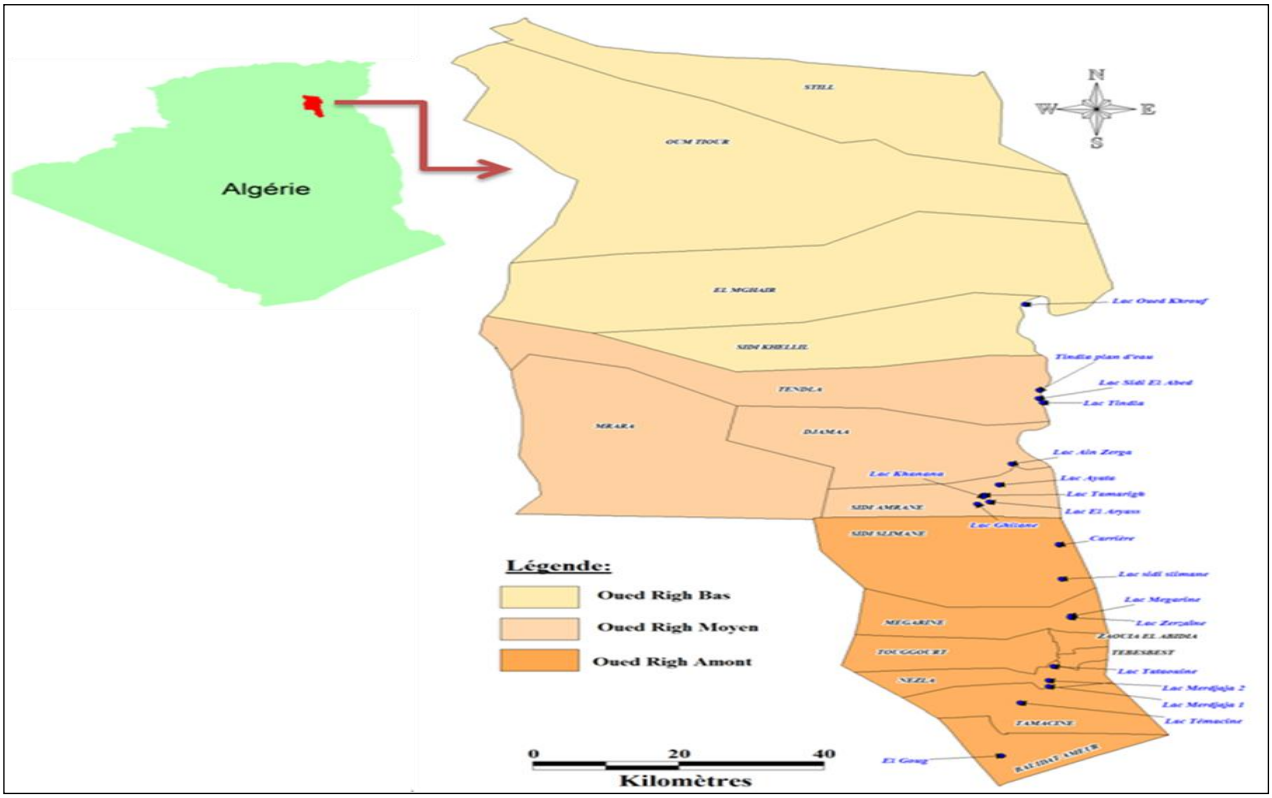

Figure 1: Geographic location of upwelling sites in the Oued Righ Valley

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3. Water upwelling mechanisms

The phenomenon of water upwelling is a direct result of intensive exploitation of groundwater in the absence of a consistently evacuation of overage water. The excess of water from deep aquifers is being released into the natural environment, or returns in the shallow aquifers but often with lower quality.

The water that returns to phreatic aquifer stem from irrigation of oases, stream, and seepage of water leakage in decontamination networks (AEP).

The absence of natural outlet, proper drainage system and the high rate of attrition (loss) in the drinking water supply systems and leaks identified in the sewerage, all these factors induce to stagnation and rising of phreatic aquifer level that is designated by water upwelling zones.

The historical existence of these water upwelling zones returns to the fifties years ago (figure 2). At first, the mobilized water came from phreatic aquifer and are deposed after use or flow into the same aquifer. Between the provided amount and the disposed amount a kind of balance is noticed and the aquifer remains stable.

With population growth and to meet the needs of drinking water supply, the deep aquifers are becoming increasingly used, which creates an imbalance between input and mine drainage. The growth of water needs implies an important exploitation. The phenomenon of infiltration to phreatic aquifer is very slow and consequently stagnated in recent surface.

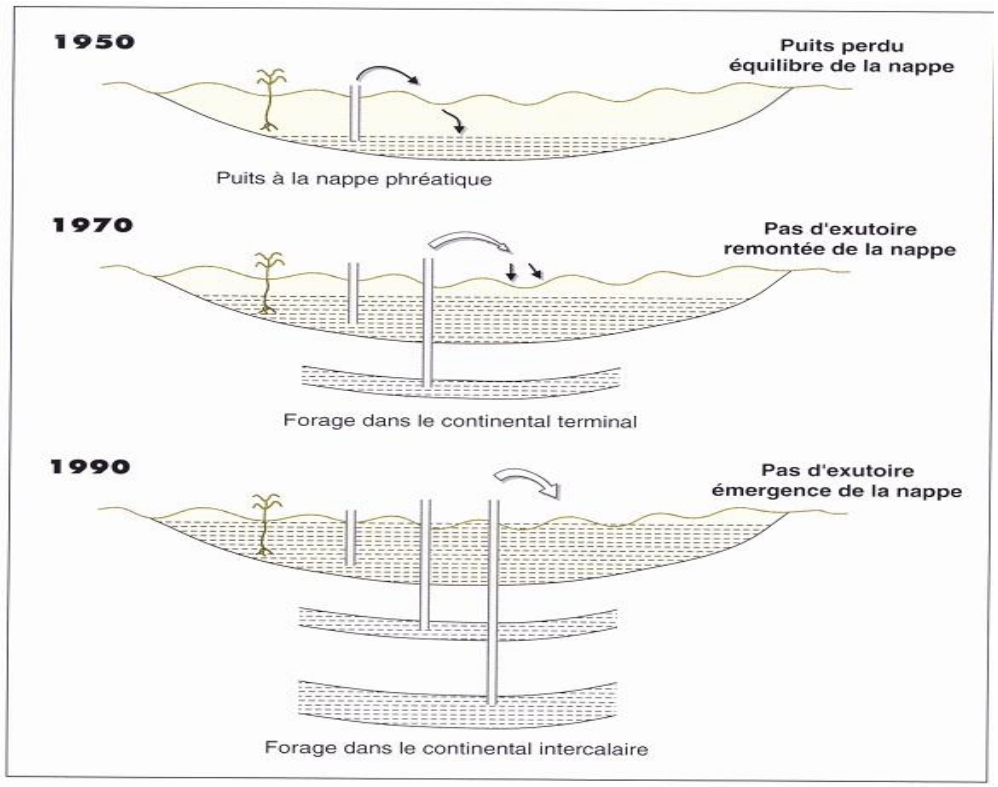

Figure 2: Evolution of the behavior of water table (according to Marc Côte)

4. Materials and methods

This work is part of a research project, which focuses on these new areas of water upwelling noticed in the valley of Oued Righ in recent years. The study consists of a complete inventory of the areas affected by the upwelling phenomenon. During this first step it was imperative to identify the extension of these same zones and to follow the seasonal variation in water levels, allowing the characterization of these zones and to

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understand the sustainability. We have identified counted twenty sites (Figure1) where most are scattered on both sides of the drainage channel of Oued Righ. In a second step, we proceeded a seasonal monitoring (of land) of physicochemical parameters of water in water upwelling zones to discriminate the chemistry of water and its seasonal evolution.

5. Results and discussion

5.1 Characteristics of some water upwelling sites

The most important water upwelling areas (in number and extension) are located in the high and medium Oued Righ (Figure 1), according to the very low slope in these regions. The most important surface areas are Blidet Ameur, Sidi Amrane and Tindla, they are ranked from top to bottom of Oued Righ in the table below (Table 1). These areas have different types, some exist on all year and others depend on the supply by rain water, drainage and / or sewage.

Table 1: Characteristics of some upwelling landscapes

Landscapes	Commune	Perimeter (Km)	Surface (Km^2)	Feeding kinds	Durability
El Goug	Blidet Ameur	3.60353	0.593893	Water drainage + Upwelling	Depending on the season
Lac Témacine	Témacine	0.960574	0.038363	Water drainage + Waste water + Upwelling	Existence during the year
Lac Merdjaja	Nezla	1.60488	0.0308611	Water drainage +Upwelling	Existence during the year
Lac Tataouine	Nezla	0.308227	0.00482274	Waste water + Upwelling	Existence during the year
Lac Megarine1	Megarine	1.3354	0.0335897	Water drainage +Upwelling	Existence during the year
Lac sidi slimane	Sidi Slimane	0.703517	0.0332348	Water drainage + Water of main channel +Upwelling	Existence during the year
Carrière1et 2	Sidi Slimane	0,529102	0,01079286	upwelling	Existence during the year
Lac Tamarigh	Sidi Amrane	0.104078	0.000840941	upwelling	Existence during the year
Lac El Aryass	Sidi Amrane	0.208439	0.00329252	upwelling	Existence during the year
Lac Ayata	Sidi Amrane	3.15543	0.48249	Water drainage + Waste water + upwelling	Existence during the year
Lac Ain Zerga	Tégdidine	0.190032	0.00271672	upwelling	Existence during the year
Lac Sidi E Abed	Tindla	0.926515	0.037291	Water drainage + upwelling	Existence during the year
Lac Tindla	Tindla	36.9023	26.2089	Water of main channel + upwelling	Existence during the year
Oued Khrouf	El Mghaïer	-	-	Water of main channel	Existence during the year

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5.2 Mineralization of water upwelling

Qualitatively, the water of the majority of identified sites are characterized by high mineralization which increases significantly, due to evaporation and leaching of soil by drainage water, throughout their path between the drains of oases and the side of release. To follow the salinity evolution in time, we realized five inquiries of in-situ measurements (multi-parameter Multi 350i/SET) of salinity. The upwelling water salinity vary irregularly in time and from one site to another (between 6 and 70 g/l) (Figure 3) due to several factors, namely, the nature of the sites (filling and emptying), the origin of water and feeding mode of these latters (drainage, stream, seepage of water leaks). The high values of salinity are recorded in most of closed sites (Sidi Slimane lakes, El Arayass, Ghilane and two sites near to the sand quarry north of the town of Sidi Slimane) due to high evaporation. The latter promotes the formation of thick layers of salt that will affect ominously to the palm trees mainly crop in the region.

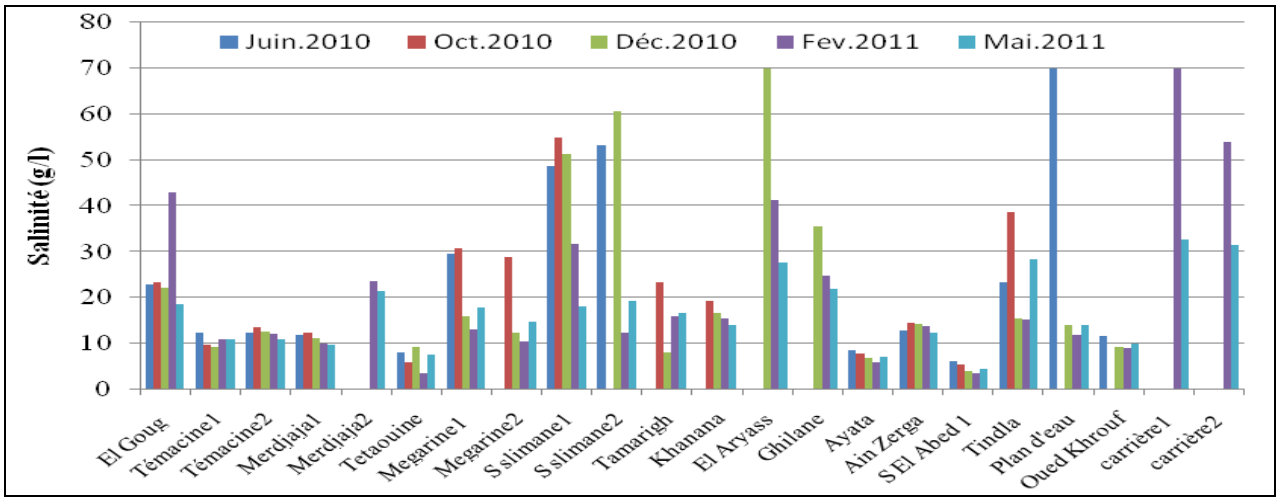

Figure 3: Evolution of water salinity resulting from the water upwelling**.**

Conclusion

Following its morphological context, the valley of Oued Righ is naturally a difficult environment where the over exploitation of water resources has inevitably led to the phenomenon of surplus water. The magnitude of this phenomenon has greatly exacerbated by the failure of the drainage and discharge systems. This caused overflowing of water on highways, the dispose of water to oases, counteracting their drainage, pollution of phreatic aquifer by sewage, involving the appearance of water diseases as well as the increase of salinity to 2 times that of seawater, the latter promotes the formation of salt efflorescence on the unfit soil for agricultural use. This study helped us to identify water upwelling zones into the valley of Oued Righ. Twenty sites were encountered with different expansion and filling method. The water salinity of water upwelling sites varies from a minimum of 6 g/l (Sidi El Abed and Tataouine) which correspond to the salinity of a few aquifers of sands in the region, and a maximum of 70 g/l (El Aryass and quarry area), these zones represent a source of groundwater contamination.
Faced with this alarming situation, urgent measures are needed to curb the phenomenon of water upwelling. Hence, it is necessary to set up a hydro-agricultural management plan and wastewater strategy, in order to respond to this pressing concern.

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