



RESEARCH PAPER

OPEN ACCESS

Water resources and management in the Biskra Eastern Zab, South-eastern Algeria

Fateh Boutouga^{*1,2}, Derradji Zouini^{1,2}, Naouel Bechiri^{1,2}

¹Geological research lab (LRG), Univ of Annaba, Algeria

²Faculty of Earth Sciences, Department of Geology, PB 12, Univ. of Annaba, Algeria

Article published on August 30, 2018

Key words: Integrated management, Biskra eastern Zab catchment, Water resources, Pollution, Water potentialities

Abstract

This study is devoted to the diagnosis and updating of surface water and groundwater resources of the Biskra eastern Zab catchment. It was carried out based on a large body of data, with the main objective of evaluating the exploitable water resources intended for domestic, agricultural and industrial uses in order to highlight the major axes of sustainable and rational management of water resources in arid environment. For the allocation of the water resources in the study area, the largest part of mobilized water is intended to meet the agricultural needs, with a volume of 280,6 Hm³/yr. However, this dominance is due to the growing needs for irrigation. The domestic needs are predominant, with a volume of 30,81 Hm³/y. The volume devoted to meet the needs for industrial use is estimated at 0,26 Hm³/yr. Generally, water intended for domestic, agricultural and industrial uses comes especially from groundwater. From the quantity point of view, the water resources in the area are generally available thanks to significant aquifers, but their physico-chemical quality is most often poor. This water salinization, a part of which is of geological origin, is constantly increasing owing to a poor management of water resources, notably groundwater management.

*Corresponding Author: Fateh Boutouga ✉ fatehgeologic@yahoo.com

Introduction

The Biskra eastern Zab is part of the Zibans located south-east of Algeria, which belong to North Africa. This latter is typically an arid area. The Biskra eastern Zab area has large groundwater resources, represented by groundwater of the two aquifer systems of the septentrional Sahara, namely the complex terminal and the continental intercalary. Conversely, the surface water is very insignificant. It would therefore be very interesting to attempt to assess the potential water resources and the water demand in this area. In this respect, several studies were carried out worldwide, regarding the integrated management of water resources including (Aidaoui, 1994; Benrabah *et al.*, 2011; Khelfaoui *et al.*, 2013; Bouznad *et al.* 2016; Mecibah *et al.*, 2016; Majour *et al.*, 2016).

The Ziban is one of the major areas of the Sahara, known for its population, its economic activities with agricultural vocation. The main economic activities of the Biskra province are associated with agriculture (palm gardens culture and greenhouse culture in winter) and livestock farming. These activities rely on the importance of groundwater resources. These last years, the hydro-agricultural development and the population growth resulted in a large demand for water. In this respect, a mobilization of water resources by boreholes is found to be necessary without actually knowing the supply/demand ratio.

The main aim of this study is to identify and to quantify the water resources for a sustainable management.

Methods and materials

Study area

The procedure adopted in this work involves collecting and analyzing data related to physical, phytoecological and socioeconomic factors of the study area and their evolution over time. We attempt to apply the concept of a rational and sustainable management of water resources in an arid setting, based on quantitative and qualitative diagnosis of water potentialities in the basin, in order to manage to set up the major axes of this new vision, which aims to improve the current sectorial management of water by favoring a best harmonization between the diverse needs and interests of human communities and those of the ecosystems. The eastern Zab oasis is located east of Biskra and groups the municipalities: SidiOkba and Chetma with the Thoudapalm gardens, Seriana and Garta. This area is part of the Biskra province, which is one of the biggest regions of south-eastern Algeria. It is located west of the province chief-town. It is limited to the north by the ElOutaya, Branis and Mechounech cities, to the east by the Ain Naga and El Haouch cities, to the south by the Still city, which is part of the EL Oued province, to the west by the Zerzour and OuledSlimane cities being part of the M'sila province and by the Chaiba city (Fig. 1).

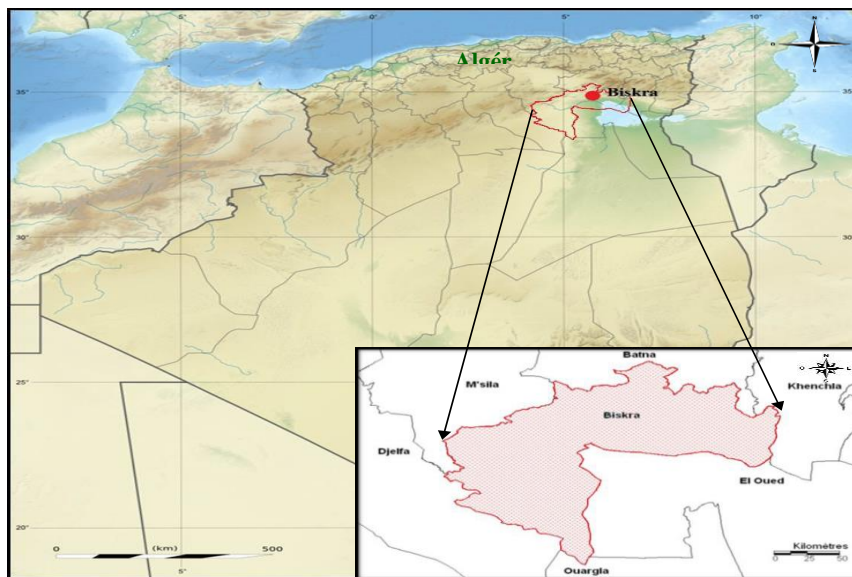


Fig. 1. Geographical location of the Biskra eastern Zab area.

Hydro-climatology

From the climatic point of view, the eastern Zab basin is subject to an arid and dry climate, with a cold and dry winter and to a hot and dry summer. The mean annual temperature at the Biskra station is of 23°C and a rainfall not exceeding 200 mm/yr at the stations of the Biskra eastern Zab area, except at the T'Kout station north in a mountainous zone exceeding 300 mm/yr.

Geology

From the geological point of view, the Biskra area represents only a structural and sedimentary transition zone: in the north, it is a mountainous zone, whereas it is a collapsed landscape being part of the septentrional Sahara in the south. The passage between these two distinct domains is made by a set of flexures and fractured folds oriented west-east called « Saharan Flexures ».

Hydrochemistry

The hydrochemical study is based on the interpretation of the chemical analyses of the samples collected in April 2011 at 27 boreholes and springs of Ain Chetma, the Fom El Gherza dam and Crochetanewadi. These analyses were performed at the laboratory of water and soil chemistry (Agence Nationale Des Ressources Hydrauliques Direction Régionale Sud Ouargla) and (ADE). The springs ANRHB is kra (F1 to F15 and F29 and F30), ADE (F16 to F24) and DHW five samples (F25 to F29).

Results and discussion

Water resources

The Biskra area has important groundwater resources, represented, in addition to the phreatic aquifer, by two aquifer systems, namely the complex terminal and continental intercalary. In the developing countries with arid climate, the role of groundwater is important, especially as it most often constitutes the only source of potable water supply, and therefore it is vital for the development of these countries [TRAVY, 1994].

For the Algerian septentrional Sahara, the resources are essentially made up of groundwater.

This latter is trapped in continental formations of continental intercalary (CI) and those of complex terminal (CT), which are among the largest hydraulic reservoirs of the world [BEL et CUCHE, 1970], the mobilisable potentialities of which are estimated at 5 billion cubic meters of water (ANRH). The lithological, hydrodynamic and hydrochemical conditions are various, notably in the eastern part of the area, thus conferring a particular interest to these aquifers. Moreover, a number of studies that have been carried out for about thirty years showed water of this area to be characterized by an excessive total mineralization, most often associated with high hardness and high fluoride concentrations.

Allocation of water resources in the Biskra eastern Zab basin

For the affectation of water resources in the Biskra eastern Zab basin, most water mobilized is intended to meet the agricultural needs, with a volume of 280, 6 Hm³/yr, or a rate of 90, 03%. However, this dominance is due to the increasing irrigation needs owing to the extension of new farmlands. The domestic needs are predominant in the water extraction in the basin, with a total volume of 30, 81 Hm³/yr, or 9, 88% of the total mobilized resources. The volume devoted to meet the needs for industrial use amounts to 0, 26 Hm³/yr, or 0, 08% of the mobilized resources.

The comparison between resources/needs is a very significant revealing indicator, which CF guides us as to the future of water policy that we are conducting in order to attenuate the water deficit impact according to the geographical space, the use sector and the considered deadline. The needs for water refer to the required quantity of water necessary to ensuring the supply of potable water (PWS), irrigation water (IWS) and industrial water (IWS). The quantitative estimate of the needs for water is based on two main parameters that are to be taken into account during the assessment of PWS's current and future needs. These parameters are the rate of population growth and the supply according to standards for PWS and technical parameters according to units for IWS.

The overall water supply presented per capitain the Biskra eastern Zab area is clearly higher than the national average (160 l/d/inh); they would be on average of the order of (360 l/d/inh). So, the potable water production passed from 44 million m³ for the year 2008, to nearly 45,83 million m³ for the year 2010, or a mean annual increase of 0,91 million m³ (Table. 2). The needs for domestic water in the eastern Zab area are of the order of 44 million m³/yrin the short term, 56, 14 hm³/yr in the medium term and 76, 11 hm³/yr in the long term (Table. 2). The needs for industrial water in the Biskra eastern Zab area are currently very low and are of the order of 0,55 hm³/yr in the short term, 0,81 hm³/yr in the

medium term and 1,14 hm³/yr in the long term (Table. 3). The irrigable surface area in the perimeter of the Biskra eastern Zab is estimated at 104803 ha, whereas we currently irrigate only 44414ha, or a rate of 42% of the total irrigable surface area. If we want to irrigate all this surface area with a supply of 15731 m³/ha/yr, we need a yearly total volume of 698 million m³.

The needs for irrigation water in the Biskra eastern Zab area are of the order of 698 hm³/yr (Table. 4) in the short term, 782 hm³/yr in the medium term and 887 hm³/yr in the long-term.

Table 1. Volume of water exploited in the eastern Zab area by aquifer.

Aquifers	Quater	Mio-Plio	Pontian	Eocene	Seno	Maastrri	Albian
Volume of water exploited(Hm ³ /yr)	5,00	231,85	6,69	11,75	15,94	10,18	5,74

Table 2. Perspective of the population evolution and of potable water demand in the Biskra eastern Zab area.

Year	2008	2010	2015	2020	2025	2030	2035
Population	334876	348747	385990	427209	472831	523324	57921
PWS needs (Hm ³ /yr)	44,00	45,83	50,72	56,14	62,13	68,76	76,11

Table. 3. Evolution over time of the needs for industrial water in the Biskra eastern Zab area (2008-2035).

Year	2008	2010	2015	2020	2025	2030	2035
Water needs (hm ³)	0,55	0,59	0,66	0,81	0,92	1,03	1,14

Table 4. Needs for irrigation water in the Biskra eastern Zab area.

Irrigated surface (ha)	Supply (m ³ /ha*yr)	Demand (hm ³ /yr)	
Water needs (hm ³)	44414	15731	698

The agriculture in southern Algeria greatly intensified. The Biskra area is the perfect example of this. The agricultural practices intensified in this area, thus requiring a rate of 90, 03% of water needs owing to the Biskra evidently hot climate, with excessive temperatures having yearly and daily high amplitudes. The insignificant rainfall and PET high intensity practically prevent any culture without irrigation. Additionally, the population growth observed is accompanied by a high water demand for domestic use about 9, 88 % of the needs. Whereas, the industry has a low rate of about 0, 08% of the water needs because the industrial network is

relatively weak. Currently, the volumes produced hardly meet the needs of all sectors together. Largely exceeding the supply in the medium-term, a most increased deficit will be brought about by the strong water demand, hence it is imperative to rationalize the exploitation of resources, with all that this implies in terms of investment.

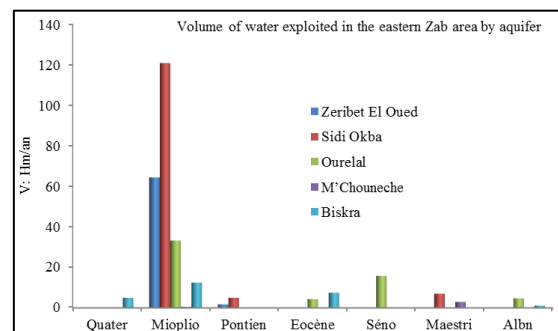


Fig. 2. Volume of water exploited in the eastern Zab area by aquifer.

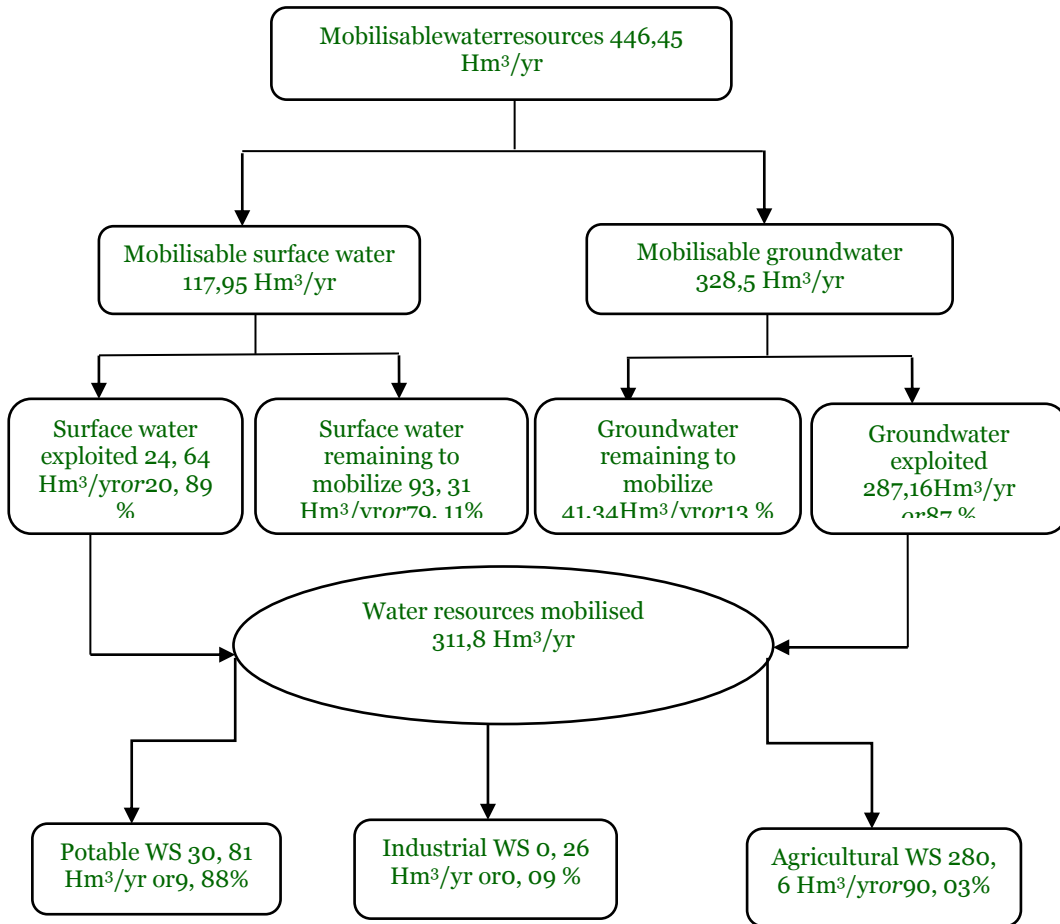
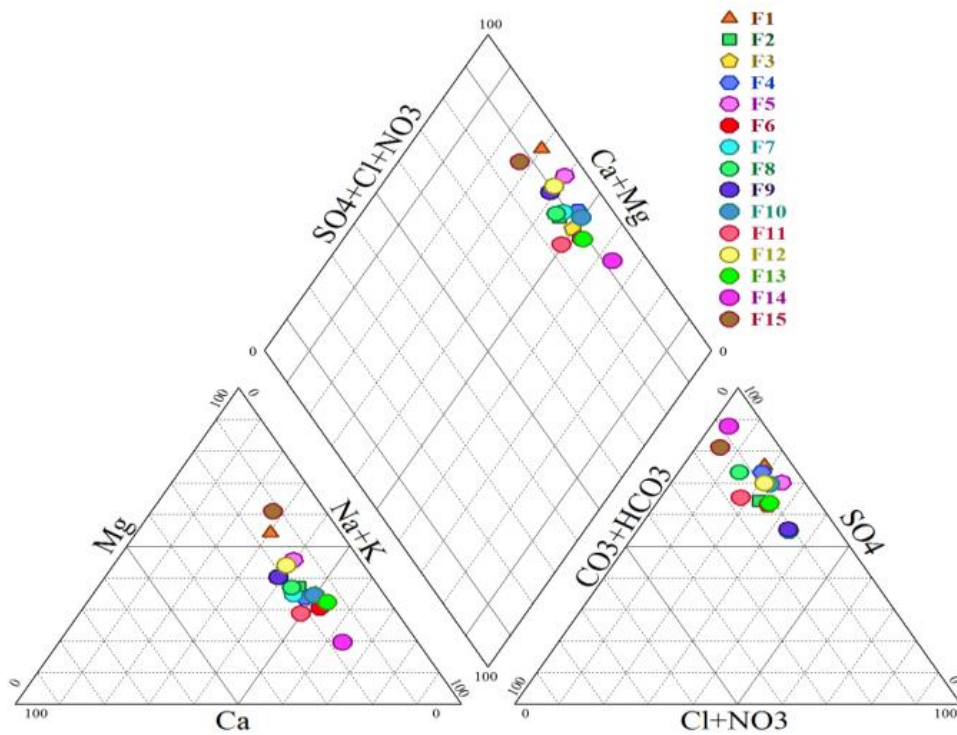


Fig. 3. Summary diagram of the water potential in the Biskra eastern Zab basin.



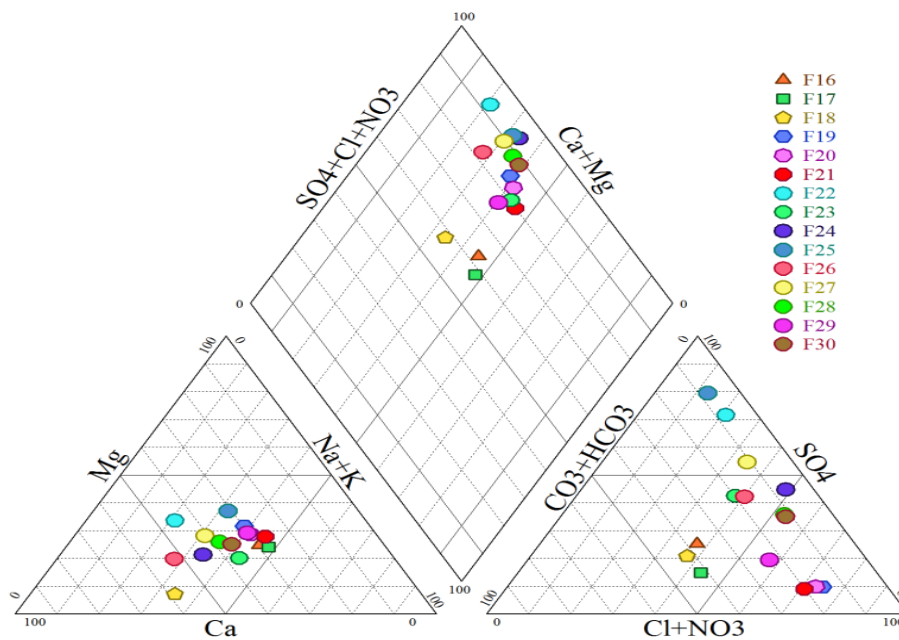


Fig. 4. Piper diagram for groundwater in the eastern Zab.

Water quality

Generally, the mineral characteristics of water of the study area appeared to be broadly poor, with values non-compliant with potability standards, especially for the most exploited aquifers (aquifers of complex terminal). The chemical characteristics of water have a controlling impact not only on public health and water potability but also on certain sectors, particularly agriculture which consumes the largest amount of water in the Sahara.

Piper diagram of groundwater shows a significant variability in chemical facies. These latter appear as follows:

Magnesium-sulfate facies: This facies is found at the boreholes F1, F5, F9, F12, F15 and F27; it comes from the gypsiferous formations separating the terraces of the ancient valley and those of the current valley.

Sodium-sulfate facies: This facies is found at the boreholes F2, F3, F4, F6, F7, F8, F10, F11, F13, F14 and F25; it comes from the gypsiferous and clayey formations. **Sodium-chloride facies:** This facies is encountered at the boreholes (F17, F19, F20, F21, F22

and F30); this facies indicates a salt-rich evaporitic dissolution owing to the existing of evaporitic lenses.

Calcium –chloride or calcium-sulfate facies: This facies is encountered at the boreholes (F23, F24, F26, F28 and F29). In general, water of this facies originates from marl, clay and sandstone formations.

Calcium-bicarbonate facies: This facies is found at the boreholes (F16 and F18) owing to dissolution of cipolinof the metamorphic basement.

Conclusion

The study area has considerable groundwater resources represented, in addition to the phreatic aquifer of Quaternary, by two aquifer systems, namely CT and CI. The exploitation of groundwater is the main resource for the supply of potable water to the population of the Biskra area. In fact, the exploitation of two dams in the area is made only for the irrigation of cultures. The Biskra eastern Zab area is not an exception; its demand for water is constantly increasing. Overall, we estimate the needs for water in the eastern Zab area to be nearly 743 million m^3/yr , unequally distributed between the three sectors.

The salinization of water resources is aggravated in certain cases by pollution of anthropogenic origin, most often domestic, industrial or agricultural, thereby causing water to be undrinkable and sometimes even unfit for irrigation. In fact, water in the Biskra area is of poor quality. This alarming situation is the result of the absence of an organizational control of the distribution and availability of good-quality water. The rapid increase in using these water resources without planning and management policy led to serious situations, which may have harmful and irreversible consequences on the environment. The only way to preserve these valuable resources, which are vulnerable in a large part of the Sahara, is to respect a coherent and rigorous management of water. It should be noted that the poor management of the water resources in certain study areas caused the creation or/and the increase in certain phenomena, notably pollution of groundwater through domestic or industrial wastewater. A rational management of the water resources makes it possible to prevent high mineralization and pollution.

References

- Abchiche M, Bedroune M, Habani H, Amia Z, Senouci M.** 1999. Etude hydrogéologique de la vallée de Oued Abdi et Bouzina (w. Batna). *Rapport*, Sonatrach, division opération, Hassi-Messaoud 36p.
- Aidaoui S.** 1994. Aménagement hydro agricole des Zibans. Thèse de doctorat université de Nancy II, France laboratoire de géographie physique 353 p.
- Baàzi H.** 2001. Etude de faisabilité d'un ouvrage de substitution dans la vallée de l'Oued l'Abiod. Thèse de Magistère, Université de Biskra.
- Bakalowich JN.** 1979. Contribution de la géochimie des eaux à la connaissance de l'aquifère karstique et de la karstification. Thèse Doctorat. Sc. Nat. Univ. P et M Curie paris. 260p.
- Bel F, Cuche D.** 1970. Etude des nappes du Complexe Terminal du bas Sahara : Données géologiques et hydrogéologiques pour la construction du modèle mathématique, rapport inédit, DHW, Ouargla.
- Benazzouz MT.** 2000. Morphogenèse éolienne holocène et actuelle dans l'Atlas saharien oriental (Algérie): Conséquence sur la désertification. Thèse Doctorat d'Etat, Université de Constantine. 350 p.
- Benazzouz MT.** 2003. A new chronology of upper Holoceneaeolian sands in the Zibans range, Algéria. *Suppl. Geogr. Fis. Dinam. Quat.* pp 47-54.
- Benrabah S, Bousnoubra H, Kherici N, Marc.** 2013. Caracterisation de la qualite des eaux de l' oued Kebir Quest (Nord Est algerien) *Rev. Sci. Technol., Synthese* **26**, 30-39.
- Besbes M, all.** 2003. Système Aquifère du Sahara septentrional : gestion commune d'un bassin transfrontalier, Eau et environnement. *Rev. la houille blanche N°5-2003.*
- Bouznad I, Zouini D, Nouiri I, Khelfaoui F.** 2016. Essai de Modélisation de la Gestion des ressources en eau dans la vallée d'Oued Righ (Sahara septentrional algérien) par l'Utilisation d'un outil d'aide à la décision WEAP. *Rev. Sci. Technol., Synthèse* **33**, 56-71.
- Brinis N.** 2003. Essai d'explication de la salinité des eaux de la nappe du mio-pliocène, cas de la zone est de la plaine d'El-Outaya Biskra ALGERIE. Mémoire de Magister, Univ.Badji mokhtar Annaba, 150p.
- Burollet PF.** 1972. Le Mésozoïque saharien. Essai de synthèse des données des sondages Algéro-Tunisiens. *Sédiment. Géol. Vol. 8.*
- Busson G.** 1971. Le mésozoïque saharien, 1ère et 2ème partie. Essai de synthèse des données des sondages algéro-tunisiens. C.R.Z.A., série géologie, N° **11**, Edition CNRS.
- Busson G.** 1989. Dynamique sédimentaire de plate-forme épicontinentale: Le Crétacé moyen du Sahara algéro-tunisien, Editions Technip, pp 125-144.Sc., Paris, 238 p.

- Castany G.** 1982. Le bassin sédimentaire du Sahara septentrional (Algérie-Tunisie). Aquifères du continental intercalaire et du complexe terminal. Bull. du B.R.G.M. Hydrogéologie et géologie de l'ingénieur. 2^{ème} série **2**, 127-149.
- Chabour N.** 2003. La remontée des eaux dans les régions du Sud: une solution le lagunage. Journée d'étude sur les applications des données géologiques et géotechniques aux plans d'aménagement, 2^{ème} SGCC International, Université de Constantine.
- Chabour N.** 2005. Caractérisation et modèle numérique de la nappe des calcaires nappe du Complexe Terminal dans la région de Tolga. 2^{ème} SGCC International. Université de Constantine.
- Chabour N.** 2006. Hydrogéologie des domaines de transition entre l'Atlas saharien et la plateforme saharienne à l'Est de l'Algérie. Thèse Doctorat d'Etat, Université de Constantine, Algérie, 176p.
- Chebbah M.** 2007. litho-stratigraphique, sédimentologie et modèles de bassin des dépôts néogènes de la région de Biskra. De part et d'autre de l'accident Sud Atlasique (Zibans Algérie) Thèse de Doctorat d'Etat. Université Mentouri-Constantine 479 p.
- Demrh.** 1980. Notice explicative de la carte hydrogéologique de Biskra, Direction des études de milieu et de la recherche hydraulique, service hydrogéologique.
- Derokoy AM.** 1975. Etudes hydrogéologiques dans le bassin du Chott El Hodna. Programme des Nations Unies pour le Développement. Rome 1975.
- Flandrin J.** 1941. Rapport sur l'hydrogéologie du bas Sahara. DEMRH Alger.
- Forkasiewicz J, Margat J.** 1982. Exploitation des réserves d'eau souterraines en zones arides et semi-arides. Essai de synthèse. B.R.G.M. Section III. N° **2**, PP. 115-126.
- Guendouz A, All.** 2003. Hydrogeo-chemical and isotopic evolution of water in the Complexe Terminal aquifer in the Algerian Sahara. Hydrogéologie journal 2003. **11**, 483-495.
- Khelfaoui F, Zouini D, Tandjir L.** 2013. Quantitative and qualitative diagnosis of water resources in the Saf-Saf river basin (North East of Algeria). Desalination and Water Treatment, DOI, **10.1080/19443994.2013.815583**.
- Laffitte R.** 1939. Etude géologique de l'Aurès. Thèse, Paris, Bull, Serv. Carte géologique Algérie, Alger. 2^{ème} édition. 484 p.
- Majour H, Djabri L, Sedrati N.** 2016. Analysis of the aquifer vulnerability of a Miopliocene arid area using DRASTIC and SI models. Vol. **9**, No. **4**, p. 124-132.
- Marsaud B.** 1996. Structure et fonctionnement de la zone noyée des karsts à partir des résultats expérimentaux. Thèse, Univ. Paris XI Orsay.
- Mecibah I, Zouini D.** 2016. Évaluation de la satisfaction des usages de l'eau d'un point de vue quantitatif et qualitatif du bassin versant d'Oued Guebli (Nord-Est algérien), Rev. Sci. Technol., Synthèse **33**, 72-81.
- Moula AS, Guendouz A.** 2003. Etude des ressources en eau souterraines en zones arides (Sahara algérien) par les méthodes isotopiques. Hydrologie of the Mediterranean and Semi arid regions (proceedings of an international symposium held at montpellier, April 2003), IAHS Publ. No. **278**, 2003.
- Nemouchi A.** 2001. Géographie hydrologique du bassin versant endoréique du Chott Hodna. Thèse de Doctorat. Université de Constantine 295p.
- Nesson C.** 1975. L'évolution des ressources hydrauliques dans les oasis du Bas-Sahara algérien ; Recherches sur l'Algérie. Mémoires et documents. Service de doc. et de cartographie géographiques. CNRS. Nouvelle série, V **17**, pp. 7- 99.

Ould Baba Sy M. 2005. Recharge et paléo recharge du Système Aquifère du Sahara Septentrional. Thèse Doctorat en Géologie, Univ. Tunis, El Manar. 271p.

Plagnes V. 2000. Structure et fonctionnement des aquifères karstiques. Caractérisation par la géochimie des eaux. Documents du BRGM 294p.

Rapport inédit ANRH. 2008. Inventaire des points d'eau et enquête sur les débits extraits de la wilaya de Biskra.

Rapport inédit DHW. 2010. Etude du plan directeur des ressources en eau du bassin versant de chott Melrhir.

Sedrati Nassima. 2011. Origines et caractéristiques physico-chimiques des eaux de la wilaya de Biskra Sud-Est algérien. Thèse de Doctorat. Université d'Annaba. 252p.

Tóth J. 1963. A theoretical analysis of groundwater flow in small drainage basins. Journal of Geophysical Research **68-16**, pp. 4795-4812.

Travy Y. 1994. The evolution of alkaline groundwater in the continental intercalaire aquifer of Irhazer Plain, Niger. Water resources research. Vol. **30**, N° 1, pp 45-61.