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This paper should be cited as follows:

Meziani, A., Remini, B. and Boutoutaou, D. (2016). **"Evaporation from Water Surfaces of Dam Lakes in Arid and Semi-Arid Region of Northern Algeria",** Athens: ATINER'S Conference Paper Series, No: **WAT2015-1811.**

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URL Conference Papers Series: www.atiner.gr/papers.htm

ISSN: 2241-2891
01/02/2016

Evaporation from Water Surfaces of Dam Lakes in the Arid and Semi-Arid Region of Northern Algeria

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Abstract

In arid regions, water is a renewable energy and at the same time a rare source and poorly distributed. The current situation of water resources and their uses in arid and semi-arid areas of Algeria have socio-economic issues. The phenomenon of evaporation in the dam lakes is considerable. A Loss of high volume is annually recorded. The five dams located in the south of Algeria are: Foum El-Gherza (Biskra), Fantaine des Gazelles (Biskra), Foum El-Guiess (Khenchela), Djorf –Torba (Bechar) and Brezina (El-Bayadh). Our paper presents an analysis of evaporation in these five dam lakes that present a paramount importance in Algeria with reference to the water management perspective.

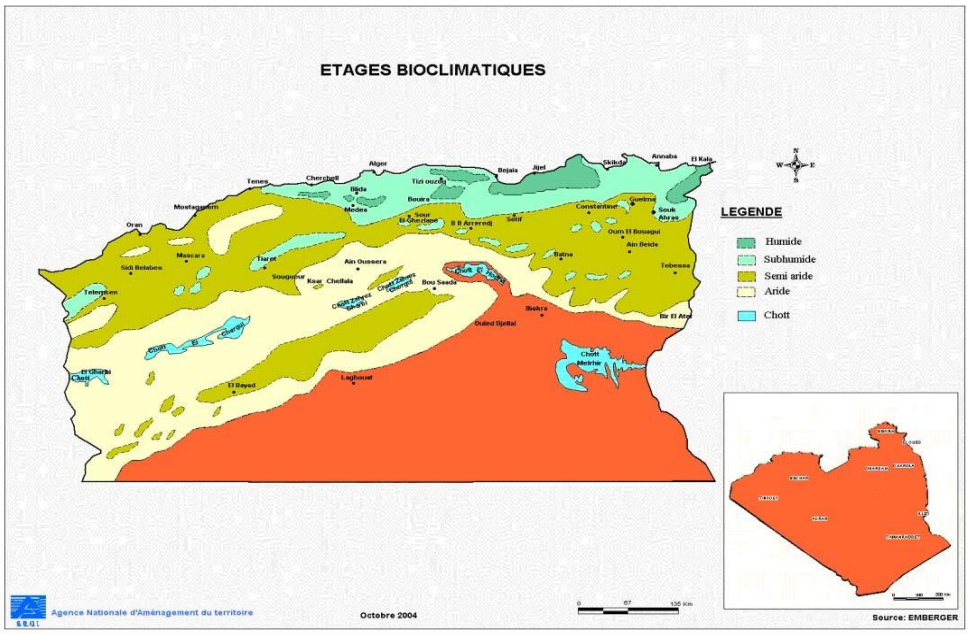
Keywords: Algeria, arid, dam, evaporation, semi-arid, water

Introduction

According to the Water Resources Department, the potentially available resources in Algeria are estimated at 18 Billion m^3, from which 10 Billion are superficial resources and 2.5 billion m^3 of groundwater resources are in the North and 5.5 billion m^3 (surface and groundwater) in the South. Today, Algeria has 70 operating dams with a capacity of 8.4 Billion m^3 (Figure 1), these mobilization and transfer structures will reach a total capacity of 9 Billion m^3 in 2025.

The arid region is characterized by high temperatures (up to 50°C), weak precipitation (less than 200 mm), low rates of humidity, and high evaporation from 2 to 3 or 4 m/year in arid zones (Saggai and Boutoutaou, 2012).

Figure 1. *Bioclimatic Map of Algeria (ANAT, 2004)*



The potential quantity of water is lowered by the silting-up of reservoirs, the evaporation from the lakes and water losses through dam foundations. The evaporation measured at 39 dams causes a mean annual loss of 250 Mm^3, 6.5% of their maximum capacity (Remini et al., 2009). These significant losses by evaporation of mobilized water resources by dam lakes encourage researchers to the intensive studies for the current state of the evaporative losses and the risk of aggravation in the future.

Materials and Methods

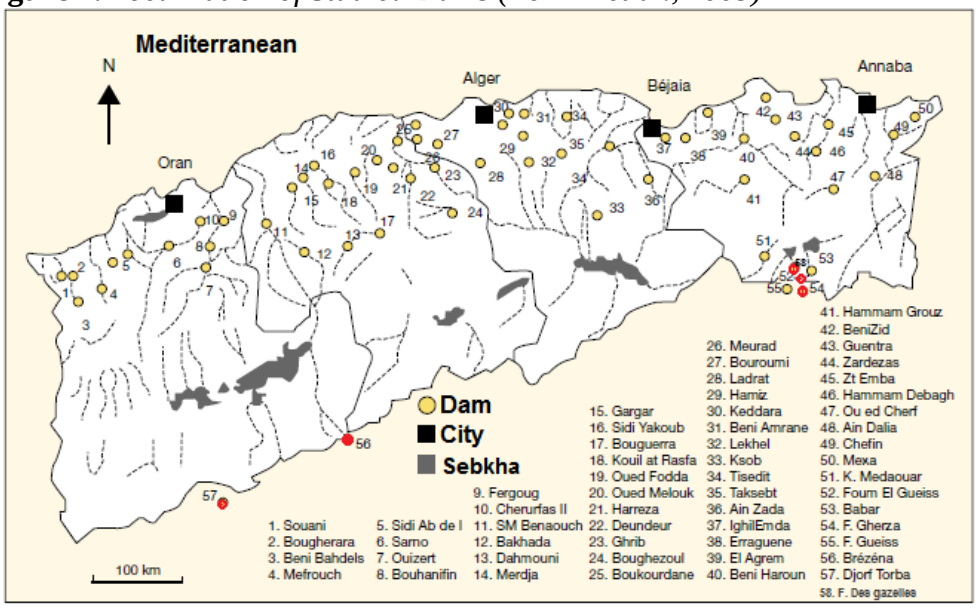
Characteristics of the Dam Lakes in Arid Regions

The Arid lands have always been important to the world's human population, but their significance has increased over the past few decades because of the augmentation of population demographics and the continuity of

the use of natural resources (Hoekstra and Shachak, 1999). In Algeria, arid and semi arid areas cover approximately 95% of the country (Halitim, 1984). In 2009, the number of dams, which reached fifty eight, were used to provide hydropower for the total area of Algeria. Five dams are located in the arid and semi-arid area (Figure 2), which are:

The Foum El-Gherza dam is located at the outlet of the Wadi El-abiod basin (put into operation in 1950), it spreads over an area of 1,300 square kilometers bounded by a perimeter of 200 km and passes through two distinct regions "Aures and Saharan plain" (Toumi and Remini, 2003). The average temperature is 22.9°C. The average annual rainfall is 250 mm, but is characterized by high irregularity. The dam regulates about 13 Mm^3 of the water conveyed by the Wadi El-Abiod ephemeral river and tributaries during a whole hydrogical cycle for catchment of 1300 km^2 (Hocini and Moulla, 2005); its capacity was 47 Mm^3/year (Remini et al., 2009).

Figure 2. *Localization of Studied Dams (Remini et al., 2009)*



Fontaine des Gazelles Dam is located in the north-east of Biskra city (put into operation in 2000). The dam is considered for irrigation and regulates the contributions of Wadi El-Hai. The main characteristics of the reservoir are: Catchment area: 1,665 km^2; total capacity of the reservoir: 55,491 hm^3; useful capacity: 48,490 hm^3, flood project: 3000 m^3/s.

The Foum EL-Gueiss Dam is located 19 km west of Khenchela. The Main characteristics of the reservoir are: Catchment area: 156 km^2, initial capacity of the reservoir is 3.0 hm^3, current capacity in 2001 around 478 000 m^3, siltation rate is about 95%, average depth of reservoir: 2 m and the flood project: 600 m^3/s.

The Djorf-Torba Dam has a theoretical capacity of 360 million m^3, it is an important hydraulic structure, located 70 km west of Bechar city, made in 1969 within the framework of the development program of the Abadla plain. In 2005, its actual capacity was 190 million m^3 with a regularized volume of 100

hm^3/year, from which 16 million m^3 are for the drinking water supply of Bechar city and about 50 million m^3/year for irrigation of Abadla perimeter (Kabour et al., 2011).

The construction of the Brezina dam was completed in 1998, with a total capacity of 123 Million m^3. The Liquid flows are exposed to considerable losses. Indeed, a contribution of 60 Million m^3, recorded during 2004-2005 of the reservoir level, remains that 12 million m^3 either losses rate is estimated 80%. Added to this problem, the sediment yield intake (about 1.2 million m^3/year), which contributes to the rapid siltation of the reservoir (siltation rate is about 5%) (Benslimane et al., 2009).

The region of Brezina (El-Bayadh) is part of a desert area, characterized by low rainfall, generally less than 200 mm/year, but with limited precipitation duration and high intensity. The annual rainfall over a period of 40 years of observation is characterized by irregularity: 329.4mm during 1971 (a wet year) and 113.5mm in 2010 (a very dry year. The minimum temperature recorded during the month of January is 0.7°C. The maximum temperature peaks in July with an average of 35°C, characteristic of a continental climate (Belaroui et al., 2013).

Methodology Used

Evaporation from water is most commonly computed indirectly by one or more techniques. These include pan coefficients measured pan evaporation, water balance, energy balance, mass transfer, and combination techniques (Jensen, 2010). Two kinds of pans are widely used in the world, the class "A" pan and the sunken pan. The class "A" pan is considered to be the standard international pan and the one used in Algeria, almost totally buried in the ground (Fekih and Saighi, 2012). Each dam is equipped by a pan installed restraint of reservoir. A high volume loss is annually recognized. The measurement period lasts from 2001 to 2012.

Results and Discussion

Evaporation is an important part of the hydrological balance, especially in arid and semi-arid regions where most crops present incomplete covers throughout a significant part of the growing season (Suleiman and Ritchie, 2003). The average annual evaporation calculated over ten years (1992-2002) in algerian arid dam lakes is 250 hm^3, representing 6.5% of total capacity. The case of the Djorf-Torba dam lake located in south-western Algeria is the most significant; it's around 90 hm^3 was reached during the hydrological year 1994-1995 (Manser, 2010).

According to ANAT, the evaporation was 1,860 mm in the dam lake of Foum El- Gueiss (measurements were made 8 hours daily throughout the year from sunken Colorado pan) and about 2,400 mm in the dam lake of Foum El Gherza, 15% in July (360 mm) and 3% in January (72 mm). Foum El Gherza lake, when the water level is wide, there has been an annual volume of 4 to 4.5 hm^3 evaporated (8% of the initial capacity of the dam) (Touati, 2010). In 2008,

the highest occupancy rate (over 75%) was recorded in the dam lake of Fontaine des gazelles 85,20% and the evaporation was 0.471hm^3. According to the data in Table 1, we realize there is a storage unbalance for each dam. The Figure 3 shows that the evaporation from the surface of lakes changes each year due to climate change of our studied region.

Table 1. *Water Capacities of the 5 Dam Lakes (ANBT, 2012)*

	Year 2001/2002		Year 2002/2003		Year 2003/2004	
Dams	Initial capacity (hm^3)	Final capacity (hm^3)	Initial capacity (hm^3)	Final capacity (hm^3)	Initial capacity (hm^3)	Final capacity (hm^3)
DJORF TORBA	138.684	164.195	164.195	89.933	89.933	218.649
F.GHEISS	0.74	0.184	0.184	0.344	0.344	0.044
F-GAZELLES	9.546	8.215	8.215	29.1	29.1	53.439
F.GHERZA	2.435	9.582	9.582	9.672	9.672	11.72
BREZINA	-	-	20.4	12.481	12.481	36.812

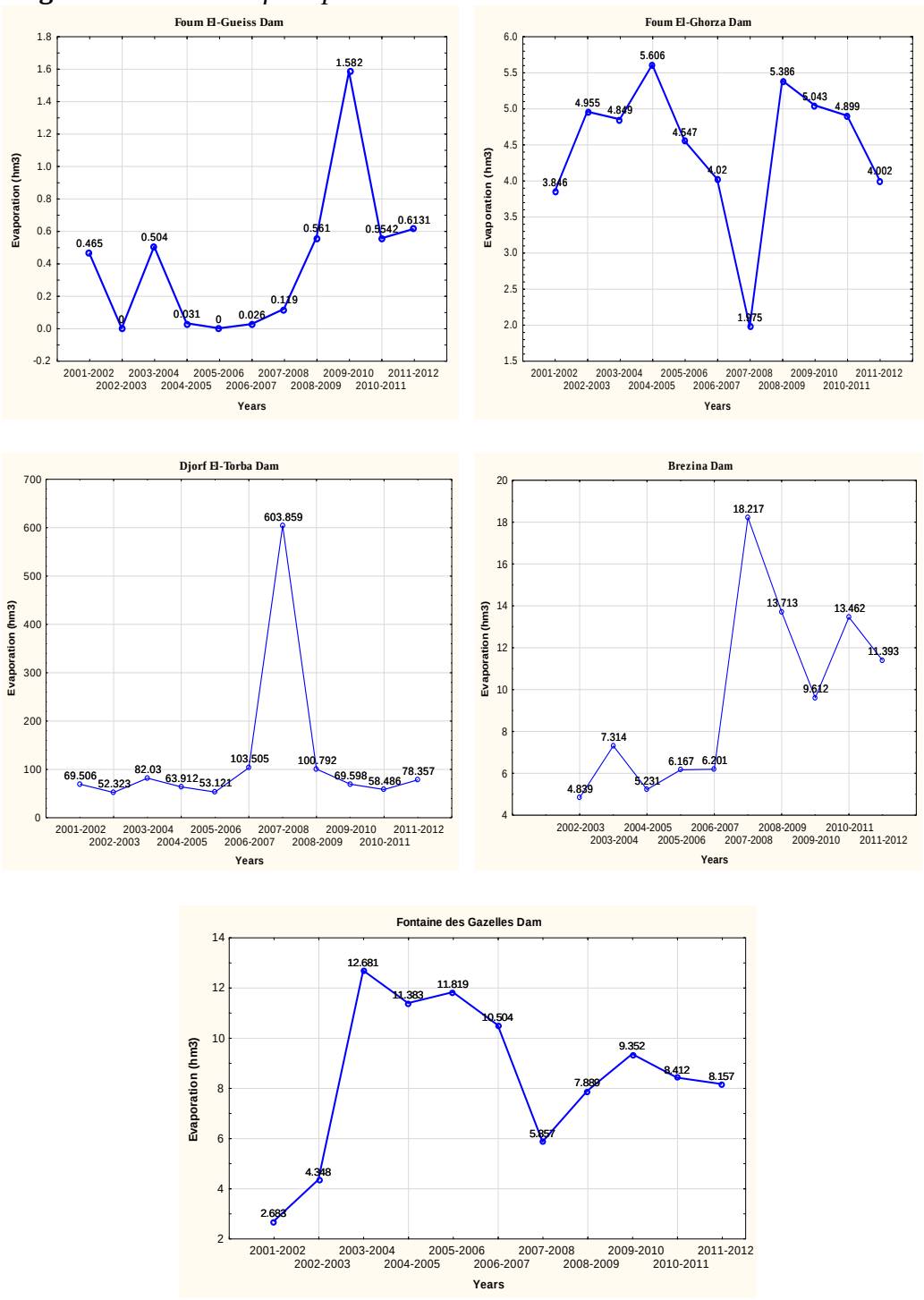
	Year 2004/2005		Year 2005/2006		Year 2006/2007	
Dams	Volume début (hm^3)	Volume fin (hm^3)	Volume début (hm^3)	Volume fin (hm^3)	Volume début (hm^3)	Volume fin (hm^3)
DJORF TORBA	218.649	73.326	72.871	205.126	225.82	179.48
F.GHEISS	0.044	0	-	-	0.424	0.43
F-GAZELLES	53.439	48.798	48.743	49.299	52.05	40.12
F.GHERZA	11.72	7.948	7.903	8.924	10.904	2.816
BREZINA	36.812	11.572	11.525	18.367	15.55	23.62

	Year 2007/2008		Year 2008/2009		Year 2009/2010	
Dams	Initial capacity (hm^3)	Final capacity (hm^3)	Initial capacity (hm^3)	Final capacity (hm^3)	Initial capacity (hm^3)	Final capacity (hm^3)
DJORF TORBA	179.012	258.519	258.519	216.881	216.881	61.269
F.GHEISS	0.43	0.024	0.424	0.344	0.344	0.349
F-GAZELLES	40.12	46.639	46.639	49.293	49.293	38.306
F.GHERZA	3.085	11.091	11.091	12.94	12.94	4.871
BREZINA	23.58	76.08	75.87	70.495	70.495	69.274

	Year 2010/2011		Year 2011/2012 (January-October)	
Dams	Initial capacity (hm^3)	Final capacity (hm^3)	Initial capacity (hm^3)	Final capacity (hm^3)
DJORF TORBA	61.269	122.122	122.122	168.976
F.GHEISS	0.349	0.43	0.43	0.181
F-GAZELLES	38.306	49.736	49.736	35.811
F.GHERZA	4.871	11.3	11.39	1.952
BREZINA	69.139	99.369	99.113	103.977

The evaporation reached a maximum value in different years for each dam lake. In 2009/2010, the evaporation of Foum El-Gueiss lake is maximal (1.582 hm^3) that means the temperature was highest than others years, the reservoir has a capacity of almost 500,000 m^3 and the water level was 1 m.

Figure 3. *Evolution of Evaporation in the 5 Dam Lakes*



In 2004/2005, the maximum evaporation of Foum El-Gherza lake is of the order of 5.606 hm^3 due to the climate change. However, the Brezina lake has a value of 18.217 hm^3 and the Fontaine des Gazelles lake has 12.681 hm^3. The highest evaporation is reached in the Djorf-Torba lake with the highest value of 603.895 hm^3.

Conclusions

The evaporation is considered important in these five dam lakes due to high temperature. A loss of high volume is annually recorded, especially in the Djorf-Torba dam lake. So, to reduce the evaporated water from these dam lakes, we propose to use an adequate to conserve the maximum water surface using chemical substances (Hexadecanol ($C_{16}H_{34}O$) and Octadeanol ($C_{18}H_{38}O$)) capable of forming thin layers on the water surface called monomolecular films. This technique showed that both Hexadecanol and Octadeanol reduced the evaporation rates in arid areas.

References

ANAT (Agence Nationale de l'Aménagement du Territoire), 2004. Carte bioclimatique de l'Algérie [Bioclimatic map of Algeria].

ANBT (Agence Nationale des Barrages et du transfèrt), 2012. Données d'évaporation des cinq Barrages [Evaporation Data for the Five Dams].

Belaroui K., Djediai H., Megdad H. (2013). The influence of soil, hydrology, vegetation and climate on desertification in El-Bayadh region (Algeria). *Journal Desalination and Water Treatment.* 52 (2014) 2144–2150. DOI=http://dx.doi.org/ 10.1080/19443994.2013.782571.

Benslimane M., Hamimed A., Seddini A., Mederbal K. 2009. Utilisation de la télédétection et des SIG pour la modélisation hydrologique du bassin versant de Brezina [Use of remote sensing and GIS for hydrological modeling of the basin of Brezina]. Journal de l'eau et de l'environnement, ENSH, no. 11-12, pp. 18-36.

Fekih M., Saighi M. (2012). Measurement and Estimation of Evaporation from Water Surfaces: Application to Dams in Arid and Semi Arid Areas in Algeria. World Academy of Science, Engineering and Technology. *International Journal of Mathematical, Computational, Natural and Physical Engineering* Vol 6, No:8, pp. 23-26.

Halitim, A. (1984). Contribution à l'étude des sols des zones arides (Hautes plaines steppiques de l'Algérie) [Contribution to the study of soils in arid zones (High steppe plains of Algeria)]. Thèse Doct. Es Sciences. Université de Rennes. 384p.

Hocini N., Moulla A. S. (2005). Detection of water leaks in Foum El-Gherza dam (Algeria). *Ninth International Water Technology Conference, IWTC9 2005, Sharm El-Sheikh, Egypt.* 17 -20 March. pp 581-589.

Hoekstra T. W. and Shachak M. Arid lands management, Toward Ecological Sustainability. University of Illinois Press (1999).

Jensen M. E. (2010). Estimating evaporation from water surfaces. *The CSU/ARS evapotranspiration workshop*, Fort Collins, CO, 15-Mar-2010. Parts of several sections were extracted from Chapter 6, ASCE Manual 70, second edition, Jul-08 draft.

Kabour A., Hani A., Mekkaoui A., Chebbah L. (2011). Évaluation et gestion des ressources hydriques dans une zone aride. Cas de la ville de Bechar (sud-ouest algérien) [Assessment and management of water resources in an arid area. The city of Bechar (south-western Algeria)]. *Larhyss Journal, ISSN 1112-3680, n° 09, Décembre 2011, pp. 7-19*

Manser A. 2010. Atelier régional "Barrages en Méditerranée" [Regional Workshop "Mediterranean Dams"] - World Trade Center Marseille - 13 & 14 Décembre, Marseille. DOI= http://bit.ly/1nOIJdx.

Remini B. Leduc C. and Hallouche W. 2009. Evolution des grands barrages en régions arides : quelques exemples algériens [Evolution of large dams in arid areas: a few Algerian examples]. *Sécheresse Journal. 96, 103(2009)*

Saggai S. and Boutoutaou D. 2012. Evaporation reduction of water plans in arid zones by monomolecular films (case of ouargla). In *Proceedings of the* Sixteenth *International Water Technology Conference* (*May* 07 – 10, 2012), IWTC 16. Istanbul, Turkey, 1-5.

Touati B. (2010). Les barrages et la politique hydraulique en Algérie: Etat, diagnostic et perspectives d'un aménagement durable [Dams and hydraulic policy in Algeria: state, diagnosis and prospects for sustainable development]. Thèse de doctorat d'état, université Mentouri, Constantine, Algérie. pp75.

Toumi A., Remini B. (2003). Contribution à l'étude des fuites dans les barrages algériens [Contribution to the Study of leaks in the Algerian dams]. International Conference on the Impact of Global Environmental Problems on Continental & Coastal Marine Waters July 17th and 18th.

Suleiman A. A. and Ritchie J. T. 2003. Modeling soil water redistribution during second-stage evaporation. Soil Sci. Soc. Am. J. 67(2), 377–386.