The underground brackish waters in South Algeria: potential and viable resources

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Abstract

The significant groundwater resources of Algeria are located in southern Saharan far away from dense population centers and important socioeconomic activities. This groundwater in South Algeria is a non-renewable resources, which are contained in huge reservoirs of the two sedimentary basins: the Continental Intercalary and the Complex Terminal aquifers.
Fresh water supply to some remote desert areas in Algeria represents one of the major constraints to development of such areas. The presence of brackish water of moderate salinity (2000–3000 mg/L) in some of these areas can present an economic and reliable fresh water supply, if an appropriate desalination scheme is adopted. In this paper, the potential role of brackish water as a source of fresh water in South Algeria and the problems related to brackish water solar desalination experience in south Algeria are discussed. A case study for brackish water desalination using reverse osmosis (RO) scheme is presented to elucidate its feasibility as compared to other water supply options. Further, planning guidelines for brackish water desalination are presented.

The paper is concluded with the economic feasibility for large-scale RO desalination system for the presented case. The purpose of our study is to bring an alternative solution of supply fresh water to the rural world of the areas of Algeria. Being characterised by very significant solar layers, the simple distillers with a greenhouse effect could adapted to these areas more especially as their design does not present a technical difficulties. However, their output of fresh water remains insufficient. With a view to ameliorate their yield, our study aims at improving condensation of the water vapour accumulated in the distiller by a natural or forced flow towards an independent condenser. This technique constitutes a means of reinforcement of condensation and makes it possible to improve notably the effectiveness.

Keywords: Groundwater resources- Southern Algeria - Groundwater exploitation –Brackish water; Solar Desalination; Economics; Solar Distillation ; Greenhouse effect; Solar energy; Brackish water.

Introduction

Algeria, with a surface of 2.4 millions km^2, is the largest country of northern Africa. Most of this surface is occupied by the Sahara, unfit to agriculture, but rich with mineral resources. More than 90 % of the population lives in the North, that includes a coastal band along the Mediterranean Sea, plains, mountains and high lands. The annual amount of rain, in the North, varies between 300 and 1000 mm. In the Sahara and south the Saharian Atlas, the annual amount of rain is below 100 mm. Algeria has 17 major hydrographic basins and shares the Medjerda basin with Tunisia, and Tafna, Draa, Guir and Daoura basins with Morocco.

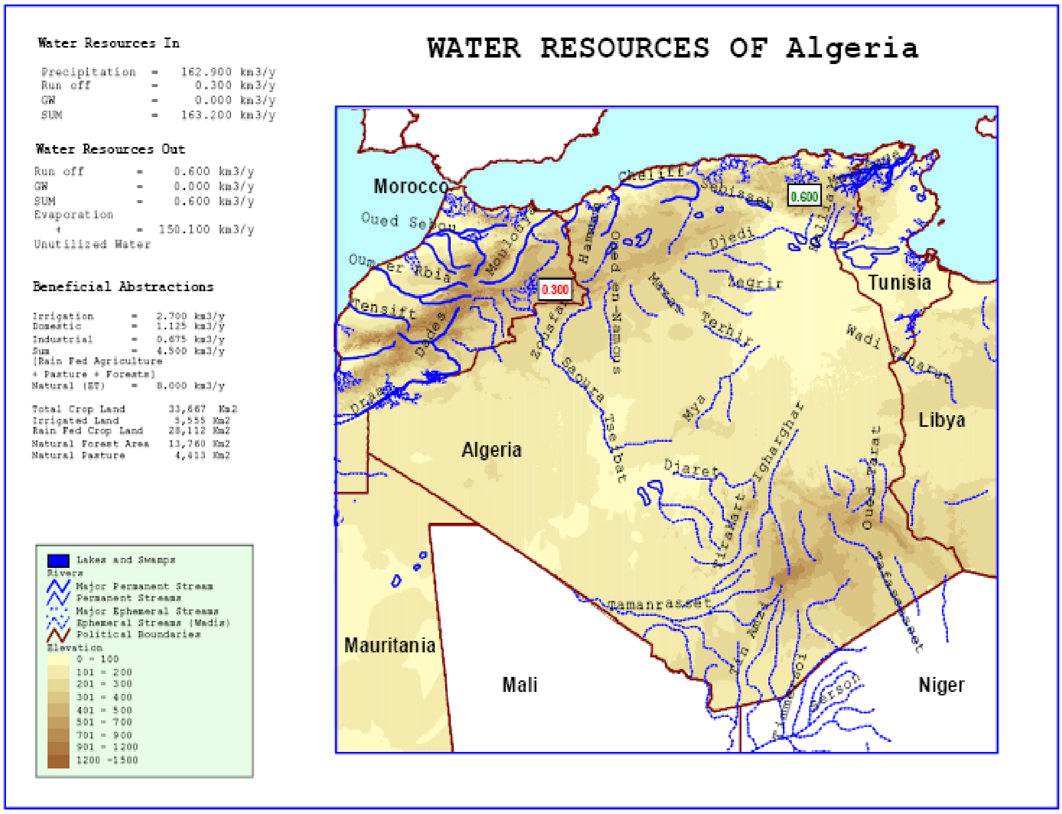
The annual amount of rain is 100 billion m^3, of which 80 % evaporate into the atmosphere. The water resources are estimated at 19.3 billion m^3/year, of which 12.4 billions of surface water and 6.9 billions of underground water. Only 6 billions could be mobilized by dams. For the moment only four billions are mobilized by nearly 110 dams.
From the 6.7 billions of groundwater resources, 5.1 billion are located in Sahara. The rest, i.e. 1.6 billion m^3, is already mobilized at a rate of 80 %, principally by wells and boreholes. We must mention the National Plan for the potable water: This large project, launched in 1990, financed by the European Investment Bank and given to an association of European consultants, had to elaborate a data bank, the more complete as possible, about surface waters, underground waters, on the urban, industrial, and agricultural water demand and to define the major axes of investment in water for the twenty next years.
The study, which is nearly done, had been cut into the five grand hydrographic basins, which are the territories of the basin agencies:

- Oranie - Chott Chergui
- Cheliff- Zahrez
- Algérois - Hodna- Soummam
- Constantinois – Seybousse – Mellegue
- Sahara

Water availability and demand in Algeria

The traditional sources are 19.3 billion cubic meters BCM annually. The surface water are12.4 BCM annually. 95 percent of resources in the north. The groundwater are 6.9 BCM annually. Seventy three percent (73%) of resources in the south. For the non-traditional sources, the use of non-conventional water resources such as treated wastewater and desalinization is not yet common.
For the demand, Algeria is a water -scarce country. Per capita renewable water resources are 470 cubic meters per year for a population of 29 millions. The water scarcity threshold is 1,000 cubic meters per capita annually. Agricultural irrigation is the primary water consuming sector followed by the domestic and industrial sectors. Water allocated for irrigation has dropped from 80 percent in 1960 to around 60 percent in 2002.

The salinity levels of surface water vary between 0.8 grams per liter (g/l) and 1.5 g/l with the majority of resources having a salinity of less than 1 g/l. In the north, most groundwater is non-saline with less than 1 g/l salinity. In the south the salinity levels are variable and some sources have high salinity levels of up to 8 g/l.
Most water resources in Algeria are polluted by uncontrolled and untreated municipal wastewater. Eighty-seven percent of the urban population is connected to a sewage network, but most wastewater treatment plants are out of service so untreated sewage is being discharged into natural water bodies.
Industries discharge untreated effluents into natural water bodies in violation of government regulations. About 200 million cubic meters per year of untreated industrial wastewater is discharged into the environment. Uncontrolled and improperly monitored leaching practices and agricultural drainage that includes nitrates and phosphorus from fertilizers pollute water. Pesticide residues can also be detected in some surface water.. Leaching from improperly discharged and untreated solid waste also pollutes water.



Government policy, strategies and activities

The new water sector policy in Algeria aims to (i) centralize water management activities and (ii) gradually increase the involvement of the private sector. Within the new institutional framework, the Ministry of Water Resources and the Ministry of Environment and Land Use Planning will be responsible for water, wastewater and irrigation planning, management, monitoring, and pollution control.

The two most important instruments in the legal and regulatory framework are:
(i) Environmental Protection Law No. 83 – 03 of 1983. This law specifically mentions water pollution.
(ii) Water Law No. 83-17 "Le Code des Eaux" (revised in 1996 under law No. 96-13). This code includes several articles related to wastewater discharge, pollution abatement, the protection and preservation of water bodies and wastewater reuse for agricultural and industrial purposes.
Few standards for water quality exist, though several water quality investments are underway. These include wastewater treatment, industrial pollution, and solid waste management programs. Institutions such as the World Bank, European Investment Bank and German Government are financing these investments.

The government is actively restructuring the water sector and grouping water, wastewater and irrigation activities under one ministry. A water quality monitoring program including some 100 stations along major watercourses and dams was established several years ago to monitor surface water. Thirty water quality parameters are tested and pollution sources have been mapped. Groundwater is tested every three months. Potable water is monitored daily by the health services and hygiene community offices. Testing for residual chlorine is used as an indicator of bacteriological contamination (higher chlorine levels indicate higher contamination).

Develop an integrated action plan for water quality management including identification and delineation of responsibilities for the organizations and institutions involved. Clarify and

prioritize objectives of the new water sector policy. Improve water quality monitoring including reconnaissance surveys of the status of water quality and the sources of pollution; identify the country's laboratory requirements; and develop a sustainable cost-effective monitoring program. Review the existing legal and regulatory framework and develop additional legal texts. Review existing standards for enforceability.
Issue application decrees for the Water Code, improve standards for industrial effluent discharge, and develop standards for other water such as potable water. Develop and implement a program for strengthening national capacities overall for
water quality management. Improve technical and financial monitoring and enforcement capabilities to test for all listed standards since to date most monitoring has been limited to the most polluting industries and a few water quality parameters such as biochemical oxygen demand (BOD), chemical oxygen demand (COD) and suspended solids.

Systematic inventory of water resources

In Algeria, the systematic inventory of water resources, in spite of many studies carried out during the last century is not completed yet, but its broad outline is known. These resources are not well distributed, in space, quantity and nature (surface or underground). The major part of the country (87%) corresponds to a desert, where precipitations are quasi null but which conceals important fossil underground water resources. The Northern part of the country is characterised by a Mediterranean climate, with renewable surface and underground water resources. Ninety percent of the surface water is located in the Tell area which covers about 7% of the territory. Another characteristic is the strong disparity between the West and East of the country. Plains are reaching on the poorly sprinkled Western area. The Eastern part of the country is a mountainous area where the principal rivers run out. The Western basins receive only 10% of the flow with a surface representing the third of that of the North of the country. Those of the East drain 40% with only 20% of the total surface and the Centre basins drain 50% of the flows with 50% of the remainder of the surface. One estimates nearly 1.6 billion the volume regularised by year. The numbers of dams reach 115 of which 45 have a capacity higher than 10 millions m^3 and 65 of lower capacity. The total of surface and underground water resources are estimated at 19.2 billion of m^3 with the distribution indicated in table 2, where we can see the water resource potential (in Hm^3) in Algerian territory. In table 1 we have the sites sampled in the C.I. Aquifer in South Algeria and South Tunisia (from W.M. Edmunds et al.). The surface water in Algeria interest primarily the Northern part which has nearly 330,000 km^2 and located to the north of the axe formed by Bechar - Laghouat – Biskra (South of Algeria). These surface water is subject to many constraints related to the physical environmental factors. The topography structure and the nature of the land determine the layout of the hydrographic network. The unity of hydrological basin is very weak and, between the sources to the mouth, is made of a succession of modest rivers, slightly connected with each other in a disproportionate valley which they borrow in heritage of wetter periods. These rivers, on short distances, present contrasts between zones of strong erosion and active deposits. No large rivers can be found in the Northern part of the country since chains parallel to the shore do not allow it.

In Algeria, underground water is an essential capital in regard to the water reserves. The repeated dryness of these last decades clearly put forward the weaknesses of balance between need and resources regarding the surface water. The advantages of underground water, as a resource, result from the characters of their occurrence, their distribution and their regime in the natural environment. One can say: Underground water does not require installations similar to regulating equipment and surface water transfer; underground water is often accessible and exploitable using simple means without requiring an excessive investment, in wide territories; underground water often offers natural characteristics in conformity with the standards required by many uses, in particular the drinking water.

Taking into account the diversity of the formations and geological structures as well as the importance of feeding the underground water reserves, all types of aquifers are represented in Algeria. It results from this point of view that the underground water potentialities and their exploitation could be radically different. A classification based on geological and morphological criteria made it possible to determine levels of much diversified resource and their exploitation. The strong potentialities allowing an intensive exploitation are localised in two principal types of aquifers:

· The large karstic, free or captive aquifers: mounts of Tlemcen, table land of Saida, karsts of Zibans.

· The large plains formed by subsidence and filled by an important alluvial filling, well fed as well by precipitated as by the rivers which cross them: plains of Sidi Bel Abbes, Mitidja, Mascara, Annaba.

· The rate of renewal of these aquifers is rather appreciable. Considering the geological environment and particular climatic conditions, one can say that in many areas of Algeria, the use of the underground water resource is limited by various factors:

- The parcelling out and the partitioning of the reservoirs as well by erosion as by tectonics,
- The morphology accentuated on a large part of the North
- The limited power of the aquifers is a real constraint for intensive exploitation
- The weakness of the unit flows of drillings which involves a number exaggerated of drills.

To this quantitative limitation of the reserves available, one can add the deterioration of the chemical quality of water. This is particularly true in the aquifers coastal (plain of Andalouses, Mitidja Eastern, plain of Annaba- Bouteldja, ... and the aquifers of the semi-arid areas, in particular those in the vicinity of the closed depressions (Chotts and Sebkhas). Excessive extraction from these aquifers often involves a fast increase in the water mineralization. For these reasons, real and direct exploitable volumes of underground water, by well and drillings, can differ notably from the values of the annually infiltrated water. In Table 3, we can see these water resources in different regions of Algeria (surface and underground waters) (Hm^3).

Table 1
Sites sampled in the Continental Intercalaire aquifer, Algeria and Tunisia[a]

Field no.[b]	Locality	Depth	T (°C)	pH	SEC (μS cm^{-1})	TDS (mg l^{-1})	δ^2H (per mil)	$\delta^{18}O$	^{14}C (pmc) (%)	$\delta^{13}C$ (per mil)	$^{87}Sr/^{86}Sr$	Na	K	Ca	Mg	HCO_3	SO_4	Cl	NO_3.N	NH_4.N	Si
												(mg l^{-1})									
1	Bouheraroua	390	29.1	7.23	2460	1618	−68	−8.3			0.708529	242	9	180	78	137	580	379	5.7	<0.01	6.1
2	Bensmara 1	371	30	7.14	2250	1431	−64	−8.6	0.9	−7.84		198	10	163	75	155	483	334	5.3	<0.01	6.0
3	Daia Ben Dahoua	467	31.6	7.41	2350	1534	−63	−8.5	1.6	−7.69		229	8.2	160	70	139	593	320	7.6	<0.01	5.7
5	El-Assafia 1	100	20.6	7.32	1650	1181	−53	−7.7	54.0		0.707985	72.9	9	185	65	168	513	159	1.5	<0.01	6.7
6	Djebel Makrane (U1)	210	29.1	7.28	2810	2166	−40	−6.3	60.0		0.707838	155	8.4	361	98	210	1090	234	3	<0.01	5.2
7	Hassi-Dalaa	350	29.4	7.27	2130	1383	−58	−8.1			0.708197	184	16.7	161	68	175	453	318	1.6	<0.01	5.4
8	Berriane 2	545	28.6	7.56	1500	964	−59	−8.1	0.5	−8.63	0.70843	137	12.5	97.2	41	184	294	189	2.2	<0.01	5.5
9	Laroui	650	28.6	7.44	1860	1213	−61	−8.4				155	17.7	133	61	198	384	256	1.8	<0.01	5.6
10	Guerrara:Laameyed	1000	37.4	7.44	2500	1548	−60	−8.3				232	19.1	164	69	166	476	411	3	<0.01	7.2
12	El-Mir	1895	50.8	7.60	2850	1767	−58	−7.8	0.8	−10.89		204	28.5	189	66	151	722	395	<0.3	<0.01	9.8
14	Blidet Omar 1989	1800	46.5	7.61	2750	1813	−62	−8.2				205	34.3	210	73	167	662	448	<0.3	<0.01	9.4
16	Ain-Sahara	1799	50.5	7.51	3000	1968	−60	−8			0.708193	240	34	215	79	153	725	510	<0.3	<0.01	10.4
17	Sidi-Slimane 1	1776	51.7	7.57	2940	1973	−59	−8.5	0.0	−10.05		268	42.7	227	92	165	663	502	<0.3	0.06	11.1
18	Sidi-Slimane 2	1775	54.7	7.38	2910	1952	−61	−8.4				263	39.5	214	95	174	666	488	<0.3	0.07	11.0
20	Meggarine	1820	53.7	7.39	3460	2282	−61	−8.3			0.708076	315	39.3	270	100	154	764	627	<0.3	<0.01	11.6
22	Ain-Choucha	1755	46.5	7.82	2630	1719	−61	−8.4	0.5	−10.46		222	37.5	191	85	174	579	419	<0.3	<0.01	10.4
37	Etteibat	1890	55.2	7.62	3210	2167	−61	−7.8			0.708135	346	46.8	280	105	139	674	560	<0.3	<0.01	14.8
38	Sehane El Berry	850	35.9	7.80	3490	2449	−60	−8			0.708262	629	36.5	185	37	108	1000	438	<0.3	0.38	11.5
39	El Oued	1850	55.7	6.93	2960	2045	−63	−8.1			0.708107	294	50	275	78	152	700	480	<0.3	0.15	14.2
40	Sidi-Mahdi	1750	37.9	7.49	2820	1953	−57	−7.7			0.708179	281	40.4	246	91	153	677	450	<0.3	<0.01	12.7
42	Khchem Er'rih	1450	48.5	7.58	2650	1745	−61	−7.6			0.708408	276	32	181	78	173	554	438	<0.2	<0.01	10.2
45	Hassi Ben Abdelleh 3	1400	49.6	7.82	2700	1700	−64	−9.1	3.7	−9.1	0.708371	271	32	188	77	168	517	435	<0.3	<0.01	10.5
47	Hassi Ben Abdelleh 4	1450	48.9	7.60	2630	1595	−63	−7.2				257	29.7	161	70	173	463	430	<0.3	<0.01	9.9
49	Zelfana 1	1000	37.8	7.59	2800	1631	−60	−7.9	1.6	−7.5	0.708453	315	11.5	163	64	152	430	482	4.4		7.6
50	Zelfana 8 (Fedj Enaam)	950	34	7.72	2290	1415	−63	−8.9				252	10.8	133	55	166	425	360	4.7		7.2
78	M'rara MR3	1700	47.5	7.20	2720	1624	−61	−8.4	0.5	−10.46		218	38.3	209	86	101	570	390	<0.01		10.3
79	M'rara MR4	1680	48	7.29	2730	1667	−59	−8.2				200	40.3	229	86	110	600	390	<0.01		10.2
101	Nefta CI 1	2068	70	7.34	5130	3368	−58	−7.1	5.80±1.00			529	69.9	412	66.5	140	1510	600	<0.3	0.465	20
102	Nefta CI 2	2326	72	7.17	4700	2717	−50	−7.7			0.708348	374	62.9	371	43.4	144	1380	320	<0.3	0.381	19
103	Tozeur CI 1	1730	67	7.16	24400	12705	−57	−7.0	8.80±0.60	−7.85	0.707826	3500	79.8	889	279	104	1840	5960	<0.3	5.02	15.1
104	Tozeur CI 2	1757	68	7.33	5880	3334	−62	−7.7	2.50±0.60	−9.05	0.708443	601	48.7	347	38.7	134	1620	520	<0.3	0.496	13.5
105	Tozeur CI 3	1885	66	7.13	4200	2519	−61	−7.6			0.708285	327	60	390	46.3	(110)	1320	356	<0.3	0.279	13.9
106	El-Hamma C I2	1469	64	8.20	5030	3377	−67	−6.8	7.30±0.80	−11.00		652	46.3	304	29.9	256	1710	360	<0.3	0.358	15.5
107	El-Hamma C I4	1339	73	7.57		3191	−57	−6.8				513	55	287	30.8	134	1450	696	0	0.075	7.7
108	Tazrarit CI 1	2052	68	8.52	5650	3362	−62	−7.5	6.40±0.50	−10.30	0.709393	925	110	196	32.9	33	454	1600	<0.3	0.955	1.5
109	Cedada CI 2	2257	38	7.11		2510	−53	−8.0				336	90.4	340	37.8	207	1030	442	<0.3	0.461	20.3
110	Chorfa CI 4	2042	70	7.18	4440	2180	−60	−8.8				330	47.3	266	74	134	691	620	<0.3	0.134	15.5
111	Zouia CI 5	2052	71	7.24	4360	2271	−57	−7.6				335	48	284	78.9	134	716	656	<0.3	0.122	15.8
112	Mansoura CI 3	1700	52	7.57	4940	3346	−64	−8.3	3.70±0.80	−11.43	0.708119	562	38.5	408	87.9	122	1260	850	<0.3	0.261	11.7

Table 1 (*continued*)

Field no.[b]	Locality	Depth	T (°C)	pH	SEC (μS cm^{-1})	TDS (mg l^{-1})	δ^2H (per mil)	$\delta^{18}O$	^{14}C (pmc) (%)	$\delta^{13}C$ (per mil)	$^{87}Sr/^{86}Sr$	Na	K	Ca	Mg	HCO_3	SO_4	Cl	NO_3.N	NH_4.N	Si
												(mg l^{-1})									
113	Mansoura CI 13	2368	65	7.74	3680	2178		−8.4	2.20±0.90	−10.77		345	43	257	67.7	140	708	600	<0.3	0.159	13.9
114	Kebili CI 10	2286	66	7.55	3930	2311	−64	−8.4	1.50±0.90	−10.44	0.708176	387	42.4	263	67.2	134	784	616	<0.3	0.21	14.1
115	Kebili CI 16	2578	70	7.20	3130	2138		−8.3			0.708198	396	41.3	185	64.9	122	703	610	<0.3	0.203	0.3
116	Taouargha CI 2	900	45.5	7.20	3130	2244	−59	−8.6	5.30±0.80	−11.49	0.708215	341	43.2	269	71.7	146	740	620	<0.3	0.171	10.1
117	El Bhaier CI 9	1268	65	7.17	3460	2421	−59	−8.1			0.708173	363	46.9	306	74.1	128	808	676	<0.3	0.159	16.3
118	Limagues CI 8	1568	67	7.30	3340	2317	−61	−8.5				365	43.7	285	70.6	110	790	634	<0.3	0.173	16.7
119	Debabcha CI 14	2159	71	7.07	4640	2167	−58	−8.1				306	44.9	271	72.2	128	734	592	<0.3	0.116	16.3
120	Souk El Ahad CI 17	2100	68	7.35	2830	1827	−59	−8.2				281	42.3	201	61.3	110	645	464	<0.3	0.005	3.8
121	Menchia CI 6	2178	72	7.04	3640	3037	−60	−8.4			0.708267	488	52	277	30.2	43	1440	700	<0.3	0.31	5.2
122	Seftimi	1666	72.5	7.54	3250	2258	−59	−8.4	6.6±1.5	−9.50		341	47.3	271	78.6	140	710	652	<0.3	0.065	12.8

[a] The results are given for field measured parameters (T °C, pH, SEC), stable isotopes and radiocarbon as well as major ions and silica.

Table 2 Water resources in Algeria (Hm^3)

Zone	Surface water	Underground water	Total
North area	12 410	1 760	14 170
Sahara	-	4 950	4 950
total	12 410	6 710	19 120

Table 3 Water resources in different regions in Algeria(Hm^3)

Area	Surface water	Underground water
ORANAIS	645	200
CHELIFF	1.660	207
ALGEROIS	3.010	412
SOUMMAM	700	122
CONSTANTINOIS	3.000	174
COTIERS-ANNABA	1.340	44
CHOTT CHERGUI	220	69
ZAHREZ-SERSOU	290	153
CHOTT-HODNA	280	133
MEDJERDA-MELLEGUE	645	75
AURES-NEMEMCHAS	300	145
SUD- ATLAS	70	20
SAHARA	250	4.950
TOTAL	12410	6.710

Strategies for integrated management of water resources

To face the water resources problems and in a preoccupation with a better management, it was adopted an integrated approach of protection and rational use of the water resources by:

· The creation of the Water National Council and five watershed agencies was adopted, whose statute specifies that the agencies manage the contributions of all nature granted by the State and intended to promote and support the projects and actions aiming at the water economy, the safeguard of its quality and the protection of the receiving mediums against the pollutant emissions; the five agencies are: - Oranie - Chott Chergui, Cheliff - Zahrez, Algiers zone - Hodna - Soummam, Constantinois - Seybouse – Mellegue and the Sahara.

· The creation of the watershed committees at the level of the five agencies made up of the representatives of the State, the local authorities and the users; they have role of formulating opinions on all the questions related to water and in particular about:

- The appropriateness of projects and installations under consideration of the level of the influence zone of the watershed.
- The contention related to water that can occur between the local authorities whose watershed includes the territory.

- The distribution of the water resource mobilised between the various potential users.
- The intervention programmes of the watershed agency.
- The revision and adoption of a new water code.
- The realisation of new stations for waste water treatment to protect water quality.
- The establishment of the national quality chart of the surface waters.
- The establishment of a cleansing tax fixed at 20 % of the invoice of consumption out of drinking water and industrial
- The institution of a royalty of saving water whose rate varies from 2 to 4% depending on the areas.
- The creation of national funds for integrated management of water resources.

In 1993, the Ministry of Equipment, after an analysis on the situation of urban water and sanitation, initiated a large process of changing in the sector. After a large concertation with the main concerned sectors (Agriculture, Industry, local collectivities), a New Water Policy was adopted, based on four main principles:

• Water must be protected, in quantity and in quality
• Water is a collective resource, whose use is subject to an agreement between all the users
• Water must me managed inside a natural hydrological unit, the hydrographic basin

In 1996, five Hydrographic Basin Agencies were created, first tools of this new water policy. They are responsible for:

• Collecting data, particularly relative to hydrology and hydrogeology, to the use and quality of water, and to the existing infrastructures of the basin
• Participating to the elaboration of regional plans for allocating the water resources.
• Sensibilisation of the consumers.
• Participating, with the help of the National Fund for Integrated Resources Management, in financing projects aiming at protecting the water resources, in the country, in quantity and in quality.

Other resources of drinking water in South Algeria

a- Solar distillation of brackish water

Many prototypes of solar stills are functioning at the laboratory of renewable energies development LENREZA (Ouargla University), many others are under construction with different dimensions.

The aim is to develop a highly efficient desalination system of simple construction, applicable in units of less than one m^3 daily fresh water production, suitable also for areas of poor infrastructure. Based on previous research work, one and two-stage multi-effect solar distillation desalination units have been developed. It is concerned with a solar distiller for arid zones, that should be very simple, hardy, easy to maintain and repair by every village artisan with limited technical means. This type of distiller is called the Capillary Film Distiller (or DIFICAP) : It is made up of identical evaporation-condensation cells. The brine to be evaporated is a thin film impregnating a fabric assumed to be very thin and adhering by capillarity forces to the wall of the plate. Its advantage reside in the recovery and reuse of latent heat of steam condensed in the one stage, for water evaporation in the subsequent stage.

The study on the performance of this solar still has been conducted under the actual insolation at the South of Algeria, where the water resources are brackish.

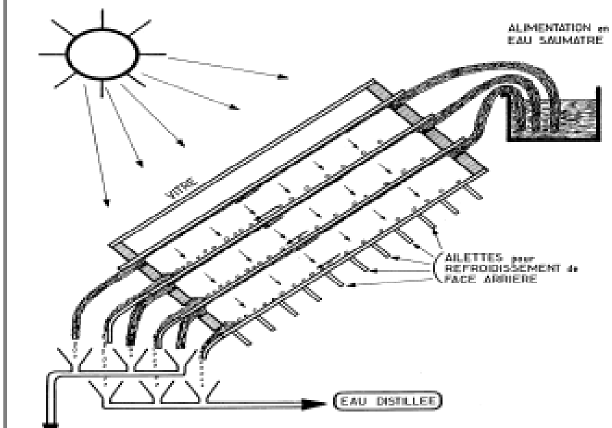


Fig. 6 bis
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b- Fresh water supply: In Salah project in South Algeria

Fresh water is an important natural resource in desert environments. The local community fresh water supply availability and quality at In Salah is typical of most other parts of Algeria. Most of the population relies on fresh water from non-renewable underground aquifers. This is true for In Salah Gas (ISG) and we seek to use this valuable resource responsibly by managing the use of aquifer and protecting the aquifers we use from contamination. The following water monitoring is carried out: Monitoring of Aquifer water; monitoring of water for domestic and industrial use; monitoring of wastewater; and monitoring of produced water. Water use minimisation is of key importance within the In Salah Gas operations as the facility is located in a water scarce country. Water minimisation is part of the sites environmental strategy and shall involve the identification of water reuse, reduction, or recycling methods where applicable. Preventative maintenance routines are defined within the MAXIMO system. Maintenance inspections are routinely carried out. In 2006, ISG implemented the use of waste water from COPA (waste water treatment) units for irrigation. Tests have started at the Krechba Camp and at the TEG camp they have started using all the water from the new waste water treatment plant. In 2006 there was a plan to install water meters to accurately measure total water usage across ISG. The mapping of all water systems at all sites is complete. A work order is now under way to install the water meters. In 2006 there was a plan to investigate options to reduce water losses. As a consequence, the REG Reverse Osmosis unit has reduced the quantity of reject water it produces. At Krechba, there is an investigation into the use of a cover for the swimming pool (to reduce evaporation losses).
The In Salah water BP project generates 6,000 litres of drinking water a day for 27,000 residents in the remote South Saharan community of In Salah. A clean water is supplied for the 800 inhabitants of Hassi Ghanem. The project involved building a 3.5km pipeline and seven water distribution centres throughout the village.

c- Experimental study of small solar desalination plant using reverse osmosis

An experimental study has been carried out by the Center of Development of Renewable Energies (CDER, Algiers). It consists of testing in real conditions of a small reverse osmosis unit coupled to a solar generator. The experimental site is located in the small village of Hassi Khebbi situated in a desert zone 1400 km southwest of Algiers. This installation produces nearly 1000 L/h of fresh water from underground brackish water.
Site characteristics: latitude: 29°11, longitude: 5°21 west, raw water: brackish, salinity: 3.5 g/L, solar radiation: between 6071 and 7510 Wh/d, number of inhabitants: 800
Experimental installation and testing: R.O. unit, photovoltaic generator, energy storage and regulation system, raw and fresh water storage system.

The installation functioned many years and has produced many million liters of fresh water. However, several stoppage periods occurred. These were more or less long and were caused essentially by:

- a mishandling by the operator, lack of skilled labor in remote areas,
- breakdown of the feeding pump (external to the experimentation)

In general, the whole system functioned satisfactorily from the technical point of view and the quality of the water produced is very convenient to use. The unit was designed to operate either in automatic or manual mode. In fact, the automatic mode was not compatible with the labor quality available in such an area, so consequently this was the source of problems.

Conclusions

In Algeria, even when not taking global climatic change into account, water scarcity is an important problem with acuity in many areas of the country. Since the seventies, dryness prevails in an intense and persistent way. The impact on the water resource already appeared through, the reduction in the rivers flow, the low level of filling dams and the global fall of the piezometric level of the principal country aquifers. In the future, the current deficits of the water resources will increase. This will lead to obvious problems of management and strategy to ensure a durable development for the country.
In the Sahara region, i.e South of Algeria, there is a large amount of groundwater. It represents non-renewable resources of brackish waters, which are contained in huge reservoirs of the two sedimentary basins: the Continental Intercalary and the Complex Terminal aquifers.
Fresh water supply to these regions in Algeria represents one of the major constraints to development of such areas. The presence of brackish water of moderate salinity (2000–3000 mg/L) in some of these areas can present an economic and reliable fresh water supply, if an appropriate desalination scheme is adopted. Solar desalination of brackish water can be chosen as an alternative solution since this technology has been useful for producing distilled water in large amounts by using simplest installations for solar driven thermal desalination called solar stills. This process uses the sun’s energy to produce fresh water from sea or brackish waters. The solar stills have been working worldwide for more than one century. The most commonly used device in solar desalination is the solar still. This device, however, has the disadvantage of having low operational efficiency and low production rate of fresh water.

Small solar stills for fresh water production were not able to compete in the past because they were too expensive for producing less than 6 litres per square metre per day of fresh water. The recent development of stills based on new concepts for stream-leading and heat recovery, like the capillary film distiller, has been successful. With heat recovery in the capillary film distiller, we can reach up to 15 litres of fresh water per square metre per day of collector for one stage; if the distiller contains many stages, we can reach up 25 litres. A many small units of reverse osmosis desalination are under construction in many towns in South Algeria, for the supply of fresh water the inhabitants on this region.

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