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Water in Algerian Sahara: Environmental and Health impact

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<http://dx.doi.org/10.5772/50319>

1. Introduction

The supply of drinking water has become difficult in many countries, thus, access to safe drinking water, is expected to become in the the world as fundamental economic and social rights and unfortunately this is not currently the case. Whether its origin, superficial or groundwater [Cheriti et al, 2011; Cheriti et al, 2009; Talhi et al, 2010], water used for human consumption are rarely consumables unchanged. It is often necessary to treat them more or less sophisticatedly, or simply by disinfection in the case of groundwater. The reserves of groundwater in Algeria are estimated to 6.8 billion m³. However, these groundwater are at significant depths and are characterized more by a strong mineralization, on the other hand, due to the particularity and specific climate of Algeria, the rivers dry frequently [ABHS, 2009]. As a rule, waters are subdivided into categories depending on a level of their mineralization or their rigidity. There are also other approaches to classification of water of various sources, for example, taking into account simultaneously its mineralization, rigidity and the contents of organic impurity. The boundary values for division of water into categories are sufficiently conventional and they differ in various sources of information [Djidel et al, 2010].

Better quality of water described by its physical, chemical and biological characteristics [Manjare et al, 2010]. The provision of good quality household drinking water is often regarded as an important means of improving health [Sanjana et al, 2011]. According to World Health Organization (WHO), there were estimated 4 billion cases of diarrhea and 2.2 million deaths annually [WHO, 2008].

The supply of clean water is limited by a lack of infrastructure, capacity and financial resources [Schafer et al, 2010]. Waterborne diseases caused by pathogens, long term exposure to chemicals such as fluoride. So, the quality of drinking water is becoming a serious public health issue for the past few years. The quality of water for drinking has deteriorated because of inefficient management of the piped water distribution system. The contamination of water with fecal material, domestic and industrial waste may result in an increased risk of disease transmission to individuals who use those waters [Radha Krishnan et al, 2007].

In another hand, in Algerian sahara, the drinking water supply is provided exclusively by groundwater from the aquifers of the Terminal Complex and Continental Intercalary (Albian water), characterized by high level of fluor, which its excessive consumption becomes toxic and constituting a public health problem especially in dental health [Bahloul et al, 2011].

The aim of the chapter focuses on the determination of water quality and assessing the possibility of wells in the Algerian sahara as an alternative source of drinking water and for domestic purposes. Characteristics of water are presented from different Saharan region. Analysis of the data shows that the general mineralization of water from the studied boring greatly exceeds the acceptable standards. Such water can be used only after demineralization. The fluoride content of drinking water of some Saharan region was measured, and health impact is discussed.

2. Characteristics of the Algerian Sahara

The Algerian Sahara is one of the hottest and driest in the world, covers an area of more than two million square kilometers and extends from the Saharan Atlas mountains to the Malian, Nigerien, and Libyan borders. It covers a distance of over two thousand kilometers (north-south). This vast territory is formed by nine Wilayates (districts) with a population estimated at three million and a half inhabitants. The vast majority of this population is generally concentrated in the chief places of wilaya, some of which exceed 150,000 ca. The vast majority of this vast territory is occupied by large bodies represented by *regs*, *erg*, and *saline lakes*, which are unsuitable areas for agriculture. The Sahara is characterized by scarce rainfall and very irregular between 200 mm and 12 mm in the north to the south, high temperatures can exceed 45°C, causing them of significant temperature fluctuations and also by low relative humidity of the air. Winds are relatively common and their speed is important from April to July, resulting in this period and the sirocco sandstorms, responsible for the formation and movement of dunes. The evaporation pan measured Colorado ranges from 2500 mm in the region of the Saharan Atlas and more than 4500 mm in the South (Adrar) [Djellouli-Tabet, 2010].

The Algerian Sahara is divided into four natural regions [ABHS, 2009]:

Chott Melghig: The hydrographic basin represented by Melghig Chott is one of the great watersheds of Algeria, it covers an area of 68,750 km², and it is distinguished by a large river of Oued Djedi. This river has many temporary tributaries that drain large areas and whose violent floods are sometimes devastating. Surges over the water and the deviations are numer-

ous, representing a non-negligible contribution water in irrigation perimeters and comes in extra-scooping into groundwater. Average annual rainfall in the basin varies between 200 and 300 mm / year.

Northern Sahara: This basin covers almost than 600,000 km² and is mainly distinguished by two important aquifers, the Continental Intercalary and the Terminal Complex [ABHS, 2009]. Groundwater provides drinking water supply and irrigation in this region. Rainfall in this region are very weak and random, varies from 200 mm / year in the north of the Saharan Atlas to the south 25mm/y.

Saoura region: Located in the South West of Algeria and covers an area of 320,273 km². It is limited by El Bayadh in the North, Mauritania in the South, Adrar in East and Morocco in West. The water surface potentials are very important (Djorf Torba Dam) and the groundwater quantity product could not solve the problem of water shortage for drinking water supply and irrigation. Indeed, all these water resources are conditioned by the contribution of rainfall, which is irregular and random [INC, 1983]. The rainfall in the region, may reach 200 mm in the north and decreases to 70 mm in the south of the region (Table 1 and 2) [AMS, 2009].

Tassili Nedjjar: This region is represented by the wilaya of Tamanrasset, which is characterized by a vast territory and a very low level of population regroupements. It covers an area of 556,100 km² and is bounded on the north by Ouargla and Ghardaia districts, to the east by Illizi, to the west by Adrar and in the south by Mali and Niger. The groundwater resources are very limited and are located mainly in the lap of the infero-flow of Oueds.

The Sahara region, is one of the vulnerable regions to climate change impacts. Climate change could have negative impacts on several socioeconomic sectors of the region like water resources.

Month	00h00	03h00	06h00	09h00	12h00	15h00	18h00	21h00
Jan.	6.7	5.5	4.6	7.6	12.9	14.6	12.3	8.8
Feb.	9.7	8.2	6.4	10.5	16.0	17.9	16.1	12.3
Mar.	14.4	12.5	11.4	15.9	20.2	21.6	19.9	16.2
Apr.	16.0	14.0	12.8	18.3	22.1	24.0	23.1	19.3
May	23.1	20.7	19.3	25.7	29.3	31.3	30.7	26.3
Jun.	27.0	25.7	24.3	31.0	34.6	36.1	35.3	30.8
Jul.	32.8	30.2	29.0	35.8	39.3	40.7	39.8	35.5
Aug.	32.1	30.0	28.3	34.3	38.4	40.1	38.5	34.6
Sept.	22.8	21.4	20.4	25.0	28.5	29.7	28.0	24.6
Oct.	20.2	18.2	16.6	23.5	28.1	29.6	27.3	22.9
Nov.	13.4	11.5	10.3	15.9	22.2	23.4	20.0	15.7
Dec.	10.3	8.8	7.4	11.3	18.0	20.3	16.5	12.7

Table 1. Monthly temperature rang in Algerian Sahara (1/10 C.) [AMS, 2009]

The first signs of changes already appear in this region through both the temperatures and the precipitation evolutions. Temperatures have increased by 1 to 2°C during the twentieth century. So, an important part of water resources in the Sahara has as origin the precipitation. Any changes in precipitation characteristics may affect water resources of this region already under water scarcity conditions [ANRH, 2001; OSS, 2001].

Month	00h00	03h00	06h00	09h00	12h00	15h00	18h00	21h00
Jan.	73.5	77.9	81.4	72.2	46.7	40.5	48.4	63.6
Feb.	64.4	72.3	78.0	65.6	42.5	34.9	39.2	53.9
Mar.	58.5	64.0	68.6	56.5	41.5	37.1	40.4	52.7
Apr.	52.4	56.7	60.9	44.8	33.3	28.1	29.4	39.5
May	39.5	44.8	49.9	36.1	28.9	24.0	23.0	29.4
Jun.	37.8	40.4	45.8	34.0	25.5	20.6	20.1	25.6
Jul.	23.1	26.2	29.3	23.7	18.7	15.4	14.3	18.9
Aug.	21.9	27.1	30.0	24.5	19.1	16.0	16.1	19.5
Sept.	62.0	66.2	69.6	53.7	41.9	38.1	41.4	53.6
Oct.	51.2	57.1	63.4	47.5	35.9	30.9	32.6	43.0
Nov.	51.6	57.3	62.1	52.8	38.4	33.6	37.2	46.3
Dec.	50.4	55.4	60.8	57.6	41.5	33.9	37.0	44.9

Table 2. Monthly relative Humidity rang in Algerian Sahara (%.) [AMS, 2009]

3. Water supply in Sahara Region

3.1. Potential water of resources in Algerian Sahara

In Algerian Sahara, the water has a vital character, because the climatic and hydrological contexts are extremely fragile. The spatial and temporal irregularity of the water availability, the impact of the droughts and flooding and the pressure of the demand of water are in continual increasing facing limited resources.

The potential water of resources in Algeria is of 17 Billion of m³ (surface water 10 Billion of m³, underground water 6.8 Billion of m³ mainly in the Sahara). According to Bouguerra [2001], the potential of the surface water resources in the north of Algeria, estimated at 13,500 hm³ per year in 1979, was reevaluated at 12,410 hm³ per year in 1986 and is more currently at only 9,700 hm³ per year. The resource is clearly declining, taking into account the dry conditions that have prevailed for the last three decades on all the basin slopes of northern Algeria as testified by the actual state of dams. The underground aquifers situated to the north of Algeria are exploited to 90%, with 1.9 Billion of m³ per year. Some aquifers are be-

coming overexploited and in the Sahara region the extracted volume is valued to 1.7 Billion of m³. The most exploited water tables are less than 50 m deep, where they are easier and less expensive to reach. A growing number of wells tap groundwater between 100 m and more than 600 m deep. Various traditional and modern means are used to access these wells, including pulley and power-driven pumps [Meddi, 2006; Mutin, 2000].

The aquiferous system of the north Sahara, extending 1 million km², is shared by Algeria, Tunisia, and Libya. The groundwater tables are fed by the winter rains and sometimes by infiltration from the Oueds (Figure 1 and 2). Algeria, Tunisia, and Libya have launched efforts to coordinate the management of these water resources. The Aquiferous System of the Septentrional Sahara (SASS) is a program initiated by the international organization Observatory of the Sahara and the Sahel (OSS) to develop dialogue between the three countries.

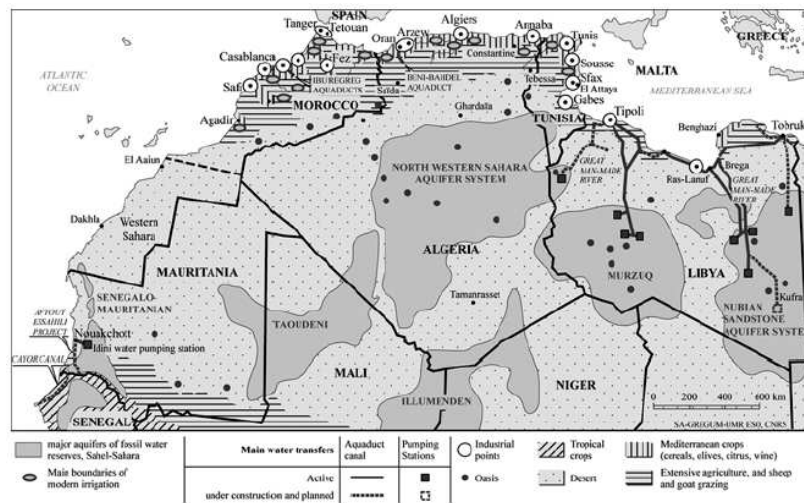


Figure 1. Groundwater resources and main water transfers in North Africa [Rekacewicz, 2006].

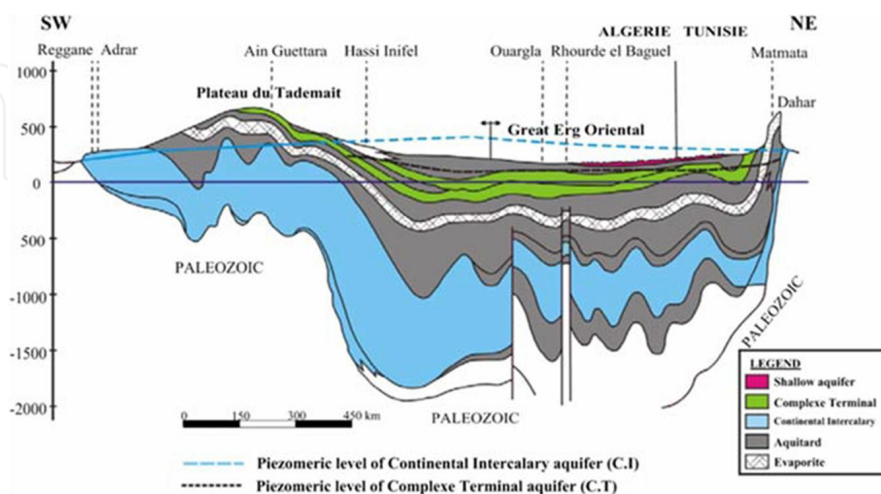


Figure 2. Hydrogeological section across the Sahara [UNESCO, 1970].

The number of pumping stations has multiplied between 1970 and 2000, to date, more than 7,000 water points exist in the countries. In 2002, a SASS report noted that “the simple continuation of the current intensity of pumping can constitute a serious danger.” The volume of water pumped annually has increased by 525% in 50 years, from 0.4 billion m³ in 1950 to 0.6 billion m³ in 1970 and to 2.5 billion m³ in 2000. The fact that these resources are nonrenewable makes them even more vulnerable in the long term [Latreche, 2005; OSS, 2001].



Figure 3. Impact of flooding – El Bayadh City on October 01, 2011. a) Satellite images, Algerian Alsat-2A [ASAL, 2011], b), c) and d) Destruction of the Historical Mahboula Bridge.

The rainy season may occur in autumn, winter, or spring according to geographical position [Djellouli-Tabet, 2010; Le Houerou, 1984]. More than 120 million hectares (ha) of arid land is threatened by the processes of desertification, according to the United Nations Convention to Combat Desertification (UNCCD), with 445 million ha already considered desertified. Natural water resources are limited, and the spatial distribution and management of these different resources varies considerably depending on locality. The recorded rainfall amounts show that the average rainfall has decreased in recent years. In the last decade, this deficit in Algeria was more than 20% for the western area, 13% for the central part of the country, and 12% for the east [Bouguerra, 2001; Ould Amara, 2000].

Water scarcity in the Sahara may appear paradoxical given the exceptional weather events that led to recent floods in several areas that can be as well very prejudicial for the public or private infrastructures that for agriculture, and to cause numerous victims among the population.

The catastrophic floodings like the Timimoun in 2000, Ghardaia in 2008, Bechar in 2008, and recently El Bayadh on October 2011 (Figure 3), are causing the destruction of several infrastructures and the historical Mahboula Bridge.

3.2. Water Collection and Distribution

3.2.1. Dams for the storage of surface water

The storage of water during the humid years in order to use it during the dry years imposes itself in Algeria. The dams of bigger sizes should be encouraged to take into account the impact of the climatic changes. Thus, the Dams National Agency (ANB) is using more than 50 dams with a capacity of 5.1 billion m³ and other dams are part of a project within the special framework emergency program to reinforce the drinking water supply in large cities.

The Algerian Sahara has a significant potential dams like: *El Gherza* (Sidi Okbba, Biskra), *Djorf torba* (Bechar) and *Larouia* (Brizina, El Bayadh) (Figure 4).

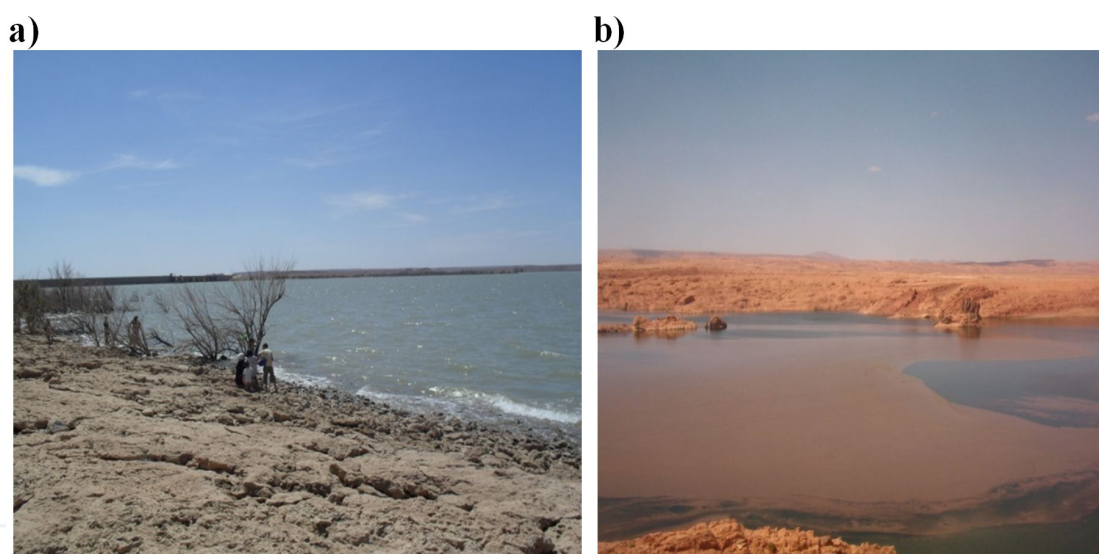


Figure 4. Dams in the Sahara, a) *Djorf torba*- Bechar- b) *Larouia*-Brezina.

3.2.2. Reuse of the Foggara

The need for people to overcome the challenges of an arid climate to meet water demand is nothing new. Traditional irrigation technique developed since ancient times in the region of the *Touat*, *Gourara* and *Tidikelt*, for capture and water supply to the aquifer through a system of draining galleries similar to qanats in Iran, khetaras in Morocco. These systems, called foggaras in Algerian sahara (Figure 5), constitute a remarkable water management and delivery network that has enabled people to live in arid environments. The system collects groundwater and carries it through small tunnels to irrigate gardens, allowing gravity irrigation. [Ahmadi et al, 2010; El Faiz et al, 2010; Senoussi et al, 2011].

Many official organizations as NOF (National Observatory of Foggara) recommend rehabilitation of this system by helping, repair, and monitor foggara systems in the oases of the Algerian Sahara to promote conservation and sustainable development of these lands, stabilize the populations of the oases, and reduce poverty and desertification.



Figure 5. Foggara system in Adrar - Algeria.

4. Ethnopharmacological uses of water in Sahara

Water is an indispensable element in the lives of living beings and especially to that of man. Natural heritage, water indelibly marks people's identity, it became a factor in the development and archeology proves that, to 3800 BC, it is the progress of irrigation that allowed the rapid demographic growth observed in the Middle East. Culture, including religion, clearly influences how people perceive and manage a resource such as water. The water culture was very different events that have evolved over the ages by taking multiple expressions. It helped to disseminate techniques, behaviors, tastes refinement [Bouguerra, 2003; Cheriti et al, 2010].

4.1. Water: Practical and Traditional Knowledge

Ariha "Jericho", the oldest city in the world, founded in 8000 BC in the Judean Desert, owes its existence to the freshwater springs that form small natural lakes near the Dead Sea. Hammurabi (Babylon), dug canals and water rights codified in 1730 BC. Well water has become a key development issue and archeology proves that around 3800 BC, it is the improved irrigation techniques that have enabled the rapid demographic growth observed in the Middle East.

Local knowledge is a valuable resource that can contribute to improved development and are the basis for decision making in the areas of food security, human health, animal health, education and natural resource management. Its well knows that water is a preferred instrument of human gathering in traditional cultures, while a sink or source can gather a tribe nomadic or sedentary [Bouguerra, 2003; Faruqui et al, 2001; Ansari, 1994].

It is known that water in addition to its importance as a vital element in the life of living beings and especially to that of man, is a natural heritage, it marks indelibly the identity of people. Moreover, as water is also found in symbolic practices and traditional knowledge, it affects our environment and our daily realities. The water culture was very different events that have evolved over the ages by taking multiple expressions. It helped to disseminate techniques, behaviors, tastes of refinement

It is observed clearly from the practice of special chemical of water, so simple molecule composed of atoms them essential to life, Hydrogen and Oxygen the particularity to pass a physical state to another: solid (ice), liquid (water) and gas (steam). Similarly it is through water that passes from one state to another: Dirt / Clean, Fatigue / Relaxation, Disease / Health and Life / Death [Cheriti et al, 2010].

4.2. Water ethnopharmacological practice (for example the region of El Bayadh)

Water as a symbol is also found in the practices and traditional knowledge; it affects our environment and our daily realities. The use of water is crucial in public health. Lack of access to water and a healthy environment is one of the first direct or indirect causes of death and disease in the world. Annually are 250 million people who suffer from diseases caused by water undrinkable. In developing countries, 80% of cases of diseases identified are rooted in poor water quality. Algeria is its strategic location and history, its large area, its diverse climate, its flora varies, has a source of materia medica and a rich and abundant traditional skills important.

We present the results in our statement of our surveys in the southwest of the Algerian instead of water in the local ethnopharmacology [Cheriti et al; 2010]. We conducted a study in El Bayadh district on the importance of water in local traditional medicine, led us to the following points:

The traditional herbal preparation use water as essential solvent for extracting, compared to fat or vinegar:

- Water (decoction, infusion, maceration...): 73%
- Material Fat: 14%
- Vinegar / Alcohol: 6%
- Other (direct saliva...): 7%

The same survey conducted in six localities in the El Bayadh district, lets us conclude that water sources is especially recommended in traditional medicine, in particular for the treatment of dermatological diseases, urinary and ophthalmic disorder (Figure 6 and 7). The most remarkable thing that the therapeutic effects of water from Ain El Mahboula remain etched in the memories of local people despite the disappearance of the source for over twenty years. Because a generation aged 15 to 25 years does not know the source only through orality relatives from old.

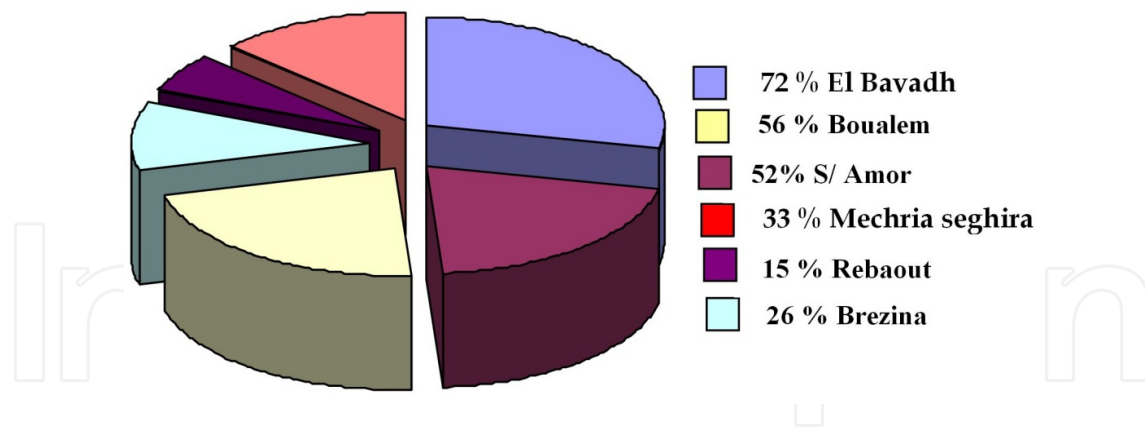


Figure 6. Frequency of traditional use of water in localities of El Bayadh district.

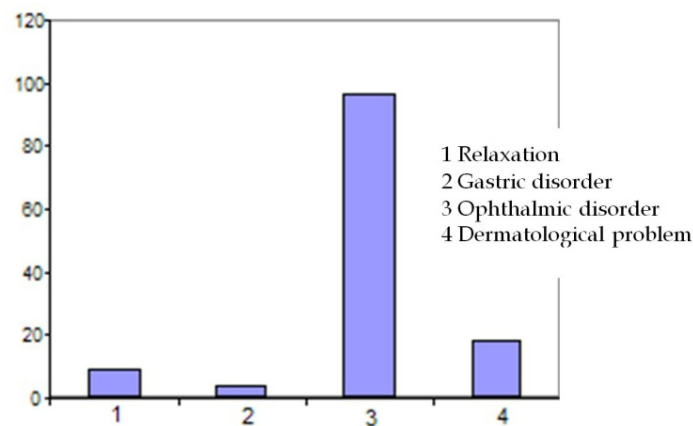


Figure 7. Traditional treatment of diseases by traditional El Mahboula spring water source.

Finally, we consider water as a heritage both natural and cultural. In southwest Algeria there is a traditional knowledge management and the involvement of water sources especially for the treatment of various pathologies. It is necessary to consider the socio-cultural interactions with other components of the natural environment for the management of water resources and enhance the traditional expertise and local medicinal heritage.

5. Analysis of the Saharan water

Chemical analysis of water from different Sahara localities (Table 3), shows that the general mineralization of water from the studied boring greatly exceeds the acceptable standards. Such water can be used only after demineralization.

The anions (Cl^- , SO_4^{2-}) show that they are not in the standards of water potability in both Tindouf, Bechar and Ouargla localities, which made water unsafe to drink. Chloride toxicity has been observed in humans, as in the case of impaired metabolism of sodium chloride (NaCl), for example, in congestive heart failure [WHO, 1996].

Location	pH	Cond (s/cm)	Rs (mg/l)	Ca ⁺⁺ (mg/l)	Mg ⁺⁺ (mg/l)	Na ⁺ (mg/l)	K ⁺ (mg/l)
Tindouf	7.36	3.66	2270	202	114	416	11
Bechar	7.29	4.09	2536	161	142	460	16
Adrar	7.28	2.08	1310	111	101	160	6
Naama	7.27	2.22	1380	120	111	190	9
El Bayadh	7.1	2.2	1250	91	109	160	5.4
Ghardaia	7.2	2.33	1226	21	149	145	13
Ouargla	8.23	4.27	2916	193	287	480	29
Illizi	7.73	4.58	4982	200	252	604	26
OMS guideline value			2000	100	250	200	-

Location	Cl-(mg/l)	SO ₄ ²⁻ (mg/l)	HCO ₃ ⁻ (mg/l)	NO ₃ ⁻ (mg/l)
Tindouf	662.5	655	210	92
Bechar	730	750	207	89
Adrar	245	380	311	64
Naama	305	395	268	73
El Bayadh	268	325	250	54
Ghardaia	265	400	128	10
Ouargla	895	725	102	14
Illizi	265	2300	128	7
OMS guideline value	250	400	-	44

Table 3. Parameters of some waters from Algerian Sahara.

Healthy people can tolerate the consumption of large quantities of chloride provided there is a concomitant intake of fresh water [Djidel et al., 2010], little is known about the effect of prolonged ingestion of large amount of chloride in diet [Kesteloot et al, 1988]. Experimental studies show that hypertension associated with ingestion of sodium chloride seem to be related to the sodium rather than chloride ion [Haijar et al, 2001]. However, high level of sulfate in water can provide dehydration and diarrhea and children are often more sensitive to sulfate than adults [NCEH, 1999].

The cations (Na⁺, K⁺) show that they are not in the standards of potability of water, which made water very salty and hard. Calcium concentration in this water is higher than OMS guidelines value. The abuse of calcium ingestion without medical advice can lead to the development of blood clots, kidney problem such as urolithiasis and potassium accumulation can cause a disturbance of heart beats [Djellouli et al, 2005; Sekkoum et al, 2012a]. When the

concentration of Ca and Mg decrease, the concentration of sodium and SAR index become more important [Eriksen et al, 1990]. This will cause an alkalizing effect and increase the pH. Therefore, when a water test indicates a high pH, this may be a sign of high content of carbonate and bicarbonate ions [Djellouli et al, 2005].

The carbonate and bicarbonate combined with calcium or magnesium will precipitate as calcium carbonate (CaCO_3) or magnesium carbonate (MgCO_3) in dry condition (the Sahara shows a permanent drought), so, the classification of these waters shows very high salinity water. [Kumar et al, 2010].

In another hand we conducted a study of water quality and assessing the possibility of wells in the Bechar district (South-West Algeria) as an alternative source of drinking water and for domestic purposes.

The artesian well of Mougheul, with depth of 185 meters is one of potential sources of water supply of district, and allows to provide initial water productivity up to 8 l/s. Requirements to the water for potable needs in district is presented according to specifications of the EU and the World Health Organization [WHO, 2004].

For definition of the opportunity to use the well as a source of water for potable and domestic needs, samples have been taken and the basic physical and chemical parameters of water are determined according to standard techniques. In table 4 are presented the analysis results of water quality of the Mougheul well in comparison with the requirements regulating quality of potable water within the framework of the international standards.

The analysis of data (table 4) shows, that the general mineralization of water of Mougheul well considerably surpasses allowable requirements of all above-mentioned standards.

As a rule, waters are subdivided into categories depending on a level of their mineralization or their rigidity. There are also other approaches to classification of water of various sources, for example, taking into account simultaneously its mineralization, rigidity and the contents of organic impurity [Gousseva et al, 2000]. The boundary values for division of water into categories are sufficiently conventional and they differ in various sources of information. The type of water and the contents of the basic impurity in it allow to choose correctly a method of its conditioning, and also to pick up the most effective materials and the equipment for water preparation.

According to the above mentioned data (Table 4), water of Mougheul well in the Béchar district can be classified in the category of salty underground waters with high hardness. The most suitable method of conditioning of such water to have a quality up to a level of the required norms for potable and domestic to water is the technology of barometric membrane or the combined technology of barometric membrane with ionic interchange method of water treatment. The development of basic alternative technological schemes of water-preparation and the evaluation of economic parameters of these schemes will allow to choose the most rational and economic scheme of water conditioning to have its quality up to a level for potable water. The development of rational technology of water conditioning received from the artesian well of Mougheul in the wilaya of Béchar will allow to receive

drinking water quality and to minimize economic expenses for process of water treatment. The introduction of such installations will allow keeping resources of dams and other existing sources of water supply for more remote regions of the country and, that is important for needs of agriculture.

Parameters	Value of parameter		
	Well of Mougheul	Normative requirements	
		WHO	European Union
pH	7,4	6,5-8,5	6,5-8,5
Overall hardness, mg-equiv./l	53,2	-	-
Calcium, mg-equiv./l	40,6	-	100
Magnesium, mg-equiv./l	12,6	-	50
Overall alkalinity, mg-equiv./l	2,64	-	0,5
Potassium, mg/l	8,04	-	12
Sodium, mg/l	1876	200	200
Overall iron, mg/l	2,54	0,3	0,2
Overall manganese, mg/l	<0,01	0,1	0,05
Nitrates, mg/l	15,6	50	50
Sulfates, mg/l	2496	250	250
Chlorides, mg/l	2851	250	250
Bicarbonates, mg/l	161	-	-
Silicates, converted in SiO ₂ , mg/l	23,4	-	-
Fluorides, mg/l	1,0	1,5	1,5
Oxidability, mgO ₂ /l	3,2	-	5,0
Overall mineralization, mg/l	8418	1000	1500

Table 4. Parameters of water from Mougheul well.

6. Fluoride content of drinking Sahara water and health impact

Fluoride is an essential element to prevent carious dental [Sohn et al, 2007]. Incorporated into the teeth, fluoride decreases the solubility of enamel in acid medium which consists mainly of hydroxyapatite and favors the remineralization of initial carious lesions of enamel [Singh et al, 2003]. Water is the main source of fluoride ions [Emmanuel et al, 2002; Featherstone, 2000].

In southern Algeria, the drinking water is characterized by high level of fluor. However, excessive consumption of this oligo-element becomes toxic. Thus, in 2001, endemic areas of fluorosis were detected in Algerian sahara (El-Oued, Touggourt, Biskra, Timimoun, Ouargla and Ghardaïa), constituting a public health problem caused by the ingestion of an excess of fluoride. In this respect, may be these regions are not concerned by the program of oral-dental health in schools [NPOHS, 2006]. In southern areas, where temperatures are high, the daily intake of water becomes more important. The standards of the World Health Organization (WHO) set at 0.8 mg/L the maximum concentration of fluorine permissible for public distribution water in these warm regions [Sekkoum et al, 2012b; WHO, 2006; 2004].

The concentration levels of samples taken from different location in the Algerian Sahara ranged from very low concentration (0.4 mg/L.) to very high level (4.32 mg/L.). As expected, most source of high fluorides levels were found in public distribution waters from the Wilaya (district) of Biskra, Adrar, Ouargla (Figure 8).

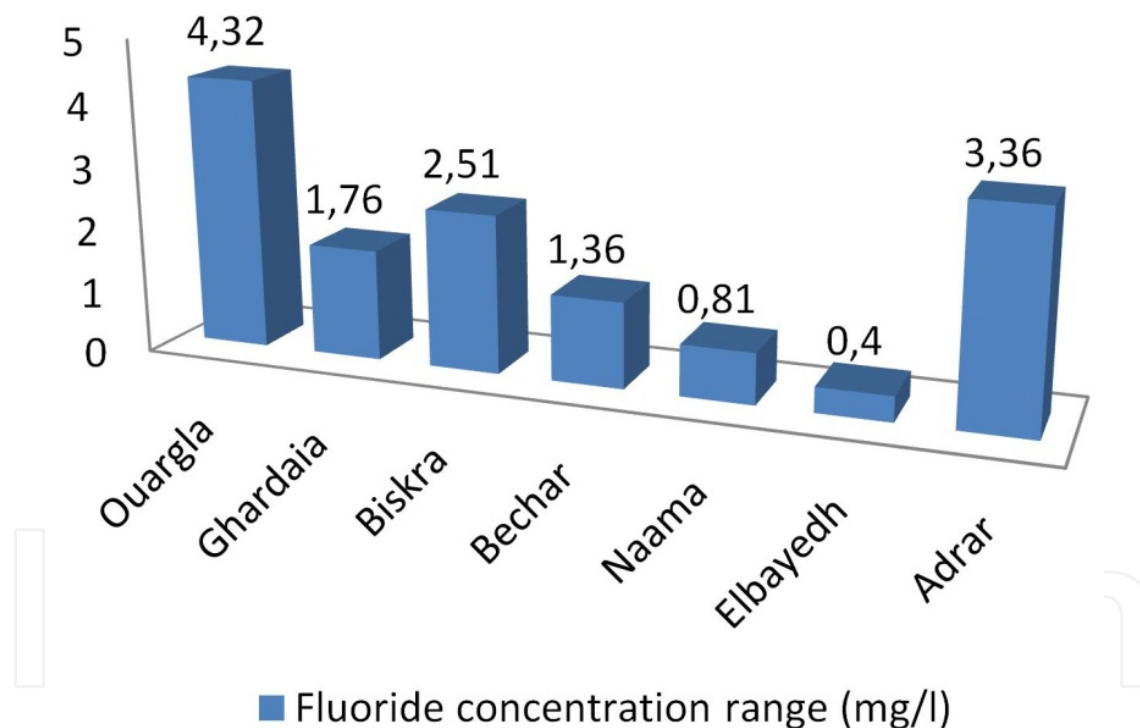


Figure 8. Fluoride levels in drinking water from South Algeria.

Taleb team [Bahloul et al, 2011] were studied the action of some Saharan waters containing different concentrations of fluoride as an inhibitor on dissolution of the hydroxyapatite. The efficacy of fluoride ions contained in the tested waters was evaluated according to the ratio of inhibition rate in presence of the drinking water and synthetic water. As indicated in Table 5, the inhibitory effects of Saharan waters are located within a range of 54.28 and 83.1%.

Water samples	VE (mL)	I %	I ref %	E = I/Iref %
Reference [F ⁻] = 0 mg/L	17.50	0	-	0
El bayadha (O. souf)	5.25	70	90.57	77.77
Tolga(Biskra)	4.80	72.5	90	80.55
Beldate amor (Tougourt)	3.90	77.71	89.54	86.78
El Guemar (O. Souf)	5.10	70.8	89.42	79.17
El Chott (O. Souf)	2.95	83.1	89.14	93.22
Hassi Messaoud	3.20	81.7	88	92.84
Oued Souf	4.10	76.57	88	87.01
Reganne	4.60	73.71	83.71	88.05
Adrar	5.30	69.71	84	82.98
Tougourt	8.0	54.28	85	63.85
Ksar Hirane (Laghouat)	4.80	72.57	77.71	93.38
Zelfana (Ghardaia)	6.80	61.14	61.71	99.07
Hassi R'Mel	7.80	55.43	65.14	85.09
El Golea	6.50	62.85	61.71	101.80

Table 5. Inhibitory effect of Saharan water on the dissolution of hydroxyapatite.

Moreover, Dissananyake [1991], showed that dental carious occurs in region where drinking water is less fluoridated, while it is absent in areas with fluorine rich water. Other studies have indicated that fluoridation of water is very important to maintain the buccodental health [Angelillo et al, 1999; Levy, 2003]. In contrary, according to the World Health Organization [WHO, 2006], the fluoride rich water causes a risk of dental fluorosis. Indeed, the amount of fluorine called "optimal dose of fluoride in drinking water" which decreases the prevalence of dental carious with the absence of a significant fluorosis varies between 0.7 and 1.2 mg/L [Emmanuel et al, 2002]. Finally, if we consider the influence of temperature, all public supply waters of the south Algeria are excessively fluoridated. On the other hand, the experimental approach, in vitro, shows the importance of fluoride of drinking water from southern Algeria in preventing dental carious. Indeed, the extremely high temperature of the South is a major factor contributing to the increase in demand for drinking water and, consequently, the increase in dental fluorosis. Therefore, to reduce this risk in this region, consumers need to correct their food habits not exceeded the needs of the body in fluorine. Thus, 0.05 to 1 mg of fluoride are considered as not toxic daily dose on the health of the adult population.

7. Conclusion

Demographic, social, and economic factors will determine the future demand and availability of water resources. Generally, the groundwater constitutes an important part of the hydraulic heritage of the Algerian Sahara. To assure their safeguard and their protection for the future generations and for the difficult moments, it is necessary to : Control the withdrawals of underground waters in order to protect them against the overexploitation; to reinforce the integrated management of water resources and water policy, generalize the economy of water for all users and sensitization of the users, the local actors, the local decision makers and the agents of authority to the constraints of water scarcity and to the risk of draining of underground waters.

In the context of the scarcity, the quality of the superficial and underground waters is threatened by numerous problems. It is important to undertake all to improve and to preserve the quality of water resources and the protection of the environment.

It is necessary to consider the socio-cultural interactions with other components of the natural environment for the management of water resources and enhance the traditional expertise and local knowledge. In another hand the study shows the importance of fluoride of drinking water from Algerian Sahara in preventing dental carious.

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References

- [1] ABHS (2009). The Sahara hydrographic basin agency, letter n 4.
- [2] Ahmadi, H., Samani, A. N., & Malekian, A. (2010). The Qanat: A Living History in Iran, Chapter 8 in *Water and Sustainability in Arid Regions*, Ed Schneier-Madanes G. & Courel M.F., Editors, Springer Science, Heidelberg.
- [3] AMS (2009). Algerian Metrological Station report.

- [4] Angelillo, I. F., Torre, I., & Nobile, C. G. (1999). Caries and fluorosis prevalence in communities with different concentrations of fluoride in the water. *Caries Research*, 33(2), 114-122.
- [5] ANRH, Agence Nationale des Ressources Hydrauliques. (2001). Banque de données pluviométriques et hydrologiques d'Algérie.
- [6] Ansari, M. I. (1994). Islamic Perspectives on Sustainable Development. *American Journal of Islamic Social Science*, 11(3), 394-402.
- [7] ASAL (Algerian Space Agency). (2011). <http://www.asal.dz/inondations-el-bayadh.php>.
- [8] Bahloul, H., Djellouli, H. M., Taleb, S., Rezgane, Z., Cheriti, A., & Benghalem, A. (2011). In vitro inhibitory effect of drinking water from south Algeria on the dissolution of dental hydroxyapatite. *Med. J. Chem.*, 1(4), 192-199.
- [9] Bouguerra, K. (2001). Potentialités en ressources en eau superficielle du nord du pays (Algérie). No 71/ANRH/DHYL, 10.
- [10] Bouguerra, M. L. (2003). Symbolique et culture de l'eau, rapport N 5, Institut Veolia Environnement.
- [11] Cheriti, A., Talhi, M. F., Belboukhari, N., & Taleb, S. (2011). Copper Ions Biosorption properties of Biomass derived from Algerian Sahara plants. , Chapter 16, in Expanding issues in Desalination, Edited by Robert Y. Ning, InTech Publishers, Austria.
- [12] Cheriti, A., Talhi, M. F., Belboukhari, N., Taleb, S., & Roussel, C. (2009). Removal of copper from aqueous solution by *Retama raetam* Forssk. growing in Algerian Sahara. *Desalination and Water Treatment*, 10, 317-320.
- [13] Cheriti, A., & Sekkoum, K. (2010). Ain Mahboula from El Bayadh, between heritage and memory (in arabic). *Al Athar Journal*, 6, 93-101.
- [14] Djellouli, H. M., Taleb, S., Harrache-Chettouh, D., & Djaroud, S. (2005). Qualité physico-chimique des eaux de boisson du Sud Algérien: étude de l'excès en sels minéraux. *Cahiers Santé*, 15(2), 109-112.
- [15] Djellouli-Tabet, Y. (2010). Common Scarcity, Diverse Responses in the Maghreb Region. , Chapter 6, in Water and Sustainability in Arid Regions, Ed Schneier-Madanes G. & Courel M.F., Editors, Springer Science, Heidelberg.
- [16] Djidel, M., Bousnoubra-Kherici, H., & Nezli-E, I. (2010). The Minerality Impact of Deep Groundwater, in Desert Regions, on Human and the Environment. South east Algeria. *European Journal of Scientific Research*, 45(4), 540-551.
- [17] Dissanayake, C. B. (1991). The fluoride problem in the groundwater of Sri Lanka-environmental management and health. *International Journal of Environmental Studies*, 38, 137-156.

- [18] El Faiz, M., & Ruf, T. (2010). An Introduction to the Khattara in Morocco: Two Contrasting Cases. , Chapter 10, in *Water and Sustainability in Arid Regions*, Ed Schneider-Madanes G. & Courel M.F., Editors, Springer Science, Heidelberg.
- [19] Emmanuel, E., Fanfan, P. N., Louis, R., & Michel, G. A. (2002). Determining the optimal fluorine dose in the drinking water of the South Center hydrological region of Haiti. *Cahiers Santé*, 12(2), 241-245.
- [20] Eriksen, E. F., Hodgson, S. F., Eastell, R., Cedel, S. L., O'Fallon, W. M., & Riggs, B. L. (1990). Cancellous bone remodeling in type I (postmenopausal) osteoporosis: quantitative assessment of rates of formation, resorption, and bone loss at tissue and cellular levels. *J. Bone Miner Res.*, 5(4), 311-319.
- [21] Faruqui, N. I., Biswas, A. K., & Bino, M. J. (2001). *Water management in Islam*, United Nations University Press.
- [22] Featherstone, J. D. (2000). The science and practice of caries prevention. *J. Am. Dent. Assoc.*, 131(7), 887-899.
- [23] Gousseva, T. V., Moltchanova, Ya. P., Zaika, E. A., Vinnitchenko, V. N., & Averotchin, E. M. (2000). The hydrodynamic parameters of environment state. Reference documents, Edition Ekoline, Ukraina.
- [24] Haijar, I. M., Grim, C. E., Gerge, V., & Kotchen, T. A. (2001). Impact of diet on blood pressure and age-related changes in blood pressure in the U.S. population. *Arch Intern Med.*, 161, 589-593.
- [25] INC (1983). Atlas of Algeria Geography and Maps Technol.
- [26] Kesteloot, H., & Joosens, J. V. (1988). Relationship of dietary sodium potassium, calcium, and magnesium with blood pressure. Belgian interuniversity Research on Nutrition and Health. *Hypertension*, 12, 594-599.
- [27] Latreche, D. (2005). Connaissance et exploitation des ressources en eau partagées au Sahara septentrional (SASS/OSS). Colloque international sur les ressources en eau dans le Sahara. Conférence Ouargla, Algérie.
- [28] Le Houerou, H. N. (1984). Rain use efficiency a unifying concept in arid land ecology. *Journal of Arid Environments*, 7, 213-247.
- [29] Levy, S. M. (2003). An update on fluorides and fluorosis. *J. Can. Dent. Assoc.*, 69(5), 286-291.
- [30] Manjare, S. A., Vhanalakar, S. A., & Muley, D. V. (2010). Analysis of water quality using physico-chemical parameters tamdalge tank in kolhapur district, maharashtra. *International Journal of Advanced Biotechnology and Research*, 1(2), 115-119.
- [31] Meddi, M. (2006). Evolution des régimes pluviométriques dans les différentes stations du nord du Sahara septentrional. Avenir des zones sèches, Tunis: UNESCO, 10.

- [32] Mutin, G. (2000). *L'eau dans le monde arabe. Enjeux et conflits*. Paris, Ellipses Edition.
- [33] NCEH (National Center for Environmental Health) (1999). *Health Effects from Exposure to High Levels of Sulfate in Drinking Water Study*, National Center for Environmental Health.
- [34] NPOHS (National Program for Oral Health in Schools) (2006). The interministerial circular of 27 March 2006.
- [35] Kumar, N., & Sinha, D. K. (2010). Drinking water quality management through correlation studies among various physicochemical parameters: A case study. *International journal of environmental sciences*, 1(2), 253-259.
- [36] OSS (Observatory of the Sahara and the Sahel) (2001). *Les ressources en eau des pays de l'Observatoire du Sahara et du Sahel, évaluation, utilisation et gestion*. 87.
- [37] Ould Amara, A. (2000). *La sécheresse en Algérie*. ANRH, Bir Mourad Raïs, 5.
- [38] Radha Krishnan, R., Dharmaraj, K., & Ranjitha Kumari, B. D. (2007). A comparative study on the physicochemical and bacterial analysis of drinking, borewell and sewage water in the three different places of Sivakasi. *Journal of Environmental Biology*, 28(1), 105-108.
- [39] Rekeawicz, Ph. (2006). *Visions cartographiques*. *Le Monde diplomatique*, Paris, <http://blog.mondediplo.net/-Visionscartographiques>.
- [40] Sanjana, C., Menka, B., & Sarita, O. (2011). Physicochemical Characterization of Some Drinking Water Samples of Jaipur City. *Water Research & Development*, 1(1), 53-55.
- [41] Schafer, A. I., Rossiter, H. M. A., Owusu, P. A., Richards, B. S., & Awuah, E. (2010). Developing Country Water Supplies : Physico-Chemical Water Quality in Ghana. *Desalination*, 251, 193-203.
- [42] Sekkoum, K., Cheriti, A., Taleb, S., & Belboukhari, N. (2012a). FTIR spectroscopic study of human urinary stones from El Bayadh district (Algeria). *Arabian Journal of Chemistry*, Under Press.
- [43] Sekkoum, K., Cheriti, A., & Taleb, S. (2012b). Fluoride analysis in water from El Bayadh district(in arabic). *Al Badr Review*, 4(2), 17-20.
- [44] Senoussi, Bensania M., Moulaye, S., & Telli, N. (2011). la foggara: Un système hydraulique multiséculaire en déclin, *Revue Des Bioressources*, 1, 1.
- [45] Singh, K. A., Spencer, A. J., & Armfield, J. M. (2003). Relative effects of pre and post-eruption water fluoride on caries experience of permanent first molars. *J. Public Health Dent.*, 63(1), 11-19.
- [46] Sohn, W., Ismail, A. I., & Taichman, L. S. (2007). Caries Risk based fluoride supplementation for children. *Pediatre Dent.*, 29, 23-29.

- [47] Talhi, M. F., Cheriti, A., Belboukhari, N., Roussel, C., & Taleb, S. (2009). Biosorption of Heavy metals from Aqueous Solutions by Retam reatem plant. *Desalination & Water treatment*, 10(1-3), 317.
- [48] UNESCO (1970). Study of water resources of the northern Sahara, Eressëa Project, Final Report- Paris.
- [49] WHO (World Health Organization) (1996). Guidelines for drinking-water quality Health criteria and other supporting information, 2nd ed. , World Health Organization, Geneva., 2
- [50] WHO (World Health Organization) (2004). Guidelines for Drinking-Water Quality Recommendations. , 1, Third Edition, Geneva, 494.
- [51] WHO (World Health Organization) (2006). Guidelines for Drinking-Water Quality Recommendations. , Geneva.
- [52] WHO (World Health Organization) (2008). World Health Organization Report, Geneva.