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Retrospective of natural mineral waters and spring waters in Algeria: Regulatory Framework and Technical Aspects

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ABSTRACT

In this paper, we present the current situation of both natural mineral waters and spring waters in Algeria. The evolution in legislation regarding the exploitation, production and marketing of bottled natural mineral and spring water are discussed in the first part. A critical analysis of this legislation, through a comparative study with European and international legislations is also exposed in this study. In the second part, an inventory of operating sites of natural mineral water or spring water is given. Then, the physicochemical characterization and classification of waters on the different sites of natural mineral waters are presented. Finally, in order to establish a database for natural mineral waters and spring waters in Algeria, the first data are then given.

Keywords: Mineral waters; Spring waters; Legislation; Exploitation; Production; Physicochemical characteristics; Environment; Algeria

1. Introduction

Promoted by the incentives for investment initiated by the government, the packaged water sector in Algeria has experienced a remarkable development in recent years. Indeed, this development has been realized by mean of the implementation of dozens of business and manufacturing companies of packaged water through the entire national territory. It was also accompanied by an unusual development in consumption per capita share of which has advanced remarkably in a period of 20 years (4 l/inhabitants/year in 1989 to 22 l/inhabitants/year in 2007) [1–3].

Through this development which was not regulated in its early days, a situation of confusion on the nature and quality of the bottled water product was introduced. This situation prompted the authorities to enact a series of regulations in order to provide guidance to the development, production and marketing of bottled water [4–5]. Conditions for selection: natural mineral water or spring water for production of drinking water have been implemented and in particular regulated [6].

The present study, which is specific to bottled mineral waters and spring waters produced in Algeria, is dictated in one hand by the interest in bottled water and the financial volume of investment that has been and will be granted. In other hand, and particularly by the conditions imposed for the environmental protection and requirements of public health.

In this regard, we note that even if this interest has already been noted a long ago during the colonial period, [7–8], few studies have been published since on natural mineral waters in Algeria, unlike thermal waters that have been subjects of an update study [9], study of the characterization and specification of sources [10] and finally application study [11].

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In this study, we present an up-to-date inventory of natural mineral and spring waters in Algeria. This paper is organized as follows: After briefly introducing, Section 2 summarizes the historical setting of mineral waters in Algeria. In this section, the evolution of the mineral-water concept from a socio-cultural and economic perspective is given. Section 3 gives the regulatory framework of the exploitation of mineral waters in Algeria. Section 4 contains the analysis of criteria for qualification of natural mineral water and spring water. This analysis is based on the Algerian and the European standards. The International Standards of the Codex Alimentarius is also taken into account in this analysis. Protection measures of environmental framework of natural mineral and spring waters are discussed in Section 5. Section 6 gives an updated configuration of the repartition of natural mineral and spring waters sites in Algeria. Physicochemical characterization and classification of Algeria mineral waters are presented in Section 7. Finally, Section 8 summarizes the main conclusions of the present study.

2. Historical setting of mineral waters in Algeria

In Algeria, mineral waters have long been subject to incentive and profit. Indeed, in a study published more than over a century ago, Olliffe [12] highlights the virtues and qualities of thermal mineral waters explored during the early period of colonization of Algeria. The author showed that those waters were highlighted via the presentation at the Universal Exposition in 1855. Thus, forty eight species of natural cold and hot water ferruginous, acidulous, saline and sulphurous have been exposed. In his work, the author stated that the ruins found at many sites of the sources of these waters, including those that are hot, indicate the importance of ancient settlements, probably of Roman origin. Later, a physicochemical study of waters from over 60 hot and cold sources in Algeria is presented by Hanriot [13]. This study was subsequently completed by Guige [14]. All these studies show the importance that has always been given to mineral waters in Algeria. This importance has notably been manifested through the various French colonial expeditions, militaries, doctors, pharmacists and chemists.

During the post-independence period in Algeria, the interest in natural mineral water has been demonstrated through the development of industry and especially the packaging of mineral water. This evolution has gone through three periods. The first period is that of industrialization followed by restructuring and finally the release and adaptation phase to market economy. During the first period, the presence of the state is strong in the monitoring mechanism of the investment, the establishment of industrial equipment and production management. This phase was characterized by the establishment of the first structures of production of bottled mineral waters. Thus, in 1966, the creation of the National Society of Mineral Waters has emerged. This institution has been given, according to the decree [15], the burden and monopoly of exploitation, production, management and marketing of bottled mineral waters in Algeria. During this period, the production of bottled water met the planned objectives in accordance with the industrial policy guidelines of that time rather characterized by a given regulation. Production units of bottled water were limited to a few brands; the most famous are given in Table 1.

The measures implemented by the government, under the economic reforms initiated from the eighties, have according to the decree on the restructuring of enterprises [17], the breakup of large industrial complexes and national parent companies to small and regional companies. Thus, the restructuring of bottled water sector has led in particular to the birth, in 1983, of three regional companies from the parent company. These regional companies are the company of the region of Algiers, the company of the region of Batna and that of the region of Saida.

This restructuring has been accompanied by the strengthening of production capacities of packaged water. Thus, other companies of production of mineral waters were put into operation. These include El Golia Company in the region of Ghardaia (1978), the company of Mostaganem (1984), the one of Hammamet in the region of Tebessa (1986) and that of Djemorah in the region of Biskra (1986).

This enhanced capacity in production has proceeded the period of economic reform in Algeria. In the track of these reforms started in 1988 and the program of structural adjustment (1995–1997) supported by the International Monetary Fund (IMF), substantial measures having as objectives freedom of the market have been undertaken. During this period, the economic policy and its implementation calls for and encourages the abandonment of the administrated regulatory system.

Thus, the option of economic regulation has been gradually abandoned in favor of freedom of economic action. The change in legislation was done by adapting the laws and requirements of the market economy. The first law enacted by the government to regulate the water sector [18] was amended once in 1996 [19] and then 2005 [20] establishing a new policy on water, adjusted for transition to the market economy. This

Table 1
Major brands of bottled natural mineral waters in Algeria.

Locality	Brand name	Number of sources	Production by brand in 2007 (l/year)	Bottled Capacity (l)	Package Type
Saida	Saida	1	60×10^6	0.33	PET bottle
				0.5	PET bottle
				0.5	PVC bottle
				1.5	PET bottle
				5	PET bottle
Mouzaia	Mouzaia	2	18×10^6	0.25	Glass bottle
				0.9	Glass bottle
Batna	Batna	1	11×10^6	0.25	Glass bottle
				0.5	PET bottle
				0.9	Glass bottle
				1.5	PET bottle
				5	PET bottle
Bouira	Benharoun	2	6×10^6	0.25	Glass bottle
				0.5	PET bottle
				0.9	Glass bottle
				1.5	PET bottle
				5	PET bottle

Source of data: [16].

approach allowed, in particular, the privatization of a large number of companies making up the industrial packaged water in Algeria.

In parallel to the privatization process which has affected a large number of companies of production and marketing of bottled mineral waters, regulatory measures established to promote investment [21] have permitted the implementation, across the entire national territory, of a large number of operating and production units of bottled mineral and spring waters. The expansion of production has contributed, through an exceptional phenomenon of simplification, to a remarkable shift in the consumption of packaged water. Fig. 1 gives an indication of the annual consumption and the yearly evolution of number companies of mineral water in Algeria. In recent years, this development is remarkably high and denotes the trend evolutionary landscape portending the potential for consumption of bottled water and the mass of investment that may be reserved to it.

3. Regulatory framework of the exploitation of mineral waters in Algeria

Characterized by a few scratches and a situation of pseudo legal vacuum for a specific recommended treatment, the legislation applied until July 2004, regarding the exploitation and production of packaged water, has generated a situation of no control and confusion, particularly in terms of quality. This situation prompted the government to adopt a series of texts relating to the exploitation and protection of bottled natural mineral water and water sources. These texts reflect greatly the will of the government to the achievement of the upgrade of the entire regulatory framework with international standards. The texts adopted meet two fundamental objectives, namely the respect of the required qualifications for the selection of this type of water and its consumption, and the conditions for respecting the environment.

Thus, and in accordance with the latest texts adopted [4,6], the central government permission has become indispensable for the exploitation,

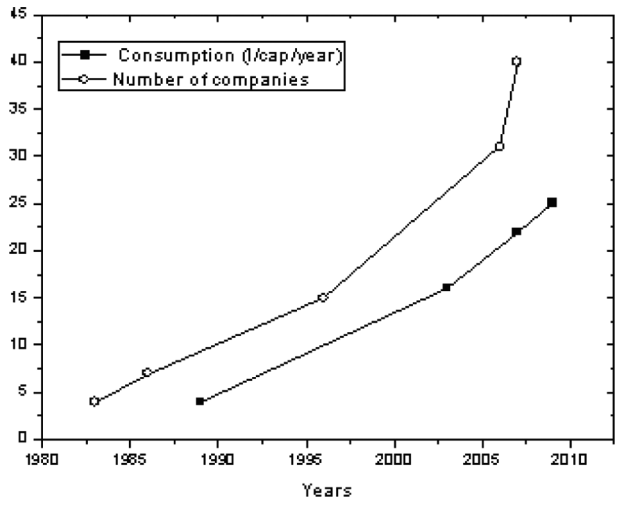

Fig. 1. Evolution of the yearly consumption and amount of companies of mineral water in Algeria [1–3].

production and marketing of bottled mineral waters and spring waters. Previously, this permission was done locally, under the decree on concession for research and collection of water [22]. With the new texts, the latter is now just one step in the process of obtaining permission to operate. This permission is subject to the review and analysis of the nature of water to operate, environmental studies and impact assessments mandated by the new regulations. These studies will be conducted exclusively under the name of spring water. The name of mineral water is granted only after a rigorous monitoring of the water quality produced. This monitoring is done for a period of one year and must prove the stability of the physicochemical characteristics of water put into operation. As for the marketing of packaged product, it is subject to compliance with new labeling, which must include the indication of solvents contained in those waters. These regulatory precautions aimed to protect the consumer and give an aid hand to choice a mineral water suitable for therapeutic expected.

4. Analysis of criteria for qualification of natural mineral and spring water

For the purposes of the last texts adopted, only two types of water intended for packaging are identified: natural mineral water and spring water. Section 2 (paragraph 1) of the decree on exploitation and protection of natural mineral waters and spring waters, give the exact definition for each of these waters [4].

Thus, natural mineral water is defined as microbiologically wholesome water. It differs significantly from other water intended for human consumption by its nature characterized by its purity, and its specific content in minerals, micronutrients or other constituents. These characteristics are assessed in terms of: Geological and hydro-geological, physical, chemical and physicochemical, microbiological and pharmacological criteria. These natural mineral waters may possess therapeutic properties favorable to human health.

In its second paragraph, the same article defines a spring water as an exclusively groundwater, suitable for human consumption microbiologically wholesome and protected against pollution hazards.

The text indicates that natural mineral water or spring water must originate in an underground water table or deposit, exploited at the sources near which the water is conditioned. The only allowed treatments or additions are:

- Separation of unstable elements and sedimentation of suspended solids by decantation or filtration.
- Incorporation of carbon dioxide or degasification.

Treatments or additions are made using physical processes, implementing inert materials, preceded, where appropriate, with aeration. They should not have the purpose or effect of changing the microbiological characteristics of natural mineral water or spring water.

The qualification of these two types of water, established under this decree is similar to that given by the usual texts related to natural mineral waters and spring water [23–30]. The European guidelines illustrate these similarities.

In the United States, the bottled water industry has its own self-regulating body; the IBWA was established in 1958 and maintains standards. Each member bottler of IBWA is required to pass a yearly unannounced inspection of its bottling facilities, and bottlers must comply with IBWA regulations called the Model Code [31]. According to this latter, the definition for mineral bottled water is more restrictive. For the sort of water, the concentration of dry residue should not be less than 250 mg/l [32].

We note also that no indication is given for the remaining types of water likely to be packaged, in particular that designated as the tap water in reference to the indications given in [33] or that of processed drinking water raised by [34]. This measure allows the assumption that the Algerian legislation exclusively predicts the packaging of two types of water: natural mineral waters and spring waters.

The quantitative conditions of qualities of natural mineral waters and spring waters are defined in accordance with the decree fixing the proportions of elements contained in natural mineral and spring waters, as well as the conditions of their treatment or additions permitted [6]. Appendix I associated with this order gives the threshold concentrations, of undesirable and toxic substances indicated, for qualification of natural mineral waters. The values of the thresholds of these substances are compared to those fixed by European [23] and international regulations through the Codex standards [27].

Table 2 gives the comparison, according to different guidelines, threshold values for all indicator elements for a possible deterioration of the quality of mineral waters. The comparison shows that with the exception of Arsenic and Selenium in which the threshold concentration in the Algerian regulation is five times higher than the recent European standards [23] and those of Codex [27], other threshold values for all regulations are comparable among themselves.

Regarding spring water, Appendix II of the same order sets out the criteria on quality and limits of quantification associated to them. The thresholds adopted

Table 2
Maximum thresholds concentrations tolerated for undesirable and toxic substances for mineral waters consumption. Comparison of Algerian legislation with that of Europe and the Codex standards.

Toxic and undesirable substances		Maximum concentration admissible in mg/l		
Characteristics	Symbol	Algerian [6]	European [23]	Codex [27]
Antimony	Sb	0.005	0.005	0.005
Arsenic	As	0.05	0.01	0.01
Barium	Ba	1.0	1.0	0.7
Borate	BO_3	5.0	1.0	5.0
Cadmium	Cd	0.003	0.003	0.003
Chromium	Cr	0.05	0.05	0.05
Copper	Cu	1.0	1.0	1.0
Cyanide	Cn	0.07	0.07	0.07
Fluoride	F	5.0	5.0	1.0
Lead	Pb	0.01	0.01	0.01
Manganese	Mn	0.1	0.5	0.5
Mercury	Hg	0.001	0.001	0.001
Nickel	Ni	0.02	0.02	0.02
Nitrate	NO_3	50	50	50
Nitrite	NO_2	0.02	0.1	0.02
Selenium	Se	0.05	0.01	0.01

by the Algerian legislation relating to such waters are compared to standards of safe drinking water for human consumption set by the European regulations [28] and is consistent with the guidelines of the World Health Organization (WHO) [29].

Table 3 gives this comparison and indicates that for this type of water, the threshold values set for each element or substance are roughly comparable to the both Algerian and European legislations. However, for some elements, particularly those of toxic substances, the European regulation seems stricter. Also, it is to be noted that the Algerian regulations on spring water give no indication for certain undesirable or toxic elements mentioned in the Appendices of the European directive such as Acrylamide, Antimony, Benzene, Boron, Bromate, 1,2-dichloroethane, Epichlorohydrin, Nickel and Pesticides.

In addition to the conditions of physicochemical characterization of natural mineral and spring waters, the Algerian legislation sets out criteria applicable for microbiological tests in the source [6]. Thus, the tests must include:

1. The demonstration of the absence of parasites and pathogenic microorganisms.
2. The quantitative determination of viable microorganisms indicative of fecal contamination:
   a. Absence of *Escherichia coli* and other coliforms in 250 ml at 37°C and 44.5°C;
   b. Absence of fecal streptococci in 250 ml;
   c. Absence of sporulated sulphite-reducing anaerobes in 50 ml.
   d. Absence of *Pseudomonas aeruginosa* in 250 ml.
3. Determination of total content of microorganisms revivable per milliliter of water, according to defined technical methods.

Table 3
Maximum threshold tolerated of safe drinking waters of concentrations of undesirable and toxic substances, and limits of physicochemical parameters. Comparison of Algerian legislation with that of Europe.

			Maximum value admissible	
Characteristics	Symbol	Unity	Algerian [6]	European [28]
Physicochemical characteristics				
pH	–	–	6.5–8.5	6.5–9.5
Conductivity at 20°C	–	µS/cm	2,800	2,500
Chloride	Cl	mg/l	200–500	250
Sulphate	SO_4	mg/l	200–400	250
Magnesium	Mg	mg/l	150	50
Sodium	Na	mg/l	200	200
Potassium	K	mg/l	20	12
Aluminum	Al	mg/l	0.2	0.2
Undesirable substances				
Nitrate	NO_3	mg/l	50	50
Nitrite	NO_2	mg/l	0.1	0.5
Ammonium	NH_4	mg/l	0.5	0.5
Iron	Fe	mg/l	0.3	0.2
Manganese	Mn	mg/l	0.5	0.05
Copper	Cu	mg/l	1.5	2
Zinc	Zn	mg/l	5	3
Argent	Ag	mg/l	0.05	0.01
Fluoride	F	mg/l	0.2–2	1.5
Toxic substances				
Arsenic	As	mg/l	0.05	0.01
Cadmium	Cd	mg/l	0.01	0.005
Cyanide	Cn	mg/l	0.05	0.05
Chromium	Cr	mg/l	0.05	0.05
Mercury	Hg	mg/l	0.001	0.001
Lead	Pb	mg/l	0.055	0.01
Selenium	Se	mg/l	0.01	0.01
Benzo (1,2,3-Cd) pyrene	–	µg/l	0.01	0.01

A protocol for monitoring and self-monitoring of mineral water and spring water is required, regulated and controlled [4]. This protocol is to control the stability and quality of waters, as well as facilities for the capture and

packaging of these waters. The nature, frequency and methods of analysis are also regulated and supervised. Strict measures for control are planned [35].

The regulations requiring that the conditions attached to the exploitation of natural mineral waters are designed to ensure that the chemical and physical characteristics, safety and microbiological purity of the water at source are maintained unchanged during exploitation. Operating equipment must also meet strict conditions of hygiene. Recognition may be withdrawn if the equipment for exploiting the water at any time fails to meet the requirements of safety. The transport of natural mineral water in bulk containers for packaging or for any other process before packaging is prohibited.

Algerian water is bottled directly from the source without treatment for removal microorganism. However, water sold in the USA may be subjected to a number of different disinfection methods [36].

The provisions relating to criteria and microbiological examinations adopted by the Algerian legislation present in some aspect of comparability a few - similarities as those prescribed by European legislation [28,30] and those of Codex [24–27] and the WHO [29].

After this description, the following remarks can be underlined:

1. The methods of analysis to be used for various substances and physicochemical parameters are not described well by the Algerian regulations.
2. The performance characteristics for analyzing the micro and traces elements are not given (including the definition of the detection threshold limit for some elements as: Acrylamide, Antimony, etc).
3. Measures that regulate the hygiene requirements for the collecting, processing (e.g., oxygenated and sand filters are used which is called inert treatment), deposition, warehousing and marketing of natural mineral waters are not identified exactly.
4. The same is true for measures that regulate implementation and maintenance technology system in the field of water extraction, the installations of adequate exploitation equipment in order to protect and preserve the intrinsic natural properties of the water at source.

A revision additive work should be initiated in order to upgrade the regulatory instruments enacted. This work must be an upgrading approach with internationally harmonized regulations in the field of bottled water.

5. Protection measures of environmental framework of natural mineral and spring waters

In Algeria, the political action of environmental protection has been truly initiated only from the early eighties [37]. Indeed, the first environmental framework legislation was developed in 1983 [38]. This law establishes the general principles of management and environmental protection, including protection of water resources. The protection component of the environmental framework on water resources has been specifically enhanced by the adoption of the law on water code [18], amended in 1996 [19] and then 2005 [20].

The period after 2000 was marked by a strengthening of the legal and regulatory framework in the environmental field. Thus, there are many texts of laws that are promulgated. Among these texts, we quote the law on the protection of the environment in the context of sustainable development [39]. This law is based on the principles of the new environmental law adopted internationally; among these principles, that of non-degradation of natural resources. In order to meeting the aim of this principle, specific regulations for the protection of sites of natural mineral and spring waters has been promulgated. Article 26 of the Decree on the exploitation and protection of natural mineral waters and spring waters predicts, in particular, the implementation of a protected area for any site hosting a source of water. Article 27 of the same Decree recalls that in accordance with the provisions of few Articles of the water code [18–20] mentioned above, is prohibited within protection zones, any activity, discharge or deposit which might affect the water quality. Restrictions are provided for all underground work of any nature whatsoever, and all work object or causing a change in the abstraction of natural mineral water or spring water in the protected perimeter. Just recently (2007), the provisions relating to the establishment of the protection area of water resources are reviewed and updated by the decree [40]. This is reinforced by the measures established by the decree [41].

In addition to provisions for site protection of water sources, the exploitation of each source of water is subject to the establishment of an impact study. The latter is the subject of paragraph 4 of Article 21 of the same Decree [4].

Indeed, the enactment of the environmental law has essentially allowed the legal treatment of all aspects of environment. It also includes the size requirement newly introduced and devoted to the procedure of impact assessment [37]. This binding process has the objective to determine, before undertaking any public or private works or facilities, the implications of these on nature. The implementation of the procedure of impact assessment is defined by the decree relating to impact assessment on environment [42]. This decree was amended and supplemented subsequently by a

decree determining the scope, content and procedures for the approval of studies and impact statements on the environment [43].

6. Updated configuration of the repartition of natural mineral and spring waters sites in Algeria

Since the implementation of recent legislation concerning the exploitation and protection of natural mineral waters and spring waters, more than 50 requests for use of mineral waters are introduced with appropriate selection services. Over 40 cases are found in compliance or near compliance. The implemented selection protocol has allowed reporting more than 20 sites like those of natural mineral waters. The remaining sites are regarded as sites of spring waters [44].

Tables 4 and 5 give the geographical indications on the sites of mineral waters and those of spring waters in Algeria. All sites are coded according to the nature of the waters, the locality and hydrographic basin to which it belongs.

Also, it should be noted that in Algeria, the brand name of the company's production of bottled water is the same as that of their source.

Fig. 2 gives the geographical distribution of all these sites in Algeria. This distribution is naturally inhomogeneous responding thus to the availability offered by the hydro-geological nature of the different regions of Algeria. Thus, this distribution indicates that the hydrographic basin Chelif-Zahrez is devoid of sites of mineral waters, unlike the two Algiers region basins Hodna-Soummam and Constantine region Seybousse-Mellegue that are characterized by a maximum of established sites. 27% of mineral water sites are located in the Algiers region basin Hodna-Soummam and 36% in the Constantine region basin Seybousse-Mellegue.

For spring waters, the same remark seems to be observed with a slight difference due to the fact that the watershed of Chelif-Zahrez shelters a site of the source Etjar of Tiaret. The maximum number of sources is observed at the Algiers region Hodna-Soummam (53%). But it is between the north and south that the distribution of mineral and spring waters sites appears to be more contrasting. For all sites, 88% are located in the north. This distribution appears to be related to the presence of the population and the demand for consumption. Indeed, on a population census in 2004, 89% was in the northern regions of Algeria [45]. In terms of distribution, 24% of water companies cover the whole of Algeria, 13% operate in one region and 63% distribute their products locally [2].

Table 4
Geographical indications of mineral waters sites in Algeria [44]

Hydrographic basin	Name of water sources	Altitude [m]	Locality	Code
Oranie-Chott Cherghi	Mansoura	833	Tlemcen	EM.1.1
	Chifaa	1154	Tiaret	EM.1.2
	Messerghine	152	Oran	EM.1.3
	Saïda	838	Saïda	EM.1.4
Algerois-Hodna-Soummam	Ben Haroun	518	Bouira	EM.3.1
	Mouzaïa	617	Blida	EM.3.2
	Ifri	58	Béjaïa	EM.3.3
	Sidi El Kebir	55	Blida	EM.3.4
	Toudja	476	Béjaïa	EM.3.5
	Lala khadija	323	Tizi ouzou	EM.3.6
Constantinois-Seybousse-Mellegue	Sidi Yakoub	653	Jijel	EM.4.1
	Djemila	1001	Sétif	EM.4.2
	Batna	847	Batna	EM.4.3
	Daouia	1000	Setif	EM.4.4
	Fendjel	278	Guelma	EM.4.5
	Hammamet	876	Tébessa	EM.4.6
	Youkous	985	Tébessa	EM.4.7
	Sidi Driss	687	Skikda	EM.4.8
Sahara	Guedila	107	Biskra	EM.5.1
	Sidi Okba	52	Biskra	EM.5.2
	Milok	765	Laghouat	EM.5.3
	El Goléa	391	Ghardaïa	EM.5.4

Table 5
Geographical indications of spring waters sites in Algeria [44]

Hydrographic basin	Name of water sources	Altitude [m]	Locality	Code
Oranie-Chott Cherghi	Sidi Ali Benyoub	769	Sidi Bel Abbes	ES.1.1
	Sidi khelifa	1127	Sidi Bel Abbes	ES.1.2
	Sfid	1121	Saïda	ES.1.3
Chelif-Zahrez	Etjar	1154	Tiaret	ES.2.1
Algerois-Hodna-Soummam	Aghbalou	460	Béjaïa	ES.3.1
	Alma	443	Béjaïa	ES.3.2
	Bourached	20	Béjaïa	ES.3.3
	El Melez	882	Bordj Bou Arréridj	ES.3.4
	Halouane	589	Béjaïa	ES.3.5
	Hayet	29	Alger	ES.3.6
	Mont Djurdjura	726	Bouira	ES.3.7
	Oumalou	929	Tizi ouzou	ES.3.8
	Ovitale	34	Béjaïa	ES.3.9
	Star	91	Béjaïa	ES.3.10
Constantinois-Seybousse-Mellegue	Guerioune	911	Oum El Bouaghi	ES.4.1
	Thevest	1003	Tébessa	ES.4.2
	Texanna	745	Jijel	ES.4.3
Sahara	Fontaine des Gazelles	120	Biskra	ES.5.1

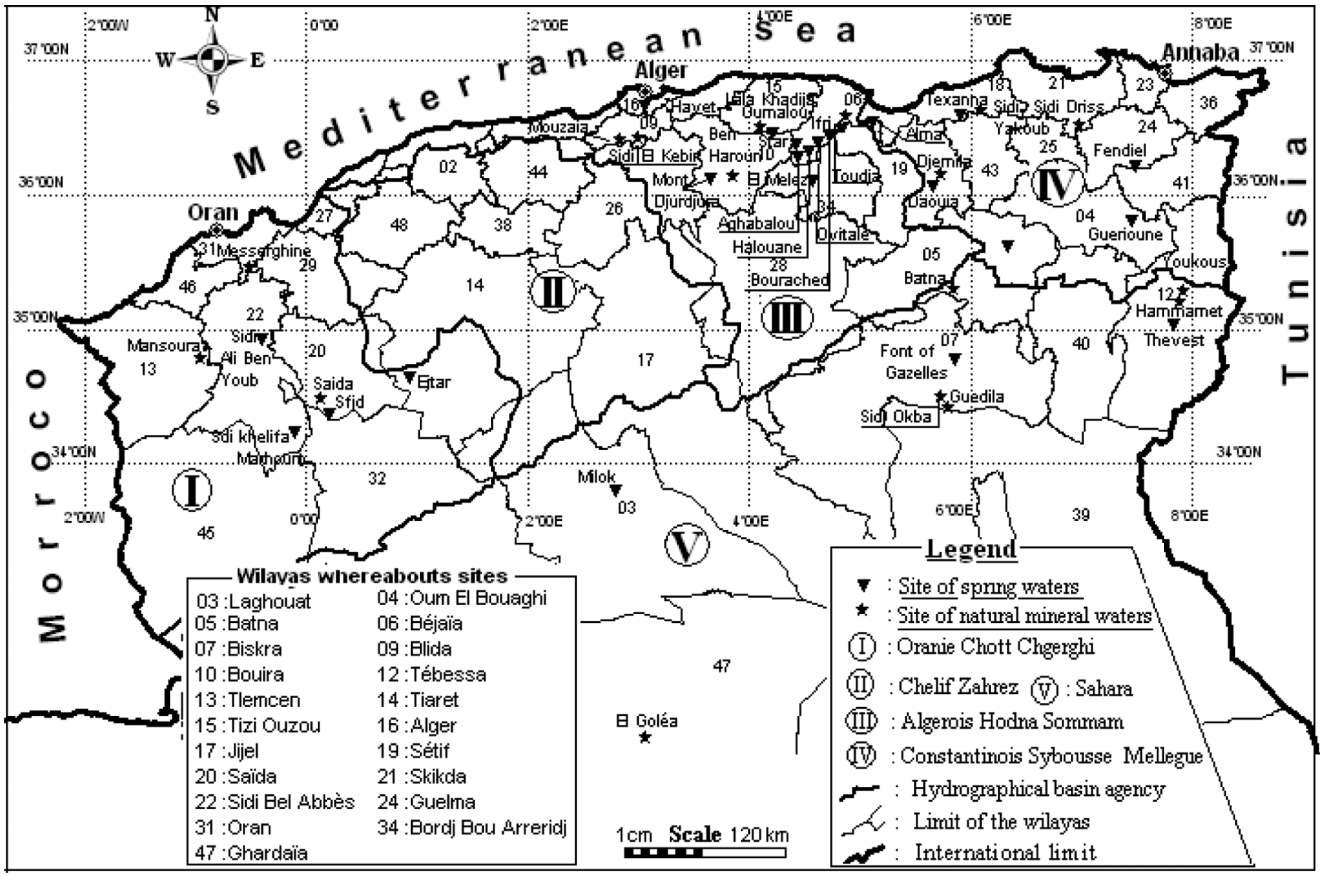

Fig. 2. Distribution of natural mineral and spring waters sites in Algeria [44].

Table 6
Chemical and physical constituents of bottled mineral waters in Algeria reported on their labels

		Concentration of anions in [mg/l]						Concentration of cations in [mg/l]					
Brand name	Year	SO_4^{--}	Cl^-	F^-	HCO_3^-	NO_2^-	NO_3^-	Ca^{++}	Mg^{++}	Na^+	K^+	pH	Dry residues [mg/l]
Benharoun	2006	514	400	–	1809	–	2.0	413	63	680	10	6.7	2800
Mouzaia	2006	85	150	–	822	0.0	1.0	136	75	138	1.0	6.5	1625
Guedila	2006	171	43	–	317	0.0	7.0	97	47	47	1.0	7.1	712
Mansoura	2007	60	90	0.15	397	–	–	89	62	30	1.0	7.2	640
Chifaa	2007	40	48	–	263		11	66	26	15	2.0	7.2	608
Messereghine	2006	35	128	0.2	331	–	–	63	41	63	8.0	7.3	577
Sidi Yakoub	2007	32	65	–	226	–	–	83	14	37	4.9	6.5	560
Saïda	2006	65	81	0.15	376	1.5	–	68	50	58	2.0	7.6	478
Djamila	2006	45	28	–	354	–	–	112	24	20	11	7.5	468
Batna	2006	29	18	–	373	–	–	58	43	13	3.1	7.2	450
Sidi Okba	2007	75	55	–	213	–	–	83	18	30	2.1	7.3	425
Ifri	2006	35	37	0.2	265	0.02	<1.5	74	20	16	2.1	7.2	380
Daouia	2007	19	41	0.5	280	–	0.4	32	20	75	7.0	7.8	325
Sidi Elkebir	2007	21	22	–	230	4.8	–	55	11	34	0.5	7.0	297
Fendjel	2007	24	5.0	–	244		15	73	15	10	2.5	7.9	268
Toudja	2006	21	71	–	212	0.02		61	14	52	0.8	7.4	248
Hammamet	2006	29	21	–	209	0.02	5.0	63	15	13	4.4	7.4	238
Youkous	2006	27	21	–	216	–	3.0	67	10	12	4.9	7.4	231
Sidi Driss	2006	10	17	–	127	0.02	0.1	39	3.0	7.2	1.0	7.7	202
Lalla Khadidja	2007	07	11	0.2	172	0.0	0.5	53	7.0	5.0	0.5	7.2	187
Milok	2007	80	10	0.4	85	–	–	53	12	8.0	4.0	7.6	180
El Golia	2006	36	20	–	118	0.5	2.5	24	7.0	28	5.0	7.4	180

7. Physicochemical characterization and classification of mineral waters in Algeria

The physicochemical characteristics of the all mineral waters in Algeria are given in Table 6. These characteristics are identified from the labeling of various brands. They correspond to the test results performed in laboratories officially authorized to carry out the operation of water characterization and this in accordance with the regulations in force. These laboratories are of course the National Center for Toxicology (NCT), the National Agency of Water Resources (NAWR) and the Pasteur Institute of Algeria (PIA). In accordance with the Algerian legislation, these three laboratories are considered as the only reference laboratories [46].

The analyses were performed for each water source in its raw state. As stated above, the only allowed treatments or additions are: separation of unstable elements, sedimentation of suspended solids by decantation or filtration and incorporation of carbon dioxide or degasification. These processes should not have the purpose or effect of changing the physicochemical characteristics of natural mineral water. So, the physicochemical characteristics for the all brands identified from the labeling bottled water which are conditioned only by the raw water source composition. The chemical composition of this latter depends on many factors, including the mineralogy/lithology of the aquifer and residence time of water [47].

Table 6 lists, for all mineral waters in Algeria, the physical parameters data such as the pH and the dry residues as well as the chemical parameters data (anions and cations concentrations). The dry residues are associated with the total dissolved solids (TDS) content in a liter of water. The quantity of dissolved solids is technically known as 'TDS at 180 degrees C'. The TDS value is obtained via a laboratory test whereby a liter of mineral water is evaporated at the temperature of 180°C. At the end of this process, the residual mineral solids are weighed and their weight, measured in milligram per liter. All data are presented according to decreasing values of the value of the dry residue [48].

Unlike to macro-elements data, the information provided by different labels of bottled water in Algeria does not provide access to information concerning micro and trace elements. The concentrations of constituents such as Al, B, Ba, Cd, Ce, Cs, Cu, Li, etc., are therefore not given.

It is important to compare the identified results of Algerian bottled mineral waters with corresponding

Table 7
Principal data of the analyzed parameters of Algerian, Greek and European bottled mineral waters

		Different data of bottled mineral waters											
		Algerian				Greek [50]				European [49]			
Parameters	Units	Min.	Med.	Max.	Spread	Min.	Med.	Max.	Spread	Min.	Med.	Maxi.	Spread
Dry residues	mg/l	180	549	2800	15.55	260	410	720	2.76	260	420	5560	214
pH	–	6.5	7.28	7.9	1.21	6	7.38	8.2	1.36	3.66	6.27	9.28	3
Conductivity	μS/cm	236	766	3294	13.95	396	604	1254	3.16	19	585	6,540	344
Ca^{2+}	mg/l	24	84.66	413	17.2	4.5	136.2	486	108	0.5	67.2	715	1430
Cl^{-}	mg/l	5.0	62.8	400	80	4.7	20.3	100	21.2	0.5	131.5	988	1976
F^{-}	mg/l	0.15	0.26	0.5	3.33	nr	nr	nr	Nr	0.1	0.2	8.8	88
K^{+}	mg/l	0.5	7.28	11	22	0.5	2.8	20	40	0.5	2.1	225	450
Mg^{2+}	mg/l	3.0	27.14	75	25	0.7	35	130	186	0.5	16.4	350	700
Na^{+}	mg/l	5.0	63.24	680	136	3	41	410	136.6	0.5	14.5	1660	3320
NH_4^{+}	mg/l	Nr	nr	nr	nr	0.1	0.24	0.26	2.6	0.1	–	3.2	32
NO_3^{-}	mg/l	0.1	4.08	15	150	1.9	4.73	6.8	3.6	0.5	1.5	52	104
NO_2^{-}	mg/l	0.01	0.99	4.8	240	0.5	0.5	0.5	1	0.01	–	2.04	204
SO_4^{2-}	mg/l	7.0	66.36	514	73	2.4	26.3	119	49.58	0.5	24.4	1820	3640
HCO_3^{-}	mg/l	85	347.2	1809	21.28	15	474	1,810	120	–		–	–

nr: No reported; spread = maximum/minimum values ratio.

data of others bottled mineral waters. For this comparison, two cases are then considered. The first one is the European bottled mineral waters and the second one is the Greek mineral bottled waters. It should be noted that the analytical results of the European mineral waters, which are presented by [49], concern 571 bottled and marketed mineral waters which are identified in 23 European countries.

As a general comparison, we select the European results analysis. This choice is justified by the importance of trade exchange that applies between Algeria and Europe. On the other hand and as a particular case, we chose the Greek mineral water study by the fact that it offers the advantage of the availability of the updated data [50].

The principal data from this comparison are presented in Table 7. The main ions concentrations and spread values (maximum/minimum ratio) are listed in the table. Noted that, the spread indicate the dispersion value like mentioned by Bertoldi et al. [49] and Misund et al. [51].

According to the analysis results presented in Tables 6 and 7, a general overview indicate that the physicochemical compositions of Algeria bottled natural mineral waters appear comparable to those of the Europe bottled mineral waters. However, it should be remembered that referring to the conditions set by the IBWA Code [31], seven mineral waters can not be registered as such. It's the case of: Toudja, Hammamet, Youkous, Sidi Driss, Lala Khadidja, Milok and El Golia, whose dry residue concentration is generally below of the minima threshold fixed at: 250 mg/l. As seen from the results presented in Tables 6 and 7, the pH value of Algeria mineral bottled waters varied in the range of 6.5–7.9 with an average value of 7.2.We note that the most of waters (86%) were alkaline with pH value more than 7.0. However, there were three water samples with acidic pH. It is a case of Benharoun, Mouzaïa and Sidi Yakoub. It must be recalled that the WHO recommended pH range for drinking water is 6.50–8.50 [29].

As can be observed from Table 6, for Algeria mineral waters, the ranges of values for cations are for calcium: 24–413 mg/l; for sodium 5–680 mg/l; for potassium 0.5–11 mg/l and for magnesium 7–75 mg/l. Furthermore, for chloride and sulphate anions, their extremum values are respectively 05–400 and 7–514 mg/l. Concerning the dry residues value; it is varied in the range from 180 to 2800 mg/l.

Moreover, the Greek bottled waters analysis indicates that pH values range from 6.0 to 8.2. Concerning the range values of calcium, sodium, potassium and magnesium, it is shown to be 4.5–486, 3–410, 0.5–20 and 0.7–130 mg/l, respectively. For anions, their extremum values are: 4.7–100 and 2.4–119 mg/l for chloride and sulphate, respectively. The dry residue concentration varies from 260 to 720 mg/l [50].

Let us consider the European mineral waters, it is shown from Table 7 that for dry residue concentrations, the values are fluctuated from 26 to 5560 mg/l. It is also noticed that the pH lies between two values 3.66–9.28. The values of calcium, sodium, potassium and magnesium range from 0.5 to 715, from 0.5 to

Table 8
Classification of mineral waters in Algeria based on mineralization in accordance with the EU mineral water directive [30]

Mineral water type	Criterion	Market waters	% Bottled water
Very low mineralised waters	Mineral content (TDS < 50 mg/l)	–	–
Oligomineral waters	TDS 50–500 mg/l	Saida, Djamila, Batna, Sidi Okba, Ifri, Daouia, Sidi Elkebir, Fendjel, Toudja, Hammamat, Youkous, Sidi driss, Lala Khadija, Milok, El Golia,	68
Waters with a medium mineral content	TDS 500–1500 mg/l	Guedila, Mansoura, Chifaa, Mess-reghine, Sidi Yakoub	23
Strongly mineralized waters	TDS > 1,500 mg/l	Benharoun, Mouzaia	09

1660, from 0.5 to 225 and from 0.5 to 350 mg/l, respectively. The ranges of values for chloride and sulphate are, respectively, 0.5–988 and 0.5–182 mg/l [49].

Due to the variety of European bottled waters (571 types of water for 23 countries), their results analyses appear to be more dispersed than those of Algeria and Greek. The maximum value of spread are 3640, 240 and 186 for Europe, Algeria and Greek, respectively.

Based on the results presented in Table 7, it is evident that for Algeria bottled waters the average values for all physicochemical parameters, with the exception of chloride, are higher than those of Europe bottled waters. Furthermore, the comparison between Algeria and Greek bottled waters indicate that, inversely to Ca^{2+}, Mg^{2+} and HCO_3^-, the averages values for dry residues, conductivity and F^- are higher in Algerian waters than in Greek waters.

Taking into account the content of dissolved calcium and magnesium salts concentration, the water hardness is determined. According to Mutschmann and Stimmelmayr [52] works, the Algerian bottled water results indicate that roughly 10% of samples could be considered as soft waters, whereas about half could be considered hard. Concerning the European bottled waters, it was found to be hard in roughly 50% and soft in 25% of total samples waters analysis [49].

Based on the results of the present analysis, a classification of mineral waters in Algeria may be also presented. As indicated in the specialized bibliography, different types of classification are discussed. Thus, based on a combination of geological, hydrochemical, therapeutic properties, a typical classification has been applied to mineral water in Russia [53]. For the present study, the classification method applied is same as that prescribed by the EU mineral water directive and the classification protocol adopted refers to European standards [30]. This method is applied systematically to rankings of mineral waters [54–58] and appears to be more consensual [59].

Then, two types of classification are considered. The first one is based on the value of TDS and the second one takes into account the content of the ionic

Table 9
Classification of mineral waters in Algeria based on ion composition in accordance with the EU mineral water directive [30]

			% of bottled water	
Mineral water type	Criterion	Markets waters	Algerian	Europe [49]
Rich in calcium	Calcium > 150 mg/l	Benharoun	4	20
Rich in sulphate	Sulphate > 200 mg/l	Benharoun	4	13.5
Rich in chloride	Chloride > 200 mg/l	Benharoun	4	4.0
Rich in bicarbonate	Bicarbonate > 600 mg/l	Benharoun, Mouzaia	9	13
Rich in magnesium	Magnesium > 50 mg/l	Benharoun, Mouzaia, Mansoura, Saida	18	13.6
Poor in sodium	Sodium < 20 mg/l	Chifa, Djamila, Batna, Ifri, Fendjel, Hammamet, Youkous, Sidi Driss, Lala Khadija, Milok	45	58

constituents (calcium [Ca^{2+}], magnesium [Mg^{2+}], chloride [CI^{-}], sulfate [SO_4^{2-}]).

The said classifications are given in Tables 8 and 9, respectively. As shown from Table 8, the majority of waters (68%) are trace mineral waters. Only Mouzaïa and Benharoun are considered as highly mineralized waters. Waters with a medium mineral content represent a percentage of (23%).

Table 9 showed, in particular, that only Benharoun water enjoys diverse properties. It is calcic sulphate, magnesic, chloride and bicarbonate. It is also showed that 66% of the remaining waters possess at least one classified property. We thus find that almost half of the mineral waters in Algeria (45%) are poor in sodium.

As comparison, the European bottled waters appear rich in calcium in 20% of samples, and then it is rich in sulphate in 13.5% of cases. It is noticed that 58% of waters are suitable for low sodium diet.

We also note that for all the mineral waters in Algeria, the concentration of fluoride focused on labeling of examined products do not exceed in extreme cases the value of 0.5 mg/l. However, if the fluorine content exceeds the value of 1.5 mg/l, the Algerian regulation requires producers to bear the obligation to indicate on the products labeling the reference of impropriety for babies' food and regular consumption of young children [60]. It has been shown that the Fluoride rich water is a cause of bone fractures and teeth disorders [61,62].

The marketing strategy of different firms producing natural mineral bottled waters in Algeria, highlight the benefits of these waters on public health. They indicate the magnitude of possible contributions to the human body, in minerals and trace elements; it ensures the use of these mineral waters. Such signs are allowed by the Directive [30]. Thus, as is shown in the popularization bibliography, dissolved sulphate in water (e.g., Benharoun) is indicated for diuresis and idle intestines, the magnesium (e.g., Benharoun, Mouzaïa, Mansoua, Saida) for muscle relaxation and nervous balance, the bicarbonate (e.g., Benharou, Mouzaïa) for digestion and acidity of the stomach, those that are low in sodium to fight hypertension. The weakly mineralized water (e.g., Benharoun, Mouzaïa) represent a limited and ideal supply of nutrients for infants [55,56]. On one hand, excess in mineral salts may have an influence on the kinetic incidence of crystallization in vitro of gallstone main component [57].

On the other hand, the WHO says that the beneficial effects of consumption of mineral water on human health have never been convincing evidence [63]. Quality guidelines for drinking water do not comment on this subject [29,64]. However, some studies indicate the specific aspect of the benefit of the consumption of mineral water [65]. So, the mineral water containing calcium and magnesium deserves to be regarded as a possible therapeutic agent or prophylactic agent in calcium oxalate kidney stone disease [66]. Also, the sodium-bicarbonate mineral waters improve lipid profile in moderately hypercholesterolemic young men and women and could therefore be applied in dietary interventions to reduce cardiovascular risk [67]. The effects on erythrocyte metabolism are also reported [68]. The study revue related on the role of water resources and the use of mineral waters in human nutrition, especially in the different stages of life, in physical activity and in the presence of some morbid conditions is presented by Petraccia et al. [55].

8. Conclusion

This study has given some important indications on natural mineral and spring waters in Algeria. These indications represent a first approach to a platform for an interesting data base for all reflections concerning the study of mineral waters and spring waters in Algeria. These indications can be useful for the treatment of such water for legal, economic, hydrogeological and geochemistry questions.

Thus, in addition, to the legislative analysis, to the description and physicochemical characterization, to the classification, a state of location of mineral waters and spring waters in Algeria has been set up.

A comparison work of the quality criteria of water between the Algerian legislation on one hand, and both the European legislation and the Codex standards on the other hand, has identified with the exception of some indications relating to physicochemical characterizations, the Algerian legislation is consistent with international standards.

With the diversity and number of sources of natural mineral and spring waters available to the Algeria, investment opportunities for both therapeutic needs that tourism can be readily offered. A rational and optimal management of these sources certainly contribute to a balanced local development in different regions of Algeria.

Through analysis of all legislation relating to the exploitation and protection of natural mineral waters and spring waters, this study, therefore, highlights the willingness of Algeria to adapt the international standards in the subject. It has been shown that, besides the fact that these texts provide quality information to citizens, choice and selection of water by type. They dedicate a fundamental right to a safe and controlled consumption, and respect for the environment.

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