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Research Article

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Assessment of the water quality of spring "La Mina". Groundwater of Parque Rural del Nublo. Biosphere Reserve by UNESCO. Gran Canaria. Canary Islands

Abstract

Based on various classifications of mineral-medicinal waters and considering its properties, the water from the spring "La Mina" is described as a hypothermal, alkaline, very soft water, with a low conductivity, a very weak mineralisation and a significant silica concentration. The water especially contains the following ions: bicarbonate, chloride, calcium and sodium. Thus, several pharmacological actions and therapeutical effects can be attributed to this water. This piece of work assesses the quality of the groundwater obtained from the spring known as "La Mina", located in the basin of Tejeda, Gran Canaria, and analyses its organoleptic, physico-chemical and bacteriological parameters. The role of this groundwater within the rural park Parque Rural del Nublo, in the island of Gran Canaria, is also studied: use for irrigation purposes and potential use as bottled "natural mineral water". This work briefly mentions two recognitions awarded by the United Nations Educational, Scientific and Cultural Organization (UNESCO). On the 29th of June 2005, the terrestrial area located in the southwest of Gran Canaria and a large marine strip known as Parque Rural del Nublo were declared a Biosphere Reserved by the International Coordinating Council of the MaB Programme. Besides, on the 7th of July 2019, the 43rd session of the World Heritage Committee adopted the decision to inscribe the Cultural Landscape of Risco Caído and the Sacred Mountains of Gran Canaria, located within this park, on UNESCO'S World Heritage List.

Keywords: analysis, Gran Canaria Island, groundwater, "La Mina" spring, Parque Rural del Nublo, properties, UNESCO

Volume 8 Issue 4 - 2024

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Received: July 01, 2024 | **Published:** July 31, 2024

Introduction

Gran Canaria is located 1,250 km away from Cádiz, Spain, with the port of Cádiz being the European continental port closest to the island. Gran Canaria also lies approximately 210 km away from the closest spot in the African coast. Within the Canary Islands archipelago, Gran Canaria is situated between Fuerteventura, 83 km away on the east, and Tenerife, 62 km away on the west. Gran Canaria has an extremely valuable natural heritage, in spite of its relatively reduced dimensions. Given the uniqueness of its ecosystems, springs and its flora and fauna, with a large number of endemic species, and considering the geology of the island, many of its areas have been declared natural protected spaces. As of this writing, Gran Canaria comprises 33 protected natural spaces, included in the European Union's *Natura 2000* protected area network, which account for approximately the 43% of the area of the island.

The *Natura 2000 Network* is an electronic publication aimed at national and international experts and professionals responsible for the preservation of the biodiversity, especially those related to biodiversity, as well as at all the individuals interested in the development of the main European biodiversity preservation initiative (the *Natura 2000 Network*).[1]

Rural parks are described as wide natural spaces that combine agricultural, farming and/or fishing activities with other activities of natural and ecological interest, resulting in a landscape of ecological and cultural value that needs to be preserved. The declaration of a rural park is intended to preserve all the elements comprising such area, while promoting the harmonic development of the local populations and the enhancement of their living conditions. These areas correspond to the spaces of categories V and VI in the international nomenclature of the International Union for Conservation of Nature (IUCN).

The rural park *Parque Rural del Nublo* is the largest natural area in the island of Gran Canaria, covering the municipalities of Tejeda, La Aldea de San Nicolás, Mogán, San Bartolomé de Tirajana, Artenara, Vega de San Mateo, Valleseco and Moya (Figure 1). Its wide range of natural and cultural elements include the main symbol of the island, the volcanic monolith known as *Roque Nublo*. The park includes around 30 villages and covers around 27,000 hectares in the western part of Gran Canaria. This area was declared a Natural Space on the 19th of June 1987 and on the 19th of December 1994. On the 29th of June 2005, this rural park was declared a Biosphere Reserved by the International Coordinating Council of the MaB Programme, joining the list of the Natural Space Network of the Canary Islands (Gran Canaria C-11, Parque Rural del Nublo).[2] The site known as *Risco Caído and the Sacred Mountains of Gran Canaria - Cultural Landscape* is located in a wide mountainous area in the centre of Gran Canaria and comprises cliffs, ravines and volcanic formations, featuring a landscape characterised by a rich biodiversity. The UNESCO recognised this area as a Biosphere Reserve on the 7th of July 2019 (Protected Natural Space Network of the Canary Islands 2005, *Risco Caído and the Sacred Mountains* 2019).[3]

Its rich natural heritage features a wide range of mineral groundwater springs and a rich flora and vegetation, with fresh forests of Canary Island pines (*Pinus canariensis*) in the mountains and scrublands with autochthonous plants at the mouth of the ravines. The average annual temperature is around 19ºC, whereas the average annual rainfall reaches 700 mm.[4] Due to the said climate conditions and its special geomorphology, *i.e.*, its uneven terrain and the

characteristics of the land, this territory has differences that become self-evident when observing the vegetal landscape. The Canary Island pine (*Pinus canariensis C. Sm*.) forests are predominant in the wet areas of the mountains, although Californian pines (*Pinus radiata D. Don*) can be also seen. This ecosystem includes almond trees, a typical element in the basin of Tejeda. Other smaller autochthonous species coexisting in this area include the yellow broom *Teline microphylla D.C*, the perennial wallflower *Erysimum scoparium B. W*., the white sage *Sideritis dasygnaphala W.B*. and the Isabel's foxglobe *Isoplexis isabelliana W. B.*. Many of these plant species provide a therapeutical effect when they are prepared and given as a medicinal product. Some meadows also feature other species that are used to feed the cattle (*e.g*., *Bramwell D.* 2001).[5]

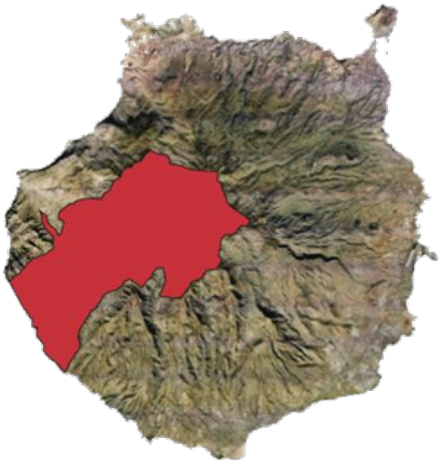

Figure 1 Parque Rural del Nublo (Gran Canaria).

This rural park features environmentally friendly industries, such as training and leisure activities, rural tourism businesses and other occupations based on the traditional use of the natural resources and the preparation of food products (*e.g*., biscuits, almond and lard-based sweets and the typical marzipan from Tejeda). The municipality of Tejeda hosts a research centre known as *Centro de Plantas Medicinales* (Medicinal Plant Centre), covering an area of 5,000 square metres intended to recover, study and disseminate knowledge about the close relationship between humans and nature through the medicinal use of plants, herbal remedies and believes. The park follows the rules of the UNESCO's "Man and the Biosphere Programme" (MaB Programme), established in 1970 to encourage interdisciplinary research in natural and social sciences and training in natural resource management, focused on the preservation and the sustainable use of the biodiversity. Thus, the MaB Programme is not only intended to gain a better understanding of the environment, but also to achieve a higher commitment, by science and scientists, to the development of policies for the rational use of the biological and cultural diversity, including the global change. On the 29th of June 2025, the terrestrial area located in the southwest of Gran Canaria and a large marine strip, known as *Parque Rural del Nublo,* were declared a Biosphere Reserve by the International Coordinating Council of the MaB Programme.

The park features a number of springs, with "El Molinillo" and "La Mina" standing out for their similarities, relevance and large volume of natural mineral water. These significant springs bubble up next to a thick basaltic layer, found on another thick layer of tufa. Two further series of similar layers, both in terms of composition and thickness, can be found above the previous layers and pour water for the irrigation of the farming lands (Ascanio y León R 1926).[6] The springs "El Molinillo" and "La Mina" were declared as "Public Utility Springs" and as sources of "Natural Mineral Water" on the Official Gazette of the Canary Islands (*Boletín Oficial de Canarias*) on the 4th of February 2014 (BOC 2014 Expte.35B00001.[7], BOC 2014 Expte.35B00002.[8]). "La Mina" is a spring that has been known for a very long time, approximately since 1501. It is located in the mountain that forms the basin of the municipality of Tejeda, close to the village of La Culata, where various fruit trees are grown (Figure 2).[9]

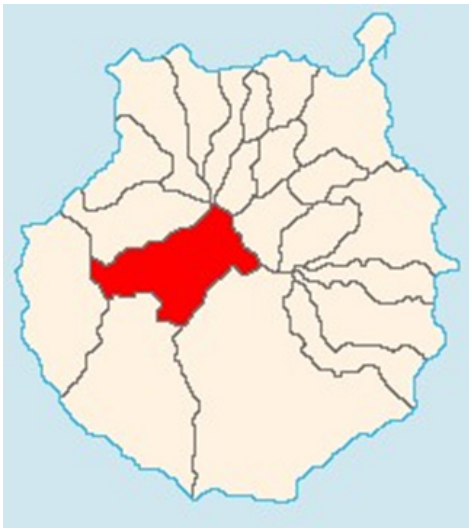

Figure 2 Picture of Gran Canaria Island. The picture is divided into 21 grids and each grid represents a municipality. The grip corresponding to municipality of Tejeda is marked in red.

The water flowing out from the spring "La Mina" are conducted through irrigation channels across 1,400 metres of water galleries. A tunnel diverts the waters to the basin of the ravine of La Mina and reaches the ravine of Guiniguada, where the waters are drained downstream (Figure 3). The spring's flow rate used to range between 45 and 50 L/s, but the measurements carried out over the last years show a flow rate between 11 and 15 L/s. At the end of the tunnel, the waters move the machinery of the mills *Molinos de la Cumbre*.[10]

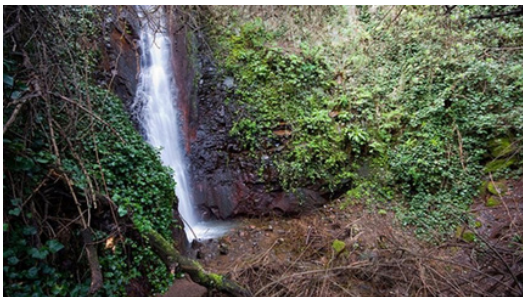

Figure 3 Spring "La Mina" and ravine of Guiniguada Grand Canaria Island.

This piece of work analyses the quality of the groundwater poured by the spring "La Mina", based on organoleptic, physico-chemical, chemical and bacteriological parameters. The water is classified as drinking water and, considering its potential pharmacological action and therapeutic indications, its capacity to be used as a mineralmedicinal water is also studied. This paper also discusses some endemic, medicinal plants found in the rural park *Parque Rural del Nublo* that benefit from this groundwater. The park was declared

as a Biosphere Reserve by UNESCO on the 29th of June 2005, whereas the 43rd session of the World Heritage Committee adopted the decision to inscribe the Cultural Landscape of *Risco Caído and the Sacred Mountains of Gran Canaria* on the UNESCO'S World Heritage List.

Material and methods

Water samples collection

A total of 12 water samples (approximately 2 L) were collected at the outlet of the spring "La Mina" (municipality of Tejeda, in the island of Gran Canaria) from July 2022 to June 2023. The water samples were collected in a 2-litre sterile bottle and submitted to the laboratory on a monthly basis to perform organoleptic, physico-chemical, chemical and bacteriological analyses.

Organoleptic properties

The organoleptic parameters (colour, odour and taste) were determined at the outlet of the spring when the water samples were collected. The water temperature (ºC) and the pH were also determined at the outlet of the water gallery.[11]

Physicochemical analysis

The physico-chemical parameters were analysed in the laboratory following standard procedures: potential hydrogen (pH), conductivity at 25ºC (microS.cm^{-1}), total organic carbon (mg C/L), total hardness (mg/LCO_3Ca), silica (mg SiO_2/L), dry residues at 180ºC (mg/L).[11]

Dissolved substances (chemical analysis)

The dissolved substance analyses were expressed in terms of mg/L, meq/L and % of meq/L. Anions: bicarbonate, chloride, nitrate, sulphate, carbonate, fluoride and nitrite. Cations: calcium, magnesium, sodium, potassium, ammonium.[11]

Bacteriological analysis

The microbiological parameters were assessed in the laboratory following standard procedures: Colony count at 22ºC/72 hours (cfu/mL). Colony count at 37ºC/72 hours (cfu/mL). Coliform bacteria. (cfu/250mL). *Eschreichia coli* (cfu/250 mL). *Salmonella spp.* (in 250 mL). Faecal Streptococci (cfu/250 mL). Sporulated sulphite-reducing anaerobes (ufc/ 50 mL). *Pseudomonas aeruginosas* (ufc/ 250 mL). (cfu) = colony forming units). (Guidelines for Drinking-water Quality 2011).[12]

Results

Table 1 shows the mean value of the parameters observed. Samples analysed (n =12).

Table 1 Physico- chemical and chemical parameters

Parameters	Maximum	Minimum	Mean	Standard deviation
pH	8.03	7.23	7.6	0.20
Conductivity at 25°C (µS.cm^{-1})	141	119	126	6.31
Total organic Carbon (mg C/L)	<0.1	<0.1	<0.1	-
Total hardness (mg/LCO_3Ca)	52	44	47	2.56
Silica (mg SiO_2/L)	43.8	39.3	42.1	1.35
Dry residue at 180°C (mg/L)	125	109	117	4.32
Bicarbonate (mg HCO_3/L)	54.7	48.0	50.0	2.02
Carbonate (mg CO_3/L)	<1.2	<1.2	<1.2	-
Sulphate (mg SO_4/L)	4.3	2.0	2.4	0.64
Chloride (mg Cl/L)	12.9	10.4	10.9	0.65
Nitrate (mg NO_3/L)	7.7	5.8	7.3	0.51
Fluoride (mg F/L)	<0.2	<0.2	<0.2	-
Nitrite (mg NO_2/L)	<0.02	<0.02	<002	-
Σ anions (meq/L)	**1.38**	**1.25**	**1.29**	
Calcium (mg Ca/L)	10.1	8.3	8.8	0.53
Magnesium (mg Mg/L)	6.9	5.6	6.0	0.17
Sodium (mg Na/L)	9.2	7.4	7.8	0.48
Potassium (mg K/L)	1.7	1.5	1.6	0.05
Ammonium (mg NH_4/L)	<0.10	<0.10	<0.10	-
Σ cations (meq/L)	1.45	1.26	1.31	

Organoleptic analysis

The water that spontaneously flows up from this spring is transparent (colourless) and has no smell (odourless) and no abnormal taste (insipid) Table 2.

Table 2 Organoleptic properties

Colour	Colourless
Odour	Odourless
Taste	Insipid

Physico-chemical analysis

For the physicochemical parameters, Table 3 shows the classification of the water, based on the following average values: spring temperature, pH at spring temperature, conductivity at 25ºC, hardness, dry residues at 180ºC, silica and total organic carbon. Therefore, this water is described as hypothermal, alkaline and very soft water, with a low conductivity, a very weak mineralisation and a significant silica content, with a total organic carbon <0.1.

Citation: Navarro E. Assessment of the water quality of spring "La Mina". Groundwater of Parque Rural del Nublo. Biosphere Reserve by UNESCO. Gran Canaria. Canary Islands. *Int J Hydro.* 2024;8(4):128–133. DOI: 10.15406/ijh.2024.08.00384

Table 3 Physico-chemical analysis

Parameter	Value	Units	Classification
Temperature of spring	17	° C	Hypothermal water
pH at spring temperature	7.6		Alkaline water
Conductivity at 25°C	126	µS.cm-1	Low conductivity water
Hardness	47	mg/CO_3Ca	Very soft water
Dry residues at 180°C	117	mg/L	Very weak mineralisation water
Silica	42.1	mg SiO_2/L	Silica water
Total organic carbon	<0.1	mg C/L	Parametric value > 5mg C/L

Predominant dissolved substances (chemical analysis)

For the predominant dissolved substances (anions and cations), Table 4 shows the mean value of the parameters observed, expressed in mg/L, meq/L and % meq/L.

Table 4 Predominant dissolved substances

Dissolved Substances							
	ANIONS			CATIONS			
	mg/L	meq/L	% meq/L		mg/L	meq/L	% meq/L
HCO_3-	50	0.808	63.67	Ca^{2+}	8.5	0.425	33.22
Cl-	10.9	0.298	23.48	Na^{+}	7.4	0.321	25.09
NO_3-	7.3	0.122	9.61	Mg^{2+}	6	0.493	38.54
SO_4^{2-}	2.4	0.041	3.23	K^{+}	1.6	0.04	3.12
Total amount	69.7	1.269	99.99			1.279	99.99

Bacteriological analysis

Table 5 shows the bacteriological parameters analysed, the results, the parametric values, and the units. It can be seen that this water has a healthy bacteriological profile.

Table 5 Bacteriological analysis

Parameters	Results	Parametric Value	Units cfu/mL
Colony count 22 °C C/ 72 hours	<3	-----	(cfu/mL)
Colony count 37 °C / 72 hours	<3	-----	(cfu/mL)
Coliform bacteria	0		(cfu/ 250 mL)
Escherichia coli	0		(cfu/ 250 mL)
Salmonella spp.	absence	absence	(in 250 mL)
Faecal Streptococci	0	0	(cfu/250 mL)
Sporulated sulphite-reducing anaerobes	0	0	(cfu/50 mL)
Pseudomonas aeruginosa	0	0	(cfu/250 mL)

(cfu) = colony forming units)

Spring "La Mina" and medical hydrology

Table 6 shows the classification of the water, based on the main parameters used in Medical Hydrology.

Table 6 Classification

Classification	
Based on its temperature	Hypothermal
Based on its mineralisation	Very weak mineralisation
Based on its composition	Predominant ions: bicarbonate, chloride, calcium, sodium
Based on its hardness	Very soft

Discussion

The water samples taken from the spring "La Mina" were collected in a sterile bottle, in accordance with the recommendations established in the 21st edition of the publication *Standard Methods for the Examination of Water and Wastewater* (Eaton HD and Franson MAH 2005).[13] The physico-chemical and chemical parameters were assessed based on the parametric values established in the handbook of Spanish mineral-medicinal waters *Vademécum de Aguas Minero-Medicinales Españolas*.[10] It has been observed that the spring "La Mina" meets the physico-chemical, chemical and bacteriological parameters established in the World Health Organization's *Guidelines for Drinking-Water Quality.* Therefore, this water is useful as drinking water. (*Guidelines for Drinking-Water Quality 2011*).[12] Upon assessing its parameters and features, the water can be classified as follows: alkaline water based on its pH. Hypothermal water based on its temperature at the outlet of the spring. Considering its mineralisation, it is classified as low-conductivity water. Based on its hardness, it is described as soft water. The dry residues found classify it as low-mineralisation water. And based on the silica contents, it is described as silica water. Its organoleptic and physico-chemical features are similar to those of the mineral water marketed by *Fuenteror*, which flows out from a spring located in the vicinity of the basin of Tejeda (Navarro E. 2013).[14] The analysis of the substances dissolved in the

water shows that the most significant anions are bicarbonate and chloride, whereas the predominant cations are calcium and sodium. Although this water is used for irrigation purposes in *Parque Rural del Nublo*, it can be also used as drinking water, considering that it is natural mineral water with a weak mineralisation and a healthy bacteriological profile.[15]

Since this type of water is included in all the mineral-medicinal water nomenclatures, various pharmacological actions can be attributed to it (Armijo Valenzuela M. 1984).[16] Considering its very weak mineralisation and its low temperature (the water flows out below 20ºC), this water especially produces a diuretic effect when given orally and is indicated for these three types of medical conditions:

I. For renal lithiasis, it can be useful, as it changes the lithogenic factors locally (infections, acid-base balance disorders, etc.).

II. For urinary infections, this water can facilitate the expulsion of urine, preventing urine retention in the urinary tract.

III. For sub-actute and chronic nonhydropigenic glomerulonephritis and chronic inflammation of the urinary tract (cystopyelitis, cystitis, urethritis, etc.).

In a crenotherapeutic context, this type of water is given orally at relatively high doses (600-1,800mL) 3 times/day, with the patient taking the dose within a period of 30-60 minutes in the morning on an empty stomach and in a prone position (to help the water flow through the hepatic portal system). Its main components may have a very mild added value in terms of vasodilation, reduction in heart rate disorders in diabetic patients and the prevention and treatment of kidney stones (oxalate and calcium carbonate), as well as in chronic infections of the urinary tract.[16] Considering its concentration, the water obtained from the spring "La Mina" is classified as silica water, SiO_2 = 42.7 mg/L. Based on its sodium level (Na^+ = 7.4 mg/L), it is also indicated for the preparation of food for babies.

Some studies suggest that the daily amount of silicon required ranges from 20 to 50 mg/day (Pennington J. A. 1991).[17] Other pieces of research, however, claim that the intake of silicon (approximately 30 mg/day of silicon) is one of the highest levels of intake of trace elements in humans.[18] Many natural mineral waters contain an amount of silicon below 10 mg/l, whereas others can reach up to 80 mg/l. It must be noted that volcanic waters have a significant amount of silicon and the Canaries are volcanic islands. Silica waters are described as waters with a concentration of SiO_2 > 30 mg/L. Almost all the mineral waters in the Canary Islands are silica waters and the importance of silicon for the human body increases as the body ages, since the skin and the connective tissue of arteries, bones and cartilages become more and more fragile and lose silicon. The administration of silicon in form of SiO_2 (silica) by adding supplementary water to the usual diet is very interesting. This substance is recommended by many experts as a vital, essential mineral that provides a good appearance and promotes the good performance of the body. Other mineral waters in the Canary Islands that have these features in common include those marketed by the commercial brands *Aguas Fuenteror*[13] and *Aguas de San Antón*.[19]

Besides, it is well known that silicon plays a positive role in the development of drought tolerance in various plants. This effect may be due to the plant's capacity to accumulate a significant volume of silicon and to use it for osmoregulation purposes, resulting in a self-evident improvement in the photosynthesis and the antioxidant enzymatic activity of the plant. Silicon is abundant in the lithosphere and previous studies have confirmed that it plays an important role in the growth of plants. Higher plants absorb soluble silicon from the soil through the roots and the substance is stored in the plant tissues, especially in form of phytoliths.[20,21]

To sum up, the evidence suggests that the water collected from the spring "La Mina", considering its physico-chemical and bacteriological features, can be used as drinking water. It may be also useful as natural mineral water for the prevention and treatment of some medical conditions. Based on its amount of silica, this water plays an important role in human health and in the growth of plants in *Parque Rural del Nublo*. A bottling plant in an appropriate location within the rural park would be advisable, as it would create employment in this protected space and help prevent depopulation in this area. *Parque Rural del Nublo* is an ecosystem that should be preserved as a World Heritage Site, due to its hydrographic and geologic features and its flora and fauna, and considering that it was declared as a Biosphere Reserve and a World Heritage Site by the UNESCO.

Conclusion

This paper aims to assess several aspects of the quality of the groundwater of the spring "La Mina", as well as the importance of the rural park Parque Rural del Nublo, which receives many visits due to its rich biodiversity. Pharmacologists and consultants in hydrologic medicine should carry out further analyses of the water obtained from the spring "La Mina" and conduct experimental and clinical trials in order to confirm its pharmacological actions and therapeutic indications. The rural park Parque Rural del Nublo has special features in terms of endemic flora and fauna, with hydrologic characteristics and geologic structures that are typical of volcanic islands. Thus, these matters should be further addressed by professionals in the fields of botany, zoology, chemistry, hydrology, geology, etc. It is well known that human beings have no future without biodiversity.

Acknowledgments

None.

Conflicts of interest

The author declares there is no conflict of interest.

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