



Original/Otros

Magnesium in tap and bottled mineral water in Spain and its contribution to nutritional recommendations

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Abstract

Introduction: An appropriate magnesium intake has proved to have beneficial effects on bone health, reduce insulin resistance and prevent atherosclerosis.

Objective: To determine the concentration of magnesium in drinking water and bottled mineral water in Spain and assess its daily contribution to dietary recommendations.

Methods: We used ion chromatography to analyse the magnesium concentrations of public drinking waters in a representative sample of 108 Spanish municipalities (supplying 21,290,707 potential individuals) and 109 natural mineral waters sold in Spain (97 Spanish and 12 imported).

Results: The water generally contained between 15 and 45 mg/L of magnesium, but in seven municipalities it contained over 45 mg/L. The average magnesium concentration of 97 brands of Spanish natural mineral water was 16.27 mg/L (range: 0.11-141.2 mg/L). Of these, 33 contained between 15 and 45 mg/L of magnesium and four contained over 45 mg/L. Of the 12 imported brands, 4 contained over 45 mg/L. Assuming water consumption is as recommended by the European Food Safety Agency, water containing 15 to 45 mg/L of magnesium provides between 9 and 76.5% of the recommended intake of magnesium for children aged one to thirteen, up to 25.7% in adolescents, between 7.5 and 25.7% for adults, and up to 27% for lactating women. Water with 60 mg/L of magnesium provides between 30 and 102% of the recommended dietary allowance, depending on the age of the individual.

Discussion: The consumption of public drinking water and natural mineral water in a third of Spanish cities can be regarded as an important supplementary source of magnesium.

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Key words: *Magnesium. Drinking water. Natural mineral water. Water softening. Nutritional requirements.*

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MAGNESIO EN EL AGUA DE CONSUMO PÚBLICO Y AGUAS MINERALES NATURALES EN ESPAÑA Y SU CONTRIBUCIÓN EN CUBRIR LAS NECESIDADES NUTRICIONALES

Resumen

Introducción: Una adecuada ingesta de magnesio condiciona una buena salud ósea y previene y la resistencia a la insulina y la arteriosclerosis.

Objetivo: Determinar el contenido en magnesio en aguas de bebida en España y valorar su contribución diaria a las ingestas recomendadas de este mineral.

Métodos: En 2012 se analizaron por cromatografía iónica las concentraciones de magnesio de distintas aguas de consumo público en una muestra representativa de 108 poblaciones españolas que abastecen a 21.290.707 personas, así como de 109 aguas minerales naturales embotelladas comercializadas en España (97 españolas y 12 importadas).

Resultados: La concentración media de magnesio en aguas de consumo público fue de 14,65±16,23 mg/L (rango: 0,07-70,08 mg/L). En 25 poblaciones el agua contenía 15-45 mg/L de magnesio y en 7 fue superior a 45 mg/L. La concentración media de magnesio de las 97 marcas españolas de aguas fue 16,27 mg/L (rango: 0,11-141,2 mg/L), 33 de ellas contenían 15-45 mg/L de magnesio, mientras que en 4 de ellas era mayor de 45 mg/L. De las 12 marcas importadas, 4 contenían más de 45 mg/L. Asumiendo la cantidad de ingesta de agua recomendada por la EFSA, si el agua contiene 15-45 mg/L de magnesio, ésta aportaría entre el 9 y el 76,5% de la ingesta de magnesio recomendada para los niños de 1-13 años, hasta el 25,7% en adolescentes, entre 7,5 y 25,7% en adultos, y hasta el 27% en lactantes. El agua conteniendo 60 mg/L de magnesio aportaría entre el 30 y el 102% de las recomendaciones según la edad.

Discusión: El agua de consumo público de un tercio de ciudades españolas y de aguas minerales naturales puede ser considerada como una fuente complementaria importante de magnesio ingerido.

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Palabras clave: *Magnesio. Agua de bebida. Agua mineral natural. Ablandamiento del agua. Necesidades nutricionales.*

Abbreviations

Mg: Magnesium.
PDW: public drinking waters.
NMW: natural mineral waters.
EU: European Union.
EFSA: European Food Safety Agency.
FESNAD: Federación Española de Sociedades de Nutrición, Alimentación y Dietética.
DRI: Dietary Reference Intake.

Introduction

Magnesium (Mg) is the fourth most abundant cation in the human body and the second most abundant in the intracellular fluid. It is a cofactor in around 350 cellular enzymes, the majority of which are related to energy metabolism, such as glycolysis and the metabolism of ATP¹. It acts as a cofactor in transporting ions and nutrients, such as sodium, potassium and calcium, across membranes. It is also involved in the synthesis of proteins and nucleic acids, and is necessary if normal insulin sensitivity, neuromuscular excitability and muscle contraction are to be maintained². An appropriate magnesium intake can help to prevent atherosclerosis, eclampsia and insulin resistance, and maintain bone health, thus preventing the onset of osteoporosis^{3,4}.

The Spanish Federation of Nutrition, Food and Dietetics Societies (FESNAD) has established the dietary reference intake (DRI) for magnesium, the values of which range between 40 and 170 mg/day for children of 1 to 9 years of age, and between 250 and 360 mg/day for adolescents and adults⁵ (Table 1). According to the National Survey of Dietary Intake (ENIDE) conducted in 2011, approximately 30% of the Spanish population presents an inadequate magnesium intake⁶. In the same vein, other studies carried out in Spain on postmenopausal women have demonstrated that the average magnesium intake is 237 ± 79.8 mg/day, and that 36% of these women ingest quantities of magnesium below 2/3 of the recommendations⁷. Insufficient intakes of Mg have also been observed in other countries^{8,9}, possibly due to a low intake of vegetables and a high intake of refined flours¹⁰.

The Mg in drinking water could be an interesting alternative means to meet the organism's magnesium needs, as it is highly bioavailable¹¹. However, the mineral content of water tends to be disregarded. When the recommendations on the type of water for human consumption are reviewed, it is customary to play down the importance of the magnesium it contains. Thus, neither the Spanish,¹² nor the European regulations¹³ on public drinking water (PDW) refer to the content of Mg. As for natural mineral water (NMW), the *Codex*¹⁴ standard does not refer to the magnesium content either. Only the Spanish¹⁵ and European¹⁶ regulations on bottled drinking water indicate that the

label can mention that it is rich in magnesium if it contains more than 50 mg/L of this mineral.

The main aim of this study is therefore to analyse the magnesium content of Public Drinking Water (PDW) and bottled Natural Mineral Water (NMW) consumed in Spain and to assess its daily contribution to the recommended intake of this mineral.

Methods

During 2012, samples of PDW were selected from 108 of the 144 Spanish towns with more than 50,000 inhabitants. The total population supplied by the water analysed in this study is calculated to be 21,290,707 inhabitants, representing 45.3% of the Spanish population. The towns where the water was analysed were selected randomly to represent all Spanish geographical areas. The number of inhabitants from each municipality was determined from the National Statistics Institute document "Población de derecho de los municipios según el Padrón Municipal de habitantes" (De jure population of the municipalities according to the Municipal Census of inhabitants)¹⁷ for the year 2012. Three samples of two litres of water were collected in each of the municipalities studied, in opaque plastic bottles, after letting the tap run for at least three minutes. The samples were collected from homes or public facilities in which there were neither home filters nor reverse osmosis systems.

Bottles of 97 Spanish and 12 imported brands of NMW were also purchased in supermarkets and grocery stores in different Spanish towns. Three bottles of each brand were purchased, each with a different bottling date. The 97 most frequently consumed Spanish brands, representing the geographic areas with the highest number of springs, were chosen from the complete list of 151 Spanish NMW recognised by the European Union¹⁸. Both the Spanish and the imported samples were stored in the dark, at room temperature, until they were analysed.

The concentrations of magnesium were determined by ion chromatography (EPA Method 300.7) with the Dionex DX-120 chromatograph, using the calibration standard Fluka 89441. The calibration and concentrations of the samples were obtained with software Peak Net 5.10d –SE. Technique 4110-B, recommended by the American Public Health Association, the American Water Works Association, and the Water Environment Federation, was followed¹⁹.

The percentage of recommended magnesium intake was calculated from the analytical data collected in this study from 108 types of tap water (Table II) and 109 bottled natural mineral waters (Tables III and IV). The daily contribution to the recommended intake was calculated for each age range using the daily fluid intake recommendations of the EFSA²⁰ (Table V) and the recommendations of the FESNAD⁵ (Table I).

Table I
Dietary Reference Intakes (DRI) and tolerable upper intake levels (UL)⁵ of magnesium

Age	DRI (mg/day)	UL (mg/day)*
0 – 6 months	40	ND
7 – 12 months	75	ND
1 – 3 years	85	65
4 – 5 years	120	110
6 – 9 years	170	110
<i>Men</i>		
10 – 13 years	280	350
14 - 19 years	350	350
20 - 29 years	350	350
30 - 39 years	350	350
40 - 49 years	350	350
50 – 59 years	350	350
60 – 69 years	350	350
> 70 years	350	350
<i>Women</i>		
10 – 13 years	250	350
14 - 19 years	300	350
20 - 29 years	300	350
30 - 39 years	300	350
40 - 49 years	300	350
50 – 59 years	300	350
60 – 69 years	320	350
> 70 years	320	350
<i>Pregnant</i>	360	350
<i>Lactating women</i>	360	350

*The ULs for magnesium represent intake only from a pharmacological agent and do not include the intake from food or water. ND, No Data.

Results

Table II shows the average magnesium content in the PDW of the 108 Spanish towns studied. It was 14.65±16.23 mg/L, ranging between 0.07 mg/L in San Vicente del Raspeig and 70.08 mg/L in Fuengirola.

In 76 of the 108 towns, the PDW contained less than 15 mg/L of magnesium. In 11, the magnesium concentrations were between 15 and 30 mg/L. In a further 14, with a total of 2,474,612 inhabitants the magnesium content was between 30 and 45 mg/L. Finally, in 7 towns, with a total of more than one million inhabitants, magnesium content was above 45 mg/L (Table VI). In this study, magnesium content was above

60 mg/L in only 2 of the 108 towns studied (Girona and Fuengirola). Figure 1 shows the location of the Spanish towns in which the content of magnesium in water was determined.

Tables III and IV show the magnesium content (mg/L) of the 97 Spanish and 12 imported brands of NMW, respectively. Only six of the NMW analysed contained more than 60 mg/L, three of which were above 80 mg/L. The location of the sources of the Spanish NMWs is indicated in Figure 2. The average magnesium concentration of bottled NMW in Spain was 16.27 mg/L, ranging from 0.11 (Font del Bou®) to 141.24 (Agua de Manzanera®) mg/L. Of the 97 Spanish brands, 60 (61.8%) contained less than 15 mg/L of magnesium, 21 (21.6 %) contained between 15 and 30 mg/L and 16 contained over 30 mg/l. The average magnesium concentration of the imported water was 33.53±25.42 mg/L, with a maximum value of 81.65 and a minimum of 6.14 mg/L. Of the 12 brands of imported NMW, 8 presented more than 15 mg/L of magnesium and 4 more than 45 mg/L.

Tables VIIa and VIIb show that water which contains between 15 and 45 mg/L of magnesium contributes between 9 and 76.5% of the DRI for children between 1 and 13 years of age, up to 25.7% in adolescents, between 7.5 and 25.7% in adults, between 7.7 and 23% in pregnant women and up to 27% in lactating women. This magnesium concentration was observed in 25 of the 108 PDWs, in 33 of the 97 Spanish NMWs, and in four of the 12 imported NMWs. Water containing a higher quantity of magnesium (60 mg/L) thus provides between 36 and 102% for children between 1 and 13 years of age. In adolescents, the intake can reach 34.3%, while in adults it ranges from 30 to 34.3%. In pregnant women, the percentage of DRI can reach 30.7% and in lactating women 36%. In menopausal women, this magnesium content can cover approximately 30% of DRI.

Discussion

An appropriate magnesium intake can help to prevent high blood pressure²¹ and insulin resistance²², and maintain adequate bone mineral density²³. The main dietary sources of magnesium are nuts, pulses, cereals and vegetables. The net absorption of dietary magnesium is approximately 50%. This absorption is lower if the diet contains a higher quantity of dietary fibre, phytates and phosphorus²⁴.

Several studies have shown that the bioavailability of the magnesium contained in water is also high. For example, in a crossover study on 10 healthy adult males, the bioavailability of magnesium from mineral water was shown to be 59%¹¹. In another crossover study performed on 10 healthy women between 25 and 45 years of age, the bioavailability of the magnesium present in the water was studied using stable isotope techniques. Although the absorption and retention of

Table II
Average magnesium concentration in public drinking water for Spanish regions

<i>Nº</i>	<i>Autonomous community</i>	<i>Cities</i>	<i>Population</i>	<i>Average magnesium concentration (mg/L)</i>
83	Andalusia	Alcalá de Guadaíra	70155	9.59 ± 0.38
49	Andalusia	Algeciras	116209	3.53 ± 0.14
44	Andalusia	Cádiz	126766	8.56 ± 0.34
76	Andalusia	Chiclana de la Frontera	77293	8.34 ± 0.33
12	Andalusia	Córdoba	328428	6.04 ± 0.24
45	Andalusia	Dos Hermanas	122943	7.25 ± 0.29
64	Andalusia	El Puerto Santa María	87696	8.42 ± 0.34
81	Andalusia	Fuengirola	71482	70.08 ± 2.80
19	Andalusia	Granada	234325	10.11 ± 0.40
25	Andalusia	Jerez de la Frontera	207532	8.55 ± 0.34
87	Andalusia	La Línea de la Concepción	64595	3.46 ± 0.14
6	Andalusia	Málaga	568305	7.08 ± 0.28
42	Andalusia	Marbella	134623	32.28 ± 1.29
57	Andalusia	San Fernando	96366	8.85 ± 0.35
86	Andalusia	Sanlúcar de Barrameda	65805	8.49 ± 0.34
4	Andalusia	Sevilla	703206	7.46 ± 0.30
106	Aragon	Huesca	52059	12.32 ± 0.49
5	Aragon	Zaragoza	674317	1.93 ± 0.08
68	Asturias	Avilés	84242	0.25 ± 0.01
15	Asturias	Gijón	277554	6.95 ± 0.28
21	Asturias	Oviedo	224005	5.68 ± 0.23
108	Asturias	Siero	51181	3.43 ± 0.14
109	Balearic Islands	Eivissa	48684	35.84 ± 1.43
8	Balearic Islands	Palma	401270	52.05 ± 2.08
74	Canary Islands	Arona	78614	14.66 ± 0.59
97	Canary Islands	Arrecife	59127	4.29 ± 0.17
9	Canary Islands	Palmas de Gran Canaria (Las)	381847	59.2 ± 2.37
105	Canary Islands	San Bartolomé de Tirajana	52161	8.12 ± 0.32
39	Canary Islands	San Cristobal de La Laguna	150661	43.85 ± 1.75
22	Canary Islands	Santa Cruz de Tenerife	222417	44.56 ± 1.78
90	Canary Islands	Santa Lucía de Tirajana	63637	8.43 ± 0.34
54	Canary Islands	Telde	100015	9.4 ± 0.38
32	Cantabria	Santander	182700	8.75 ± 0.35
101	Cantabria	Torrelavega	55947	7.81 ± 0.31
99	Castille and Leon	Ávila	56855	2.64 ± 0.11
34	Castille and Leon	Burgos	178966	0.65 ± 0.03
43	Castille and Leon	León	134305	5.12 ± 0.20
37	Castille and Leon	Salamanca	155619	4.07 ± 0.16
13	Castille and Leon	Valladolid	317864	13.25 ± 0.53
102	Castille La Mancha	Cuenca	55866	30.71 ± 1.23
63	Castille La Mancha	Talavera de la Reina	88856	7.82 ± 0.31
71	Castille La Mancha	Toledo	82291	3.03 ± 0.12

Table II (cont.)
Average magnesium concentration in public drinking water for Spanish regions

<i>Nº</i>	<i>Autonomous community</i>	<i>Cities</i>	<i>Population</i>	<i>Average magnesium concentration (mg/L)</i>
23	Catalonia	Badalona	219547	11.92 ± 0.48
2	Catalonia	Barcelona	1621537	10.36 ± 0.41
93	Catalonia	Castelldefels	62080	45.51 ± 1.82
98	Catalonia	Cerdanyola del Vallés	58747	12.49 ± 0.50
65	Catalonia	Cornellà de Llobregat	86519	26.46 ± 1.06
92	Catalonia	El Prat de Llobregat	63418	23.12 ± 0.92
58	Catalonia	Girona	96188	62.52 ± 2.50
96	Catalonia	Granollers	60658	12.56 ± 0.50
16	Catalonia	Hospitalet de Llobregat	257038	33.09 ± 1.32
41	Catalonia	Lleida	135919	6.72 ± 0.27
77	Catalonia	Manresa	76558	56.86 ± 2.77
46	Catalonia	Mataró	121722	16.06 ± 0.64
104	Catalonia	Mollet del Vallès	52484	13.54 ± 0.54
52	Catalonia	Reus	107118	31.6 ± 1.26
80	Catalonia	Rubí	72987	15.42 ± 0.62
69	Catalonia	Sant Boi de Llobregat	82428	31.91 ± 1.26
47	Catalonia	Santa Coloma de Gramenet	119717	12.23 ± 0.49
24	Catalonia	Tarrasa	210941	32.91 ± 1.28
91	Catalonia	Viladecans	63489	41.18 ± 1.65
94	Valencia	Alcoy	61552	18.24 ± 0.73
11	Valencia	Alicante	334757	17.86 ± 0.71
82	Valencia	Benidorm	71034	28.84 ± 1.15
33	Valencia	Castellón de la Plana	180005	33.6 ± 1.34
20	Valencia	Elche	230112	17.75 ± 0.71
73	Valencia	Gandía	80020	10.06 ± 0.40
67	Valencia	Orihuela	86164	1.16 ± 0.05
89	Valencia	Paterna	64023	47.14 ± 1.89
85	Valencia	Sagunto	66070	43.62 ± 1.74
103	Valencia	San Vicente del Raspeig	53126	0.07 ± 0.01
75	Valencia	Torrent	78543	39.63 ± 1.57
53	Valencia	Torre Vieja	101792	24.69 ± 0.99
3	Valencia	Valencia	814208	44.89 ± 1.80
107	Valencia	Vila-real	51205	39.34 ± 1.57
40	Extremadura	Badajoz	148334	4.3 ± 0.17
60	Extremadura	Cáceres	93131	4.62 ± 0.18
100	Extremadura	Mérida	56395	17.11 ± 0.68
79	Galicia	Ferrol	74273	3.7 ± 0.15
17	Galicia	La Coruña	246056	5.2 ± 0.21
56	Galicia	Lugo	96678	1.9 ± 0.08
51	Galicia	Orense	107742	2.9 ± 0.12
59	Galicia	Santiago de Compostela	95092	1.9 ± 0.08
14	Galicia	Vigo	297332	1.1 ± 0.04

Table II (cont.)
Average magnesium concentration in public drinking water for Spanish regions

Nº	Autonomous community	Cities	Population	Average magnesium concentration (mg/L)
38	La Rioja	Logroño	152107	24.6 ± 0.98
27	Madrid	Alcalá de Henares	204574	2.97 ± 0.12
50	Madrid	Alcobendas	109104	2.18 ± 0.09
35	Madrid	Alcorcón	167967	2.23 ± 0.09
62	Madrid	Coslada	90280	2.35 ± 0.09
29	Madrid	Fuenlabrada	197836	2.31 ± 0.09
36	Madrid	Getafe	167164	3.41 ± 0.14
66	Madrid	Las Rozas	86340	2.23 ± 0.09
30	Madrid	Leganés	186066	2.23 ± 0.09
1	Madrid	Madrid	3255944	3.29 ± 0.13
84	Madrid	Majadahonda	68110	2.35 ± 0.09
26	Madrid	Móstoles	206478	2.33 ± 0.09
70	Madrid	Pozuelo de Alarcón	82428	2.35 ± 0.09
78	Madrid	San Sebastián Reyes	75912	2.26 ± 0.09
48	Madrid	Torrejón de Ardoz	118162	1.98 ± 0.08
61	Murcia	Lorca	91906	12.28 ± 0.49
88	Murcia	Molina de Segura	64065	0.39 ± 0.02
7	Murcia	Murcia	436870	0.44 ± 0.02
28	Navarre	Pamplona	198491	8.39 ± 0.34
55	Basque country	Baracaldo	98460	3.85 ± 0.15
10	Basque country	Bilbao	354860	2.78 ± 0.11
72	Basque country	Getxo	80770	4.29 ± 0.17
95	Basque country	Irun	60951	1.06 ± 0.04
110	Basque country	Portugalete	48105	4.57 ± 0.18
31	Basque country	San Sebastián	185357	1.06 ± 0.04
18	Basque country	Vitoria	235661	4.72 ± 0.19

Data expressed as means + SD.

the magnesium from mineral water was high, the authors observed that it was even higher when consumed with a light meal²⁵. It should be pointed out, however, that both studies were of short duration and undertaken on a relatively small sample of individuals. Their results should therefore be viewed with caution.

The long-term bioavailability of the magnesium present in mineral water was also determined by a randomised crossover study of 12 healthy Caucasian men from 18 to 40 years of age, consuming 1.5 litres of mineral water with 84 mg/L of magnesium. The results indicate that the absorption of magnesium from mineral water when consumed in two doses was 32.4%, while the absorption was higher (50.7%) when the consumption was in seven doses. In order to meet magnesium needs more efficiently, then, the authors recommend that magnesium-rich water be consumed in several doses throughout the day²⁶.

Given that an appropriate magnesium intake is important for the prevention of osteoporosis, insulin resistance and atherosclerosis, and that the bioavailability of drinking water is high, the magnesium concentration of PDW and NMW needs to be known so that the extent to which water can help to meet recommended intake can be calculated.

This study, like others before it, has shown that the magnesium content of PDW varies considerably, probably due to factors such as the type of rock on which the aquifer is located, and whether it is ground or surface water. In a review of the mineral content of PDW in 44 US towns²⁷, the average magnesium content of 36 surface PDWs was 10±8 mg/L, while for the 8 groundwater PDWs it was 20±13 mg/L (range: 0-48 mg/L). Other studies have also shown that magnesium content varies enormously depending on the source of the water: in Jordan, it ranged

Table III
Magnesium content of 97 Spanish brands of natural mineral waters

Nº	Brand	Spring	Region	Bottle	Magnesium on label	Average magnesium concentrations (mg/L)
1	Agua de Bejis®	Los Cloticos- Bejis	Bejis (Castellón)	Plastic 1500 ml	6.2	7.28 ± 0.29
2	Agua de Beteta®	Fuente del Arca	Beteta (Cuenca)	Plastic 1500 ml	19.2	20.89 ± 0.84
3	Agua de Bronchales®	Bronchales 3	Bronchales (Teruel)	Plastic 2000 ml	3	4 ± 0.16
4	Agua de Chovar®	Fuente Barranco Carbón	Chovar (Castellón)	Plastic 2000 ml	27	30.29 ± 1.21
5	Agua de Cuevas®	Fuente de Cuevas	Aller (Asturias)	Plastic 1500 ml	25.1	20.74 ± 0.83
6	Agua de Sousas®	Sousas II	Verín (Ourense)	Plastic 1500 ml	1.1	1.57 ± 0.06
7	Agua del Rosal®	Agua del Rosal	Calera y Chozas (Toledo)	Plastic 1500 ml	11.1	11.77 ± 0.47
8	Aguadoy®	Aguadoy	Calera y Chozas (Toledo)	Plastic 2000 ml	8.9	11.61 ± 0.46
9	Aguas de Manzanera®	El Salvador	Manzanera (Teruel)	Plastic 5000 ml	131	141.24 ± 5.65
10	Aguasana®	A Granxa/La Granja	Baiona (Pontevedra)	Plastic 1500 ml	0.8	1.45 ± 0.06
11	Aiguaneu®	Aiguaneu	Espilneves (Girona)	Plastic 1500 ml	6.2	4.03 ± 0.16
12	Alzola®	Alzola	Elgoibar (Guipúzcoa)	Plastic 1500 ml	5.3	6.46 ± 0.26
13	Aqua Nevada®	Aqua Nevada	El Tesorillo, Albuñán (Granada)	Plastic 1500 ml	7	7.07 ± 0.28
14	Aquabona Fontoira®	Fontoira	Cospito (Lugo)	Plastic 1500 ml	7.6	7.3 ± 0.29
15	Aquabona Fuen-Mayor®	Fuen-Mayor	Cañizar del Olivar (Teruel)	Plastic 1500 ml	19.4	21.27 ± 0.85
16	Aquabona Santolín®	Santolín	Quintanaurria (Burgos)	Plastic 1500 ml	2.8	3.21 ± 0.13
17	Aquadeus®	Fuente Arquillo	El Robledo (Albacete)	Plastic 1500 ml	27.6	31.36 ± 1.25
18	Aquarel-Las Jaras®	Las Jaras	Herrera del Duque (Badajoz)	Plastic 1500 ml	2.1	2.35 ± 0.09
19	Aquarel-Los Abetos®	Los Abetos	Arbúcies (Girona)	Plastic 1500 ml	4	5.09 ± 0.20
20	Babilafuente®	Antigua Fuente del Caño	Babilafuente (Salamanca)	Glass 1000 ml	6.7	6.5 ± 0.26
21	Belascoaín®	Belascoaín	Belascoaín (Navarra)	Plastic 1500 ml	77.5	73.44 ± 2.94
22	Betelu®	Ama-Iturri	Betelu (Navarra)	Plastic 1500 ml	11.7	15.62 ± 0.62
23	Bezoya Trescasas®	Bezoya Trescasas	Trescasas (Segovia)	Plastic 1500 ml	1.8	1.2 ± 0.05
24	Cabreiroá con gas®	Cabreiroá	Verín (Ourense)	Glass 750 ml	12.8	14.68 ± 0.59
25	Cabreiroá sin gas®	Cabreiroá	Verín (Ourense)	Plastic 1500 ml	5	4.09 ± 0.16

Table III (cont.)
Magnesium content of 97 Spanish brands of natural mineral waters

N ^o	Brand	Spring	Region	Bottle	Magnesium on label	Average magnesium concentrations (mg/L)
26	Calabor [®]	Calabor	Pedralba de la Pradería (Zamora)	Glass 500 ml	0.8	1.08 ± 0.04
27	Caldes de Bohí [®]	Font del Bou	Barruera (Lleida)	Plastic 1500 ml	0.4	0.11 ± 0.01
28	Carrizal II [®]	Carrizal II	Cuadros (León)	Plastic 1500 ml	2	1.91 ± 0.08
29	Corconte [®]	Balneario de Corconte	Soncillo (Burgos)	Plastic 1500 ml	3	2.61 ± 0.10
30	Cortes [®]	Penyagolosa	Cortes de Arenoso (Castellón)	Plastic 1500 ml	5.7	10.97 ± 0.44
31	El Cañal [®]	Cañar	Jaraba (Zaragoza)	Plastic 1500 ml	35.9	36.19 ± 1.45
32	Font del Regàs [®]	Font del Regàs	Arbuices (Girona)	Plastic 8000 ml	3.4	2.51 ± 0.10
33	Font Natura [®]	Font Natura	Loja (Granada)	Plastic 1500 ml	15.7	12.77 ± 0.51
34	Font Nova del Pla [®]	Font Nova del Pla	Aiguamúrcia (Tarragona)	Plastic 1500 ml	36	36.19 ± 1.45
35	Font Sol [®]	Aguas de Sierra	La Font de la Figuera (Valencia)	Plastic 1500 ml	51.4	51.94 ± 2.08
36	Font Vella Sacalm [®]	Font Sacalm	Sant Hilari Sacalm (Girona)	Plastic 5000 ml	9.7	10.5 ± 0.45
37	Font Vella Sigüenza [®]	Sigüenza	Sigüenza (Guadalajara)	Plastic 1500 ml	24.2	27.09 ± 1.08
38	Fontdor [®]	Fontdor	Sant Hilari Sacalm (Girona)	Plastic 5000 ml	3.2	2.82 ± 0.11
39	Fontecabras [®]	Fontecabras	Jaraba (Zaragoza)	Plastic 1500 ml	39.6	38.6 ± 1.54
40	Fontecelta [®]	Fontecelta	Sarriá (Lugo)	Plastic 1500 ml	-	1.3 ± 0.05
41	Fontedoso [®]	Fontedoso	El Oso (Ávila)	Plastic 5000 ml	2.06	1.66 ± 0.07
42	Fonteide [®]	Fonteide	La Orotava (Santa Cruz de Tenerife)	Plastic 500 ml	3.7	4.9 ± 0.20
43	Fontenova con gas [®]	Fontenova	Verín (Ourense)	Glass 1000 ml	-	6.84 ± 0.27
44	Fontenova sin gas [®]	Fontenova	Verín (Ourense)	Glass 1000 ml	-	6.2 ± 0.25
45	Fonter [®]	Fonter	Amer (Girona)	Plastic 1250 ml	7.3	8.01 ± 0.32
46	Fontxesta [®]	Fontxesta	Láncara (Lugo)	Plastic 5000 ml	1.3	1.91 ± 0.08
47	Fuencisla [®]	Fuencisla	Requena (Valencia)	Plastic 1500 ml	27.8	27.62 ± 1.10
48	Fuensanta [®]	Fuensanta de Buyeres	Nava (Asturias)	Plastic 1500 ml	10.4	11.59 ± 0.46
49	Fuente del Val [®]	Fuente del Val 2	Mondariz (Pontevedra)	Plastic 1500 ml	6.3	4.34 ± 0.17
50	Fuente Estrella [®]	Fuente Estrella	Arbúcies (Girona)	Plastic 1500 ml	4.1	3.01 ± 0.12

Table III (cont.)
Magnesium content of 97 Spanish brands of natural mineral waters

Nº	Brand	Spring	Region	Bottle	Magnesium on label	Average magnesium concentrations (mg/L)
51	Fuente Liviana®	Arroyo de la Hoz	Huerta del Marquesado (Cuenca)	Glass 1000 ml	18.3	20.77 ± 0.83
52	Fuente Liviana®	Serranía I	Huerta del Marquesado (Cuenca)	Plastic 2000 ml	17	19.58 ± 0.78
53	Fuente Madre®	Fuente Madre	Los Navalmorales (Toledo)	Plastic 1500 ml	30	30.79 ± 1.23
54	Fuente Primavera®	Fuente Primavera	Requena (Valencia)	Plastic 1500 ml	23.4	23.65 ± 0.95
55	Fuentelajara®	Fuentelajara	Belvis de la Jara (Toledo)	Plastic 5000 ml	18.7	24.44 ± 0.98
56	Fuentes de Lebanza®	La Cueva	Lebanza (Palencia)	Plastic 1500 ml	2.48	3.35 ± 0.13
57	Fuente vera®	Fuente vera	Calera y Chozas (Toledo)	Plastic 5000 ml	3.9	3.95 ± 0.16
58	Insalus®	Insalus	Lizarza (Gipuzkoa)	Plastic 1500 ml	19.3	19.51 ± 0.78
59	La Ideal II®	La Ideal II (El Rapador)	Fingas (Las Palmas)	Glass 750 ml	31.1	34.69 ± 1.39
60	Lanjarón Fonteforte®	Fonteforte	Lanjarón (Granada)	Glass 500 ml	12.3	15.84 ± 0.63
61	Lanjarón Salud®	Salud	Lanjarón (Granada)	Plastic 1500 ml	8.8	10.88 ± 0.44
62	Les Creus®	Les Creus	Maçanet de Cabrenys (Girona)	Glass 1000 ml	8	9.31 ± 0.37
63	Los Escudos®	Montalvo V	Aldeatejada (Salamanca)	Plastic 1500 ml	9.8	10.04 ± 0.40
64	Los Riscos®	Los Riscos de la Higiela	Aburquerque (Badajoz)	Plastic 1500 ml	2.8	2.54 ± 0.10
65	Lunares®	Lunares	Jaraba (Zaragoza)	Plastic 1500 ml	38.1	38.58 ± 1.54
66	Malavella®	Malavella	Caldes de Malavella (Girona)	Glass 750 ml	-	9.04 ± 0.36
67	Manantial Ballanes®	Ballanes	Arbúcies (Girona)	Plastic 50 ml	15.9	12.86 ± 0.51
68	Manantial Fontboix®	Fontboix	Barruera (Lleida)	Plastic 2000 ml	0.7	0.83 ± 0.03
69	Mondariz®	Mondariz IV	Mondariz (Pontevedra)	Plastic 1500 ml	6	5.39 ± 0.22
70	Montepinos®	Montepinos	Almazán (Soria)	Plastic 1500 ml	3.4	3.92 ± 0.16
71	Natura®	Natura	Los Villares (Jaén)	Plastic 1500 ml	17	18.14 ± 0.73
72	Neval®	Neval	Moratalla (Murcia)	Plastic 1500 ml	31.1	41.57 ± 1.66
73	Pascual Nature Camporribles®	Camporribles	Camporribles (Valencia)	Plastic 1500 ml	17.8	17.48 ± 0.70
74	Pascual Nature Los Barrancos®	Los Barrancos	La Ribera de Folgoso (León)	Plastic 1500 ml	14.4	12.06 ± 0.48
75	Peñaclara®	Riva Los Baños	Torreclilla en Cameros (La Rioja)	Plastic 1500 ml	30.6	27.13 ± 1.09

Table III (cont.)

Magnesium content of 97 Spanish brands of natural mineral waters

Nº	Brand	Spring	Region	Bottle	Magnesium on label	Average magnesium concentrations (mg/L)
76	Ribes®	Fontaga	Ribes de Freser (Girona)	Plastic 1500 ml	7	5.91 ± 0.24
77	Rocallaura®	Agua de Rocallaura	Vallbona de les Monges (Lleida)	Plastic 1500 ml	92.7	89.89 ± 3.60
78	San Andrés II®	San Andrés II	Cuadros (León)	Plastic 8000 ml	2	1.77 ± 0.07
79	San Antón II®	San Antón II	Firgas (Las Palmas)	Glass 750 ml	11.2	9.68 ± 0.39
80	San Joaquín®	S. Joaquín de Huemos de Cañedo	Valduniel (Salamanca)	Glass 750 ml	12.3	13.62 ± 0.54
81	San Narciso®	San Narciso	Caldes de Malavella (Girona)	Glass 1000 ml	-	11.02 ± 0.44
82	Sant Aniol®	Sant Aniol	Sant Aniol de Finestres (Girona)	Glass 1000 ml	16.5	17.43 ± 0.70
83	Sierra de Cazorla®	Sierra Cazorla	Villanueva del Arzobispo (Jaén)	Plastic 1500 ml	37.1	42.39 ± 1.70
84	Sierra de Segura®	Fuente Blanca	Villanueva del Arzobispo (Jaén)	Plastic 1500 ml	40.3	36.24 ± 1.45
85	Sierra del Aguila®	La Majuela	Cariñena (Zaragoza)	Plastic 5000 ml	15.1	16.31 ± 0.65
86	Sierra Dúrcal®	Sierra Dúrcal	Dúrcal (Granada)	Glass 500 ml	26	27.03 ± 1.08
87	Sierra Fría®	El Chumacero	Valencia de Alcántara (Cáceres)	Plastic 5000 ml	0.6	0.86 ± 0.03
88	Solán de Cabras®	Fuente de Solán de Cabras	Beteta (Cuenca)	Plastic 1500 ml	25.5	26.8 ± 1.07
89	Solares®	Fuencaliente de Solares	Solares (Cantabria)	Plastic 1500 ml	15.5	15.58 ± 0.62
90	Teleno®	Teleno	Palacios de la Valduerna (León)	Plastic 1500 ml	1.2	1.64 ± 0.07
91	Valtorre®	Valtorre	Belvis de la Jara (Toledo)	Plastic 1500 ml	23.2	17.74 ± 0.71
92	Veri I®	Veri	Bisauri (Huesca)	Plastic 5000 ml	1.5	1.26 ± 0.05
93	Veri V®	Veri V	Castejón de Sos (Huesca)	Plastic 1500 ml	9	8.87 ± 0.35
94	Vichy Catalán®	Vichy Catalán	Caldes de Malavella (Girona)	Glass 1000 ml	-	6.53 ± 0.26
95	Viladrau®	Fontalegre	Viladrau (Girona)	Plastic 1500 ml	4.5	3.06 ± 0.12
96	Vilajuiga®	Vilajuiga	Vilajuiga (Girona)	Glass 1000 ml	44.1	42.05 ± 1.68
97	Vilas del Turbón®	Vilas del Turbón	Vilas del Turbón - Torrelarribera (Huesca)	Glass 750 ml	1.1	1.71 ± 0.07

Data expressed as means + SD.

Table IV
Magnesium content of 12 imported brands of natural mineral waters

<i>N°</i>	<i>Brand</i>	<i>Spring</i>	<i>Region</i>	<i>Country</i>	<i>Bottle</i>	<i>Magnesium on label</i>	<i>Average magnesium concentrations (mg/L)</i>
1	Badoit®	Badoit	Saint Galmier (Loire)	France	Glass 750 ml	85	81.65 ± 3.27
2	Evian®	Cachat	Evian (Haute-Savoie)	France	Plastic 1500 ml	26	31.14 ± 1.25
3	Jouvence de Wattwiller®	Jouvence	Wattwiller (Haute-Rhin)	France	Plastic 1330 ml	11	13.94 ± 0.56
4	Pedras Salgadas®	Pedras Salgadas	Vila Pouca de Aguiar (Trás-os-Montes)	Portugal	Glass 250 ml	24	31.16 ± 1.25
5	Perrier®	Perrier	Vergèze (Gard)	France	Glass 750 ml	6.8	7.25 ± 0.29
6	San Martino®	San Martino	Codrongianos (Sassari)	Italy	Plastic 1000 ml	50	64.67 ± 2.59
7	San Pellegrino®	San Pellegrino	San Pellegrino Terme (Bergamo)	Italy	Glass 1000 ml	52	54.12 ± 2.16
8	Saint Geron®	Gallo romaine	Saint Geron (Haute Loire)	France	Glass 750 ml	53.7	60.37 ± 2.41
9	Ty Nant®	Ty Nant Water	Bethania (Llanon)	United Kingdom	Glass 750 ml	11.5	15.64 ± 0.63
10	Vichy-Célestins®	Célestins	Vichy (Allier)	France	Plastic 1250 ml	10	12.91 ± 0.52
11	Vittel®	Bonne Source	Vittel (Vosges)	France	Plastic 1500 ml	20	23.42 ± 0.94
12	Volvic®	Clairvic	Volvic (Puy de Dôme)	France	Plastic 1500 ml	8	6.14 ± 0.25

Data expressed as means + SD

Table V
Appropriate water intake according to the European Food Safety Agency (EFSA)²⁰

<i>Age</i>	<i>Appropriate intake of water (mL/day)</i>		
	<i>Food*</i>	<i>Water and drinks</i>	<i>Total water</i>
0-6 months	-	-	680
6-12 months	160-200	640-800	800-1000
1 year	220-240	880-960	1120-1180
2-3 years	260	1040	1300
4-8 years	320	1280	1600
<i>Men</i>			
9-13 years	420	1680	2100
> 14 years	500	2000	2500
<i>Women</i>			
9-13 years	380	1520	1900
> 14 years	400	1600	2000
<i>Pregnancy</i>	460	1840	2300
<i>Breastfeeding</i>	540	2160	2700

*The EFSA states that foods contribute approximately 20% of the daily recommendations for water intake; water and other drinks provide the remaining 80%.

Table VI
Distribution of magnesium concentration in public drinking water according to number of regions and inhabitants

Average magnesium concentration (mg/L)	Number of regions (n=108)	Number of inhabitants (n=21.290,707)
< 15	76	16,310,252
15-30	11	1,352,395
30-45	14	2,474,612
> 45	7	1,153,448

Table VIIa
Percentage of daily magnesium recommendations provided by water consumption (0-19 years)

	0-6 months	7-12 months	1-3 years	4-5 years	6-9 years	10-13 years (M)	10-13 years (W)	14-19 years (M)	14-19 years (W)	
Magnesium DRI (mg/day)	40	75	85	120	170	280	250	350	300	
Daily recommended water intake (ml/day)	680	640-800	880-1040	1280	1280	1680	1520	2000	1600	
<i>Percentage of daily magnesium recommendations provided by water consumption</i>										
Average magnesium concentrations (mg/L)	15	25.5	12.8-16	15.5-18.3	16	11.3	9	9.1	8.6	8
	30	51	25.6-32	31-36.7	32	22.6	18	28.2	17.1	16
	45	76.5	38.4-48	46.6-55.1	48	33.9	27	27.4	25.7	24
	60	102	51.2-64	62.1-73.4	64	45.2	36	36.5	34.3	32

Abbreviations: M, men; W, women. *Suitable intake.

Table VIb
Percentage of daily magnesium recommendations provided by water consumption (≥ 20 years)

	20-59 years (M)	20-59 years (W)	60-69 years (M)	60-69 years (W)	≥70 years (M)	≥70 years (W)	Pregnant	Lactating women	
Magnesium DRI (mg/day)	350	300	350	320	350	320	360	360	
Daily recommended water intake (ml/day)	2000	1600	2000	1600	2000	1600	1840	2160	
<i>Percentage of daily magnesium recommendations provided by water consumption</i>									
Average magnesium concentrations (mg/L)	15	8.6	8	8.6	7.5	8.6	7.5	7.7	9
	30	17.1	16	17.1	15	17.1	15	15.3	18
	45	25.7	24	25.7	22.5	25.7	22.5	23	27
	60	34.3	32	34.3	30	34.3	30	30.7	36

Abbreviations: M, men; W,women.

between 12.7 and 35.1 mg/L²⁸; and in Italy, Algeria and north European countries the average content was 12.7 mg (range: 0.01-52.6 mg/L; n=157)²⁹, 120.4 mg/L (range: 21.04 to 341.9 mg/L; n=40)³⁰, and 1.6 mg/L (range: 0.4 to 15.4 mg/L)³¹. According to the information provided by the Spanish health authorities, in Spain the magnesium content of most of the 333 public drinking waters analysed was below 100 mg/L. And only in 4 was it above 200 mg/L

³². It should be pointed out that in our study and in the others mentioned, the magnesium content of water samples was determined at one particular point in time, and that this content may vary considerably over the year.

The mineral content of bottled NMW also varies considerably. In North America³³, magnesium concentrations have been reported to range from 0 to 126 mg/L, while in Europe, in a study of 571 NMWs,

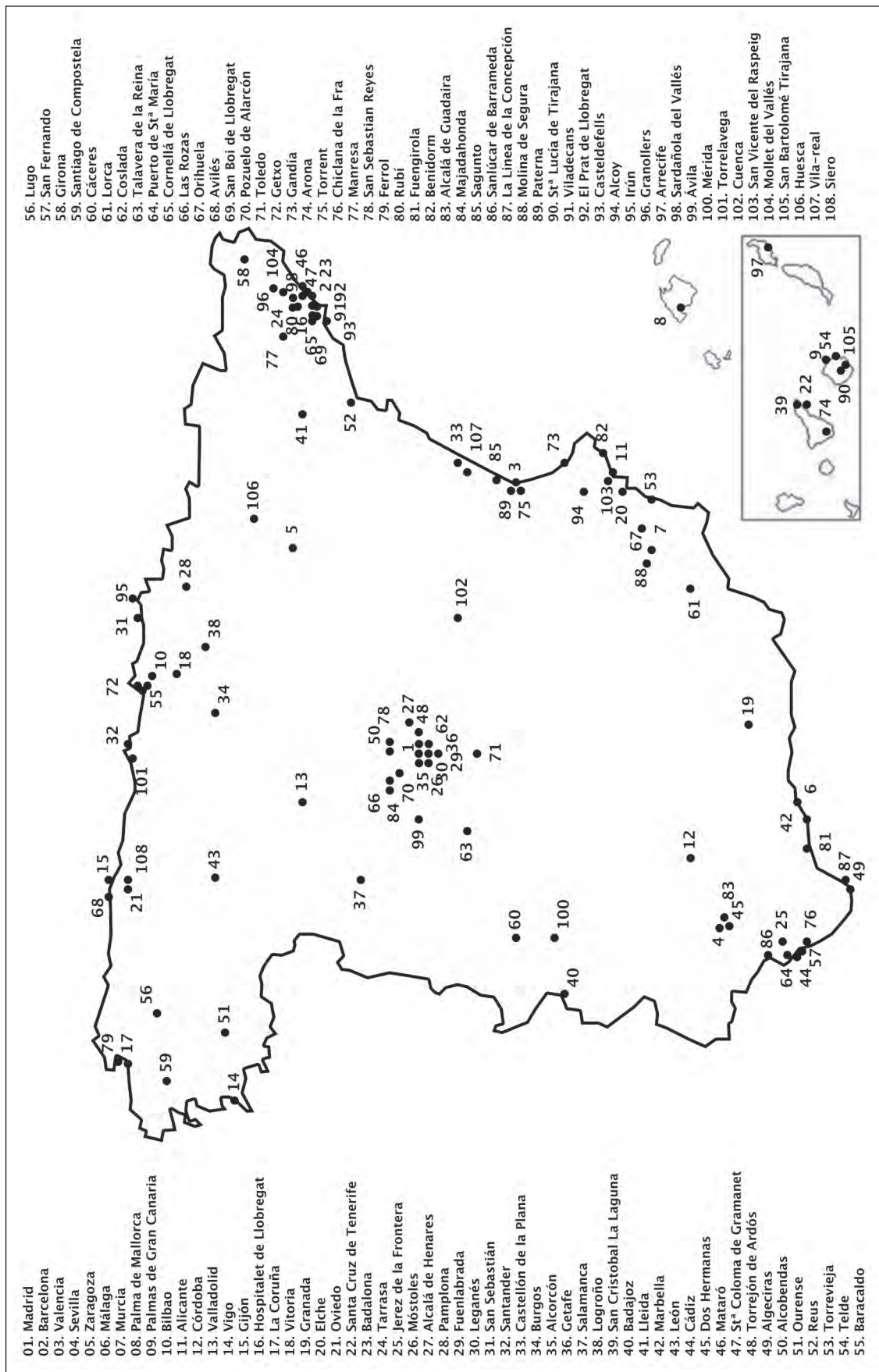


Fig. 1.—Spanish cities from which public drinking waters have been analysed to determine the magnesium content.

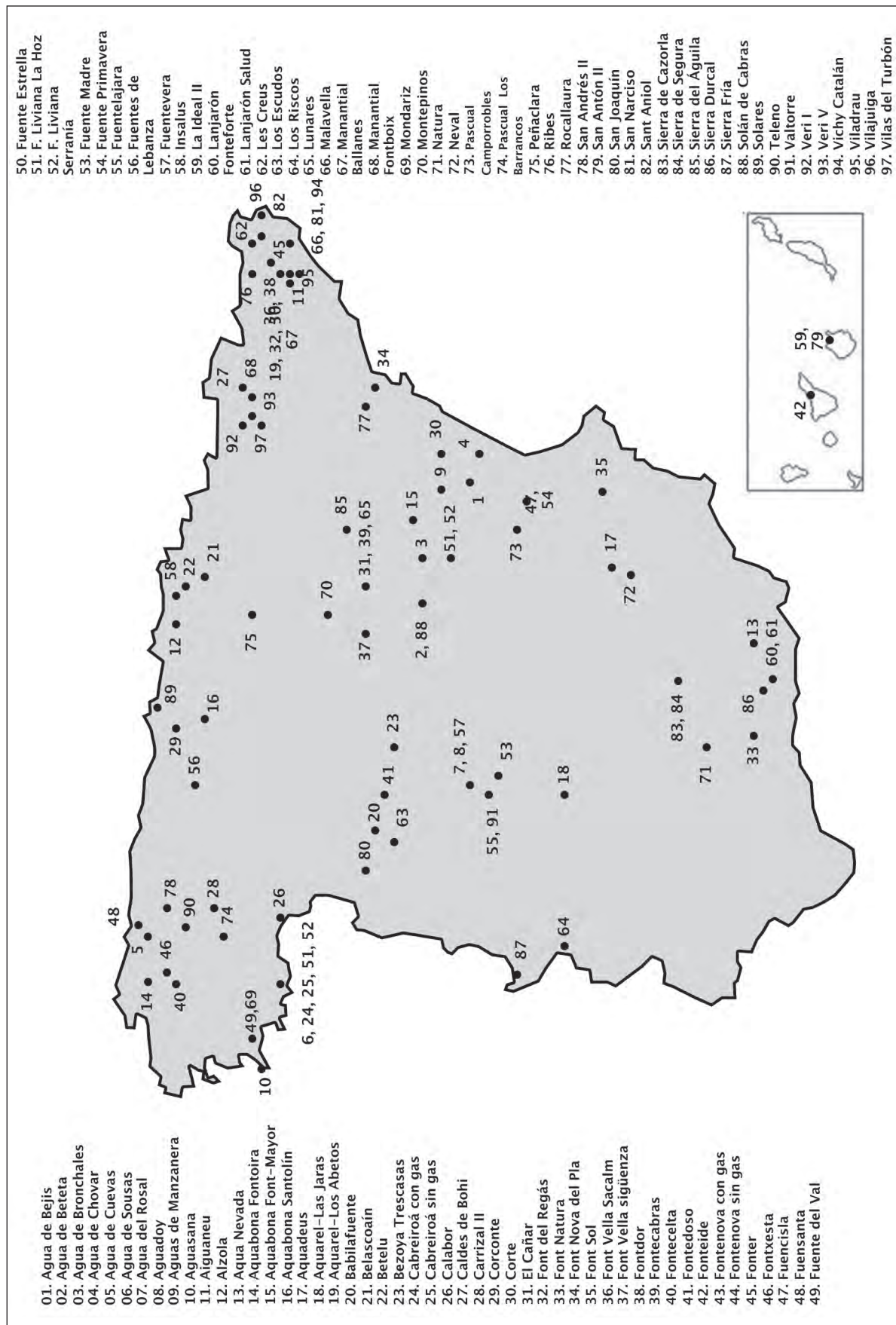


Fig. 2.—Sources of Spanish natural mineral waters.

average values were of 16.4 mg/L, but dispersion was considerable (range: 1.7-350 mg/L)³⁴. In a study carried out in Italy of 178 NMWs, the average magnesium concentrations were somewhat lower (8.4 mg/L; range: 0.26 to 75.7 mg/L)²⁹, although another Italian study of 54 NMW observed a magnesium content of over 100 mg/L in 11 of them³⁵.

The results of the present study show differences in magnesium content within the same country. However, the differences between countries are also considerable. In a broad study of 908 German NMWs, the average magnesium value observed was 21.9 mg/L (range: 0.55-242 mg/L)³⁶, while in NMWs from Nordic countries the average concentration observed was 1.01 mg/L (range: 0.31-30.7 mg/L)³¹. In a study carried out in Turkey³⁷ on 15 NMWs, the average content was 50.2 mg/L (range: 2.3-138 mg/L), while in Portugal³⁸ it was 8.3 mg/L (range: 0.27-37.0 mg/L) and in Slovenia³⁹ 34.9 mg/L (range: 11.7-1000 mg/L; n=16). The present study has also demonstrated that European natural mineral waters in general –and those bottled in France and Italy and consumed in Spain in particular– contain a higher quantity of magnesium than those from Spanish springs.

This article has calculated the extent to which the DRI of magnesium is satisfied by water consumption. This is particularly important in Spain because it has been proved that the Spanish population has a low dietary magnesium intake⁶. This is especially important during pregnancy, when appropriate magnesium intake can protect against eclampsia⁴⁰. The different types of water analysed in this study can provide between 7.5 and 102% of the required magnesium intake, depending on their mineral concentration and the age of the individual. Even water with lower concentrations of magnesium can make a substantial contribution to the diet. Therefore, if health professionals were to recommend mineral water as a part of the diet, magnesium intake would increase and daily dietary recommendations could be met.

The main limitation of our study is that the magnesium content was determined in water samples obtained at one particular point in time and that this content, mainly in PDW, can vary greatly over the year. Although not all the waters from Spain were analysed, those that were are representative of the water supplied to a part of the Spanish population, and the results are a faithful reflection of the amounts of magnesium consumed in drinking water. This study also analysed many of the most widely sold bottled waters on the market.

In conclusion, a third of the PDW from 108 Spanish towns and 36 of 109 NMWs marketed in Spain contain between 15 and 45 mg/L of magnesium. They make a considerable contribution to meeting magnesium needs. Given its bioavailability and usefulness as a healthy form of hydration, drinking water should be considered as a supplementary dietary source of magnesium.

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