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Nutritional contribution in trace elements of bottled water in Morocco

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ABSTRACT

Production and variety of bottled waters in Morocco have experienced an increase in recent years in response to a growing consumption increased. There are now several brands with different labels, packaging and volumes. Our work is focused on the quality of study, specifically the load of trace elements in these waters. The analysis is performed by ICP-MS spectroscopy. All results are discussed according to Moroccan standards and WHO guidelines for assessing the nutritional contribution of the samples studied. The study showed that all waters contain a fairly large amount of Si. Moreover aerated mineral waters are loaded with total trace elements for the geological nature of the area in which they arise. Comparing the abundance of a trace element with respect to the total concentration outside the silicon showed a high variability in the strongly dependent on water composition of the geographic zone in the water sample, This finding was confirmed by the study of the importance of trace elements in relation to the total dissolved ions, Carbonated mineral waters provide more than 24% of trace elements necessary outside of the silicon, As against other waters do not bring more than 0.5% of the necessary contributions.

Keywords: Trace elements, Nutrition, Sources water, Bottled water, carbonated mineral waters, ICP-MS, Morocco.

INTRODUCTION

Trace elements are constituents of the earth's crust to the number 68, whose concentration is each less than 100 ppm; and represent only 0.6% of all chemical elements [1,2]. They participate in biogeochemical cycles. [3]. The accumulation of trace elements in the food chain is one of the most serious consequences of their biological and non-chemical degradation, their concentrations can reach, at the end of these channels, contents of ten times higher than those found in water. [4].

There are about 21 chemical elements which were considered essential for humans: Cl, P, Mo, F, Ca, Mg, Na, K, Fe, Cu, Zn, Mn, B, Cr, Ni, Si, V, I and Cr. [5]. They are available in drinking water, mainly in ionic forms, which considerably improves their absorption by the gastrointestinal tract [6]. Although certain of these elements can not be made in significant amounts through drinking water, they are essential to human health [7].

Among these trace elements, some, called trace elements, are essential for biological activity at reasonable concentrations. [8]. Trace elements which are not synthesized by the body, is essential for its proper functioning. They act in most enzyme systems, metabolism and cellular construction.

Such as vitamins, trace elements are being recommended daily nutritional contribution. They are needed at all ages of life, and needs vary with age, gender, and general health status. [9]. They are provided by food in small quantities, in the microgram (mcg), and they participate in most chemical reactions. Their deficiencies as their excesses have biological and clinical consequences [10, 11]. They are similar to drugs to treat specific pathology.

[12]. Absence or presence of a mass of them may be the main source of failure and disease development in the body, the effect of providing a trace element depends on the amount ingested.

Trace elements have different utilities, depending on whether one is for the animal species or plant species. [13]. For the animal species, the elements such as Cu, Co, Fe, Mn, Ni, Zn, As, Cr, Se and V, are essential to the success of their biological process, whereas the plant species are only essential B, Cu, Co, Fe, Mn, Mo, Ni and Zn. Zinc and Copper, for example, are often added to the diet of animals, particularly in pig farming [2].

Fifteen trace elements are considered "essential" [10,14]. The essential trace elements demonstrated risk of deficiency in humans which are: Iodine, Iron, Copper, Zinc, Selenium, Chromium, Molybdenum and Fluorine. The essential trace elements at low risk of deficiency (unproven in humans) are: Silicon, Cobalt, Nickel, Manganese, Tin, Vanadium and Lithium. [15]. Indeed, an essential element is revealed when its deficiency is objectively reflected by a functional disorder, and when its contribution to physiological doses prevents or cures the disorder [16].

Trace elements are involved in many biological mechanisms and their role is predominant. A simple lack of trace elements is likely to evolve into more or less serious functional disturbances. The action of trace elements in the human body is often targeted, their effect on the growth, biomass production, and the biological activity is positive only if there is an optimum concentration, and this at the appropriate location within the body [4]. Excess micronutrients can cause serious disorders, a balance must be found between excess and defect of these elements in the human body. The oligotherapy is used to prevent or offset a deficit or deficiency, or to achieve a therapeutic effect.

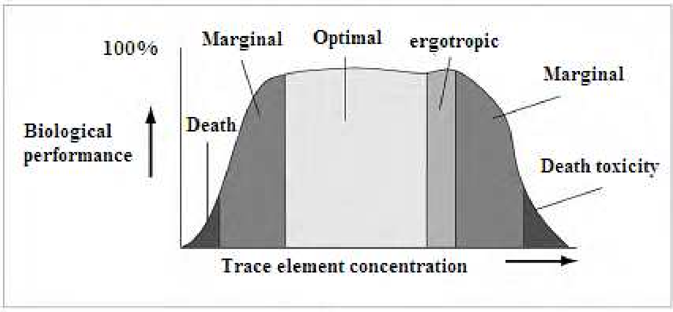

Figure 1: Effect of biological trace element as a function of concentration [12]

The pharmacological effect is the "ergotropic" area, located between the optimum supply and toxic area, shown in Figure 1[12]. In metabolism, the trace element can be stored without being used. Indeed the richest cellular tissues may contain the metal in a form metabolically unusable, which is often the case of bone cellular tissue. Lysing the cells containing storage proteins explains the increase plasma levels of certain micro-elements in said cytolysis syndromes. In the blood are never found trace elements as free ions, but related to various types of carriers. In human blood, the zinc is found in approximately 85% red blood cells; its plasma protein binding is done mainly with serum albumin. It especially distributes in the liver, kidney, muscle, bone, prostate, and the retina [4]. The absorption of trace elements in the body is not complete, and there are several, mechanisms, Iron, for example, provided by food is absorbed as heme iron (10-30% is absorbed) and non-heme (1-5% is absorbed).

Zinc absorption takes place along the small intestine by a mechanism mediated by a factor, its bioavailability is much more important for the aqueous solutions and drinking water for solid meal [17]. Zinc absorbed is carried by the blood via the serum proteins mainly albumin (65%) and other (35%) and the total mass of zinc in the body is distributed mainly in 2g of the circulatory system, body tissues such as the liver, bones, and kidneys.

Food copper is mainly absorbed from the stomach and duodenum of the gastrointestinal tract. In the bloodstream, the copper is in the red cells bound to a specific cupro-protein 98% and 2% by serum albumin.

Selenium is metabolised to an intermediate selenide before borrowing other metabolic pathways. It is then transported in the plasma where it binds selectively with albumin and is transferred to the liver where it is methylated and then excreted in urine for high doses.

Nickel uses the same distribution channels within the body than the iron and calcium or replaces the Zinc. Lithium is completely absorbed from the upper gastrointestinal is distributed throughout the total body water and does not bind to serum proteins.

The absorption of manganese is in the small intestine by an active mechanism and influenced by a large number of dietary factors. In the case of low doses, the bioavailability of this element is enhanced by the presence of ascorbic acid and a meat diet, whereas it is inhibited by certain sources of dietary fiber, 25% of the total load of Manganese is retained in the skeleton and the rest accumulates in tissues rich in mitochondria and endoplasmic reticule [18].
Water being the most consumed food in quantity by a human being. A standard adult man absorbs 2.5 liters [19,20] to 3 liters of water per day in various forms [21]. Half of this amount consists of drinking water, so it could reach an average of 1.5 liters per day is 547 liters a year, and even a large quantity in people who undergo some plans. [22]. Infants aged 0 to 1, and the weight of the milk beverage ingested by 24 hours is one sixth to one tenth of the body weight increased by 300 g [23]. The average consumption of 1 liter of water per day, or 365 liters in the first year of life [22]. The adequate fluid intake varies from 100-190 mL/kg per day for infants in the first half of the first year of life, through 800-1000 mL/day from six months to reach 2.5 liters per day for an adult [24].

Some trace elements present in ionic form in the water are both absorbed and utilized by the body only when food or drug induced. Ions dissolved in water are generally more easily absorbed by the intestine [6]. It has long been known that trace elements in drinking water can have adverse or beneficial effects on human health depending on their concentration [25]. Bottled water is considered by the consumer as pure, intact and rich in trace elements and minerals needed for good health. Generally, only the major elements are shown on the bottle labels, the concentrations of the trace elements are ignored. Some trace elements are quite stable in water, others, especially in mineral waters, is complexed to the light or exposure to air making their limited absorption. This explains why the mineral water consumed locally at a much more effective action than bottled water.

Moroccan law distinguishes three types of bottled water:
• Table water (ET) which is a drinking water of any origin that meets health standards,
• Sources water (ES) that satisfies the standards and was bottling without undergoing any chemical treatment,
• Natural mineral water (EM) which has, in addition to source of water, therapeutic properties. Some of these mineral waters are naturally stored gas concentrations, and fall under the qualification carbonated natural mineral waters (CMW).
• Natural mineral water or natural waters of medical interest according to law 10-95 on water must meet the conditions for this label [25]. Mineral water from deep sources is bottled charged ionic particles in the most stable state.

Hydrochemical facies different bottled waters are dominant in Morocco with chloride sodium and potassium for table waters. The mineral and spring waters have a rather facies bicarbonate calcium or sodium bicarbonate. The chemistry of mineral waters and source can be completely connected to the geological nature that traverses these waters and local tectonic conditions allowing the lift gas and deep source fluid [27].

For deep thermal waters, previous studies of water withdrawn directly to sources well highlighted the richness of these waters with dissolved ions [28,29].

Other studies have focused on changes in trace elements in bottled water in different countries. [30,31]. Other studies have raised the health impacts including toxic elements found in some bottled waters [32,33].

In Morocco, the consumption of bottled water has quadrupled over the past ten years and this trend tends to continue [27]. This study will examine the relationship between trace elements concentration in bottled water in Morocco with the type of chemistry of various waters. The calculation of the dietary intake of trace elements, following optimal water consumption placed on the Moroccan market will be determined taking into account the guidance on safe drinking water. This work will be complemented by a study of the role of the different trace elements and their possible toxicity of the analyzed waters.

MATERIALS AND METHODS

Different water samples (sixteen 50 cL bottles) were purchased in a supermarket according to the recommendations of reference [34], the study has taken different bottle types listed in Table 1. There are five waters natural mineral (EM1, EM2, EM3, EM4, EM5), a carbonated natural mineral water EMG, a natural mineral water carbonated EMGF, light carbonated natural mineral water (EMGL), three water sources (ES1, ES2, ES3) four table water (ET1, ET2, ET3, ET4) and carbonated table water (ETGF).

Table 1: Analytical indicators studied waters

Samp,	Elements (mg/L) Ca^{2+}	Mg^{2+}	K^+	Na^+	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-	TDS	Type of water
EM_1	56.07	43.64	0.5	16.6	366	53.25	3.8	7	351	Ca-Mg-HCO_3-Cl
EM_{1GF}	70.49	45.07	0.5	15.1	368	55	3.8	7	341	Mg-Ca-HCO_3
EM_2	16.02	7.67	2.3	22.6	73.2	21.3	41.7	0.1	200	Na-Ca-Mg-HCO_3-SO_4
EM_3	69.68	37.87	2.4	148	341.6	246.72	20	4	680	Na-Ca-Mg-Cl-HCO_3
EM_4	19.22	9.1	5.6	34.2	170.8	17.75	7.85	3.81	231	Na-Ca-Mg-HCO_3
EM_5	76.9	33.06	0.7	2.4	402.6	15.97	5.13	5.18	314	Ca-Mg-HCO_3
EM_G	108.21	57.39	21.5	267.2	744.2	301.75	11.22	4.96	1406	Na-Ca-Mg-HCO_3-Cl
EM_{GL}	102.53	58.24	21.4	267.2	854	291.1	11.22	4.96	1358	Na-Ca-Mg-HCO_3-Cl
ES_1	76.1	46.5	0.7	3.4	442.25	17.75	3.7	19	363	Mg-Ca-HCO_3
ES_2	82.1	15.3	0.5	10.2	315	21	20.9	0.32	283	Ca-Mg-HCO_3
ES_3	23.23	6.46	1	10.6	100.65	7.98	12.5	0.5	114	Ca-Mg-Na-HCO_3
ET_1	6.41	3.83	1.1	61.4	42.7	92.3	15.69	0.2	140	Na-Cl-HCO_3
ET_2	11.21	4.31	0.4	30.2	65	31.95	19	2.4	88	Na-Ca-HCO_3-Cl
ET_3	16.02	9.58	0.8	45.8	54.9	82.53	20.55	3.49	187	Na-Ca-Mg-Cl-HCO_3
ET_4	14.42	7.67	0.2	9.6	30.5	35.5	12	1.5	158	Ca-Mg-Na-Cl-HCO_3
ET_{GF}	50.46	10.04	1.1	48.6	268.4	49.7	10.3	2	536	Ca-HCO_3-Cl

The major elements (Table 1) were the subject of a preliminary work to determine their potability characteristics and chemical facies [27].

The analysis of eleven trace elements was done by ICP-MS model iCAP Q ThermoScientific Laboratory Hydro - Science in Montpellier. International certified reference material and water standards for trace elements were used in the framework of the quality control procedure.

RESULTS AND DISCUSSION

The results obtained by ICP-MS analysis of trace elements are reported in Table 2. Note that the levels measured are all lower than the maximum levels of potability different international standards. Only the amount of manganese slightly exceeds international standards for carbonated mineral water while respecting Moroccan standard. The amount of silicon measured in mineral waters and those sources is large and the silicon can be considered a major factor in those waters. It is of the order of a few milligrams per liter.

Table 2: Concentrations of trace elements (in mg/L) in bottled water in Morocco

	Cr (µg/L)	Co (µg/L)	Cu (µg/L)	Fe (µg/L)	Li (µg/L)	Mn (µg/L)	Mo (µg/L)	Si (µg/L)	Zn (µg/L)	V (µg/L)	Ni (µg/L)
EM1	0.318	0.013	0.082	0.398	0.51	0.069	0.083	3128	0.347	1.101	<LOD
EM1GF	0.396	0.058	0.364	0.778	0.64	0.096	0.084	2690	0.421	0.952	0.010
EM2	0.035	0.003	0.562	0.203	76.54	0.054	0.727	20581	6.087	2.203	0.654
EM3	0.344	0.004	0.104	0.498	87.81	0.037	0.531	5665	0.383	1.351	0.020
EM4	0.119	0.003	0.030	0.197	25.98	0.011	2.513	19531	0.207	14.78	<LOD
EM5	0.688	0.010	0.119	0.134	0.313	0.002	0.115	10840	0.968	1.243	0.098
EMG	0.035	0.020	2.019	2.141	4241.90	501.800	0.055	81094	5.422	0.019	1.742
EMGL	0.024	0.033	11.76	5.218	4281.90	470.600	0.065	80617	16.66	0.034	8.708
ES1	0.155	0.019	0.283	0.939	0.46	0.034	0.074	2744	0.773	0.751	0.179
ES2	0.046	0.007	0.052	0.440	1.62	1.143	0.236	4542	3.010	0.134	<LOD
ES3	0.036	0.024	0.026	0.250	0.43	21.600	0.024	4025	1.965	0.105	0.054
ET1	0.088	0.007	0.016	0.581	2.76	0.026	0.143	816	0.308	0.213	0.060
ET2	0.411	0.004	0.192	0.268	0.53	0.034	0.013	<LOD	0.429	0.010	0.117
ET3	0.037	0.010	0.345	8.215	3.39	0.161	0.193	573	0.929	0.388	0.072
ET4	0.659	0.010	0.273	0.075	0.87	0.073	0.025	<LOD	4.727	0.021	0.433
ETGF	0.081	0.090	1.325	1.204	4.86	0.254	0.837	4236	2.300	1.815	0.234
*** OMS**	50		2000	--		400	70		3000	--	70
**** US-EPA**	100		1300	300		--	--		5000	--	--
***** MN**	50		2000	300		500	--		3000	--	20

** WHO: [17] and US-EPA **; U, S, Environmental Protection Agency and *** NM; Moroccan standard [35];*

Figure 2 shows the wide variation in load trace elements different waters. Carbonated mineral water (EMG, EMGL) are the richest in trace elements followed distantly by mineral waters EM2, EM4 and EM5. Carbonated mineral waters being hydrothermal water, they are loaded much more easily trace elements due to the chemical alteration of the basic magmatic rocks [36]. This chemical alteration occurs through chemical reactions mainly water or fluid-rock, responsible for the release of trace elements [37,38]. Indeed, these carbonated mineral waters are from plateau Oulmes, a batholith with a strong halo of metamorphism, which marked the sedimentary host rocks several hundred meters thick. At these courses are supplemented by basic volcanic formations under-saturated, composed of nephelinites, phonolites and murites [39].

Mineral waters, which show a high TDS, also contain significant quantities of trace elements. In contrast, sources water, show a much lower amount of trace elements, which justifies the non-designation of these waters as waters with therapeutic effect. For water tables, which come from the drinking water distribution networks with advanced treatments, micronutrient content is very low. The water consumed Morocco tap water is predominantly after the surface network, which leads to a weak interaction with the rock and therefore a lower mineralization.

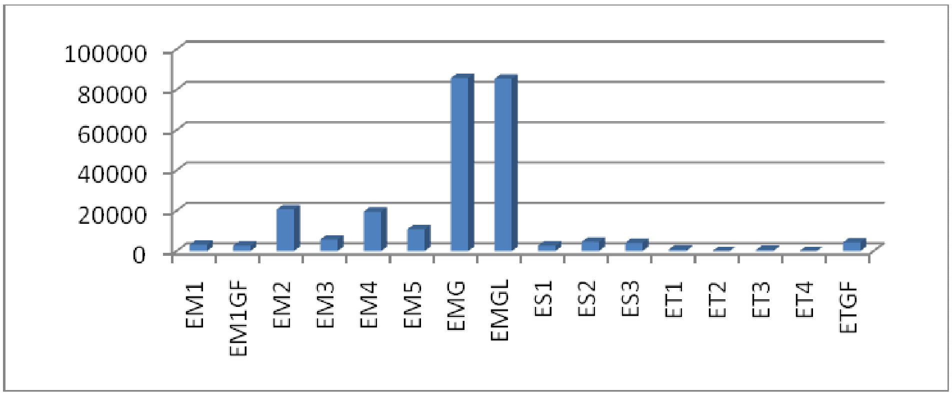

Figure 2: Total concentration of trace elements (µg/L)

The note (Table 2) that the silicon is the controlling factor in most waters (between 0.944 and 0.999 wt trace elements measured) except ET2 and ET4 table waters where if is not detected. The filtration system used in the bottling process of these waters and the ET1 and ET3 waters may explain the absence or presence of any silicon in these waters.

Silicon is the most abundant trace element in the waters studied; it is in the form of silicic acid monomer SiO_4H_4. Silicic acid contained in drinking water and in beer has a protective effect against oxidation induced by aluminum [40]. A sufficient intake of silica in drinking water lowers the risk of Alzheimer's disease linked to aluminum [41].
At low concentrations at neutral or acid pH, the silica is in the form of a true solution [42]. The solubility can reach 0.14 g/L at 25°C. It is the most abundant component in groundwater, due to the erosion of rocks and minerals, compared to surface water. Dissolved silica has no known harmful effects to humans.

Water of sources and mineral water EM1 did not show a significant presence of trace elements. The content of trace elements of water tables can be considered negligible. Apart carbonated mineral water, trace elements, by not taking into account the Silicon, in whole do not exceed 100 µg/L.

The percentage contribution of each of the trace element according to the total concentration of the analyzed trace elements (excluding silicon) is given in Figure 3. This comparison shows a high variability in the composition of water, but water from the mineral the same geographical area show a relatively close distribution of trace elements. The gasification process of mineral water EM1, alters little distribution of trace elements.

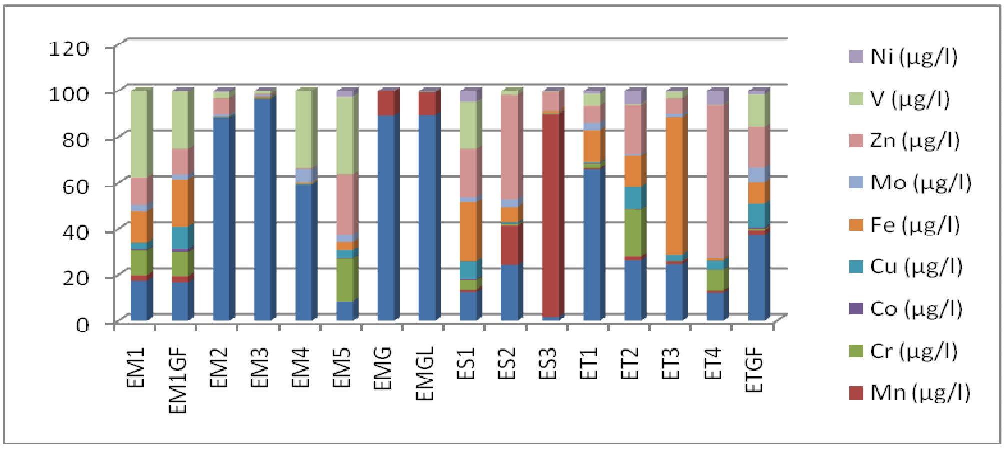

Figure 3: Values in% relative to the total concentration of trace elements excluding silicon; ([Xi] / Sum ([Xi] - [Si]) * 100)

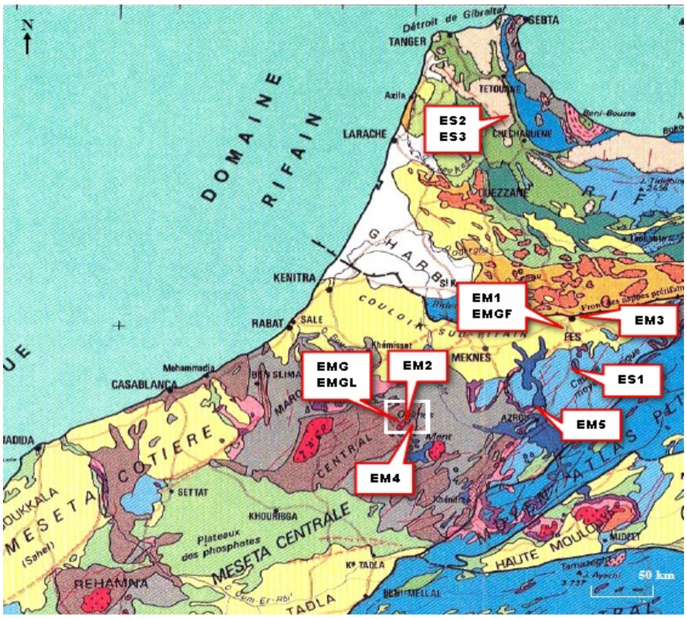

Figure 4: The geological situation of the main sources of bottled water in Morocco [43]

The most abundant element after silicon in carbonated mineral water is the Lithium for 6 of the analyzed waters. This element also appears predominant in mineral water (EM2, EM3, EM4 and EM5) and table water ET1. These mineral waters are from the same area as where were taken carbonated mineral waters (Middle Atlas) (Figure 4). The ET1 table water is bottled by the same company that the waters EM2 and EMG, which suggests an origin of water in common area, explaining the large concentration of Lithium in ET1. Manganese is the most important element in water source ES3 representing almost 90% of these trace elements, Zinc for water table ET4 (70%) and Fe for table water ET3 (60%). Water EM5 allows a contribution of the same size of the transition elements (Cr, V and Zn).

Nutrient intake of trace elements

The daily need of major elements of the mg to g / day, while the trace elements are needed in doses of the order of micrograms /day [44]. The World Health Organization (WHO) has adopted rules setting maximum concentrations of metallic elements in drinking water to avoid the risk of poisoning. These guidelines are intended for use by national authorities as a basis for the establishment of national standards for drinking water. The concentrations of trace elements in drinking water may be on the order of the necessary daily needs, but sometimes higher.

Table 3: Daily intake (in µg/L) by the consumption of bottled water in Morocco on the basis of 1.5 L/day

	Si (mg/l)	Li (µg/l)	Mn (µg/l)	Cr (µg/l)	Co (µg/l)	Cu (µg/l)	Fe (µg/l)	Mo (µg/l)	Zn (µg/l)	V (µg/l)	Ni (µg/l)
* (µg)		11.6	20	2.69	0.18	20		0.54	0.02		9.05
** (mg/Kg)			0.2	0.02	0.02	1	60	0.1	33	0.3	0.1
EM1	4.69	0.77	0.1	0.48	0.02	0.12	0.6	0.12	0.52	1.65	0
EM1GF	4.03	0.96	0.14	0.59	0.09	0.55	1.17	0.13	0.63	1.43	0.02
EM2	30.87	114.81	0.08	0.05	0	0.84	0.3	1.09	9.13	3.30	0.98
EM3	8.49	131.72	0.06	0.52	0.01	0.16	0.75	0.80	0.57	2.03	0.03
EM4	29.29	38.97	0.02	0.18	0	0.05	0.3	3.77	0.31	22.17	0
EM5	16.26	0.47	0	1.03	0.02	0.18	0.2	0.17	1.45	1.86	0.15
EMG	121.64	6362.85	752.7	0.05	0.03	3.03	3.21	0.08	8.13	0.03	2.61
EMGL	120.92	6422.85	705.9	0.04	0.05	17.64	7.83	0.1	24.99	0.05	13.06
ES1	4.11	0.69	0.05	0.23	0.03	0.42	1.41	0.11	1.16	1.13	0.27
ES2	6.81	2.43	1.71	0.07	0.01	0.08	0.66	0.35	4.52	0.2	0
ES3	6.03	0.65	32.4	0.05	0.04	0.04	0.38	0.04	2.95	0.16	0.08
ET1	1.22	4.14	0.04	0.13	0.01	0.02	0.87	0.21	0.46	0.32	0.09
ET2	0	0.8	0.05	0.62	0.01	0.29	0.4	0.02	0.64	0.02	0.18
ET3	0.86	5.09	0.24	0.06	0.02	0.52	12.32	0.29	1.39	0.58	0.11
ET4	0	1.31	0.11	0.99	0.02	0.41	0.11	0.04	7.09	0.03	0.65
ETGF	6.35	7.29	0.38	0.12	0.14	1.99	1.81	1.26	3.45	2.72	0.35

** Estimated Daily Intake of some trace elements in water for adults (µg) [44].*
*** Amount (mg/Kg) trace elements in the human body [45-47].*

A standard adult man absorbs a maximum of 1.5 liters per day in the form of drinking water [21]. Knowledge of the contents of trace elements bottled water in Morocco and allows the consumer to know the quantity absorbed in liquid form on the basis of 1.5 l / day (Table 3) and% from the estimated daily needs. (Table4). Note that the amount of silicon available is very important in mineral water, water of sources and carbonated table.

Lithium is present in large quantities in mineral water (EM2, EM3, EM4) and carbonated mineral waters that bring more than recommended amounts. As for molybdenum, it is provided in sufficient quantity in the case of mineral water EM1, EM2 and carbonated water table. Carbonated mineral waters are rich in nickel. For zinc, the contribution is more than the daily amount recommended for all bottled water in Morocco.

Table 4: Percentage of trace element introduced by the consumption of bottled water (Percentage consumption to 1.5 L/day) compared to estimated needs

	Si (%)	Li (%)	Mn (%)	Cr (%)	Co (%)	Cu (%)	Fe (%)	Mo (%)	Zn (%)	V (%)	Ni (%)
* (mg/day)	5	0.5	3	0.056	0.1	2	9	0.15	12	0.02	0.075
EM1	93.8	0.15	0.003	0.734	0.02	0.006	0.007	0.083	0.004	8.258	0
EM1GF	80.7	0.19	0.005	0.914	14.5	0.027	0.013	0.084	0.005	7.140	0.020
EM2	617.4	22.96	0.003	0.081	0.75	0.042	0.003	0.727	0.076	16.523	1.308
EM3	169.9	26.34	0.002	0.794	1.00	0.008	0.008	0.531	0.005	10.133	0.04
EM4	585.9	7.79	0.001	0.275	0.75	0.002	0.003	2.513	0.003	110.850	0
EM5	325.2	0.09	0	1.588	2.5	0.009	0.002	0.115	0.012	9.323	0.196
EMG	2432.8	1272.6	25.09	0.081	5.00	0.151	0.036	0.055	0.068	0.143	3.484
EMGL	2418.5	1284.6	23.53	0.055	8.25	0.882	0.087	0.065	0.208	0.255	17.416
ES1	82.3	0.14	0.002	0.358	4.75	0.021	0.016	0.074	0.010	5.633	0.358
ES2	136.2	0.49	0.057	0.106	1.75	0.004	0.007	0.236	0.038	1.005	0
ES3	120.7	0.13	1.080	0.083	6.00	0.002	0.004	0.024	0.025	0.788	0.108
ET1	24.4	0.83	0.001	0.203	1.75	0.001	0.010	0.143	0.004	1.598	0.120
ET2	0	0.16	0.002	0.948	1.00	0.014	0.004	0.013	0.005	0.075	0.234
ET3	17.2	1.02	0.008	0.085	2.50	0.026	0.137	0.193	0.012	2.910	0.144
ET4	0	0.26	0.003	0.734	2.50	0.020	0.001	0.025	0.059	0.158	0.866
ETGF	127.1	1.46	0.005	0.914	22.50	0.099	0.020	0.837	0.029	13.613	0.468

**Recommended dietary allowances per day in milligrams [9].*

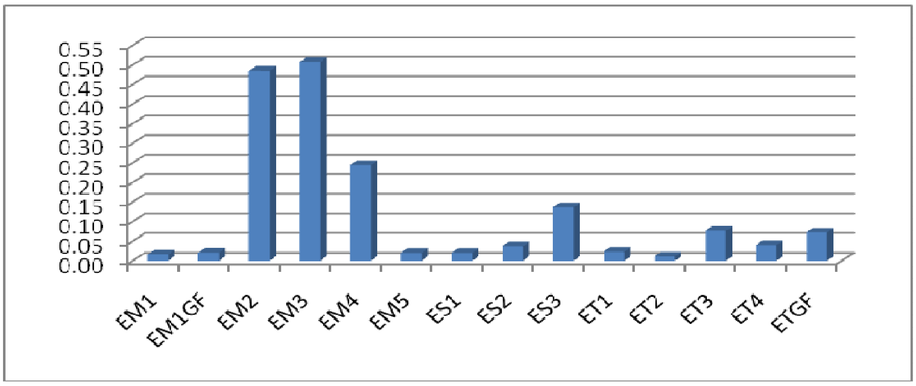

Figure 5: Percentage intakes by total trace elements. (Excluding silicon and carbonated mineral waters)

To all studied trace elements, carbonated mineral waters provide more than 24% of trace elements necessary outside of the silicon. As against other waters (Figure 5) that adduces no more than 0.5% of the necessary contributions. The most important contributions concerning mineral waters: EM2, EM3 and EM4.

The intake of carbonated mineral waters Manganese is important; this trace element is known for its excellent bioavailability.

Table 5: Importance of trace elements in relation to the total dissolved ions

	Total Trace elements µg	TDS mg	Total / TDS %	(Total-Si) / TDS (en ppm du résidu solide)
EM1	3130.92	480	0.89	6.09
EM1GF	2693.80	481	0.79	7.89
EM2	20668.07	161	10.33	539.30
EM3	5756.08	676	0.85	134.68
EM4	19574.84	233	8.47	188.54
EM5	10843.69	490	3.45	7.53
EMG	85849.15	1274	6.11	3732.72
EMGL	85412.00	1386	6.29	3458.84
ES1	2747.67	539	0.76	6.80
ES2	4548.69	402	1.61	16.63
ES3	4049.51	121	3.55	202.38
ET1	820.20	136	0.59	30.79
ET2	2.01	146	0.00	13.80
ET3	586.74	158	0.31	86.97
ET4	7.17	75	0.00	94.98
ETGF	4249.00	536	0.79	24.23

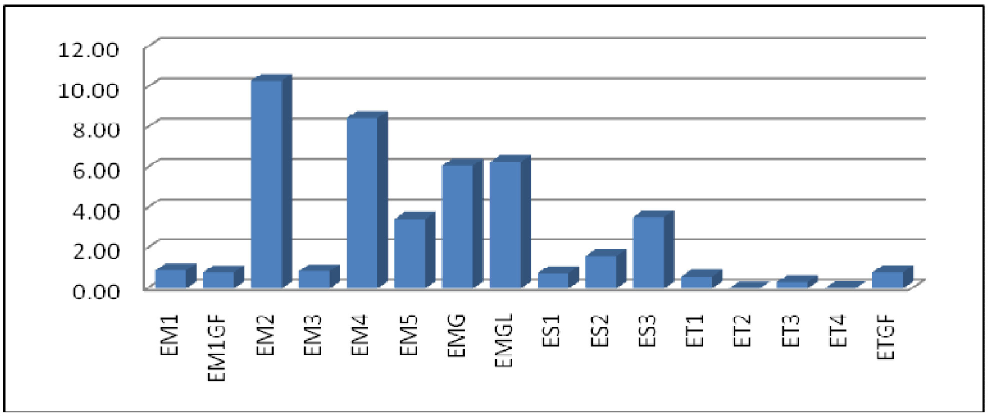

Figure 6: The importance of trace elements in relation to the total dissolved ions (%)

Trace elements present in water are among the solid residues when the water is evaporated. Table 5 shows the proportion of trace elements based on the total ions dissolved in water. Note that, in mineral waters: EM2, EM4 and EM5 and carbonated mineral waters: EMG and EMGL and in water of sources: ES3, trace elements ions represent more than 3% of dissolved salts (Figure 6). It may be noted that this water originates from the same geographical area

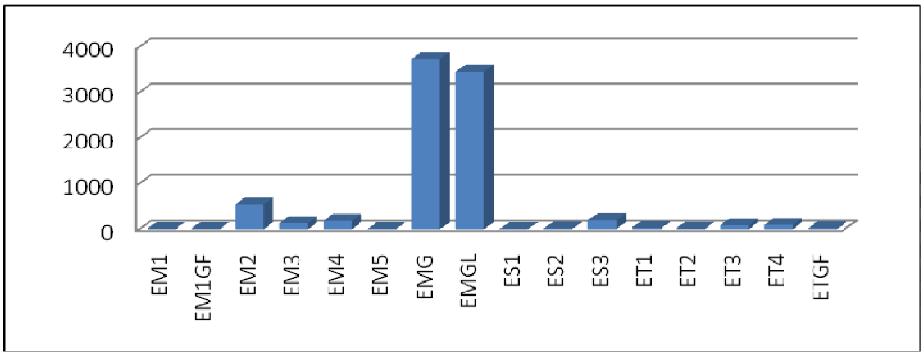

Figure 7: Importance of trace elements outside the Si relative to total dissolved ions (ppm of the total solid residue)

CONCLUSION

If one does not consider the silicon content present in the waters, other trace elements are only a few ppm of solid waste. (Figure7). Deep mineral waters EMG, EMGL, EM2, EM4 are the richest. Water of sources: ES3 is relatively rich in trace elements.

Food security at the individual, household, national, regional and global is effective when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and preferences food to lead healthy and active lives [48].

The nutritional quality is available at two levels: first, the diversity and the nutritional balance of the diet in terms of nutrient components (Carbohydrates, lipids and proteins), vitamins and trace elements, and secondly, standards and food hygiene.

The nutritional contribution of food, especially trace elements is the essence of nutritional quality. Water is the most food consumed by humans, and trace elements provided by the water are more easily absorbed by the body.

The trend of the consumption of bottled water is growing, including mineralized and spring waters, it is important to know the percentage of trace elements and thus control inputs to prevent deficiencies or excesses.

The overall content of trace elements in Bottled Water in Morocco does not depend on the classification of waters (Mineral water, sources water and table water). The predominant parameter in the concentration and the predominance of trace elements is related to the geographic area, so local geological conditions, where water is removed.

As for the nutritional contribution of water studied, compared to the estimated daily intake required in adults, few waters exceed this quantity, especially for Zinc and Lithium. But this excess is not observed with respect to nutritional contribution trace elements recommended daily. The absolute overshoot is marked as the silicon in mineral waters and aerated and the lithium in the case of sparkling mineral waters.

Those are the mineral waters: EM2, EM4 and EM5 qualified therapeutic effect to contain the most trace elements. Conversely, mineral water EM1 is not particularly rich in trace elements, and there are sources waters and table waters that are much richer of the trace elements.

Apart from silicon, plasters or aerated water will provide about 0.5% by recommended amount of trace elements. Only mineral water EM2, EM3 and EM4 and ES3 spring water provide significantly trace elements.

These results were confirmed by studying the mass importance of trace elements in relation to the total dissolved ions recovered as solid residue (TDS).

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