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Classification and Evaluation of Commercial Bottled Drinking Water in Tirana, Albania

Sonila Duka, *Loreta Vallja, Alma Shehu, Nevila Broli, Majlinda Vasjari*
University of Tirana, Faculty of Natural Sciences, Department of Chemistry, Tirana
e-mail: sonila.duka@fshn.edu.al; soniladuka@hotmail.com

Demand for bottled water registered a significant increase due to the growing population and concern about contaminants in natural water supplies. Due to an increasing demand, several new brands have been introduced in the market.

21 bottle water samples were collected over a 4-month period in 2017 in different markets in Tirana capital.

- Physico-chemical determinations on the water samples were carried out through standard methodologies of the American Public Health Association APHA (2005).
- pH and conductivity were measured using Multi/Parameter Meter (5465015-ION 156). Spectrophotometric determinations for the study were carried out with a UV-VIS Spectrophotometer, SHIMADZU 2401.
- A reference sample of fresh water QC3198 SIGMA-ALDRICH was analysed for the purpose of validating data obtained. Each parameter was determined in triplicate and the average of three values was recorded.
- The purpose of this study was to investigate almost all the physico-chemical characteristic of the most consumable and very high sales brands between other bottled mineral waters in the capital of Albania, compared them with parameters printed on their labels and estimation of DRI of Ca^{2+} and Mg^{2+} as the most recommended parameter established by nutritional experts recently.

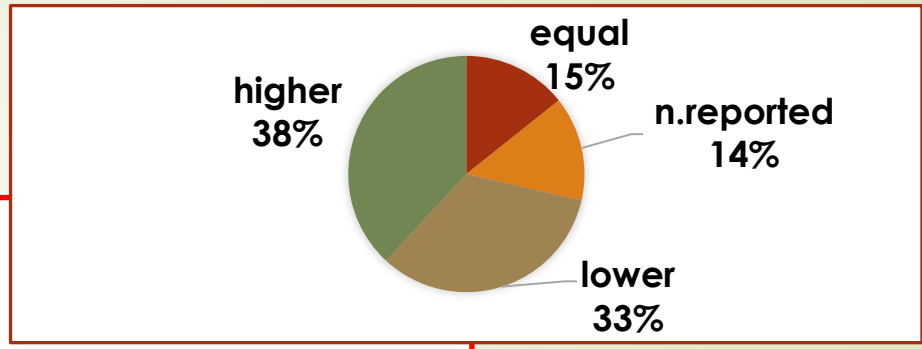
Internationals standards **WHO** - World Health Organization and **IBWA** - International Bottled Water Association for quality of bottled drinking water

Parameter	Unit	WHO (2008) drinking water	IBWA (2004) Bottled water
pH	-	6.5-9.5	6.5-8.5
Conductivity	µS/cm	1000	1000
TDS	mg/L	500	500
Alkalinity	mg $CaCO_3$/L	200	200
Hardness	mg $CaCO_3$/L	200	200
Ca^{2+}	mg/L	100	100
Mg^{2+}	mg/L	30	30
NO_3-N	mg/L	11.3	10
SO_4	mg/L	250	250
Cl^-	mg/L	250	250

Bottles water samples	pH values
Lajthiza	7.51
Tepelena	7.44
Trebeshina	7.51
Qafshtama	7.8
Sophie	7.6
Fab	8.07
Oro	7.4
Dukati	7.64
Naturel	7.9
Qafë Mali	7.23
Spring	7.2
Acqua Julia	7.99
Mon Cheri	7.6
Alba	7.21
Sant' Anna	7.04
Vera	7.4
Levvisima	7.65
Evian	7.1
Acqua Panna	8.03
Korpi	7.58
San Benedetto	7.82

Slightly alkaline water is preferable as heavy metals are removed by carbonate or bicarbonate precipitates. The lowest pH value (7.04) was found in Sant Anna brand, while the highest value (8.07) was recorded in Fab brand.

The pH variations in the studied brands are related to HCO_3 concentration, which is the most abundant ion. Recommended pH values for drinking water according to local and international standards are 6.5 to 8.5.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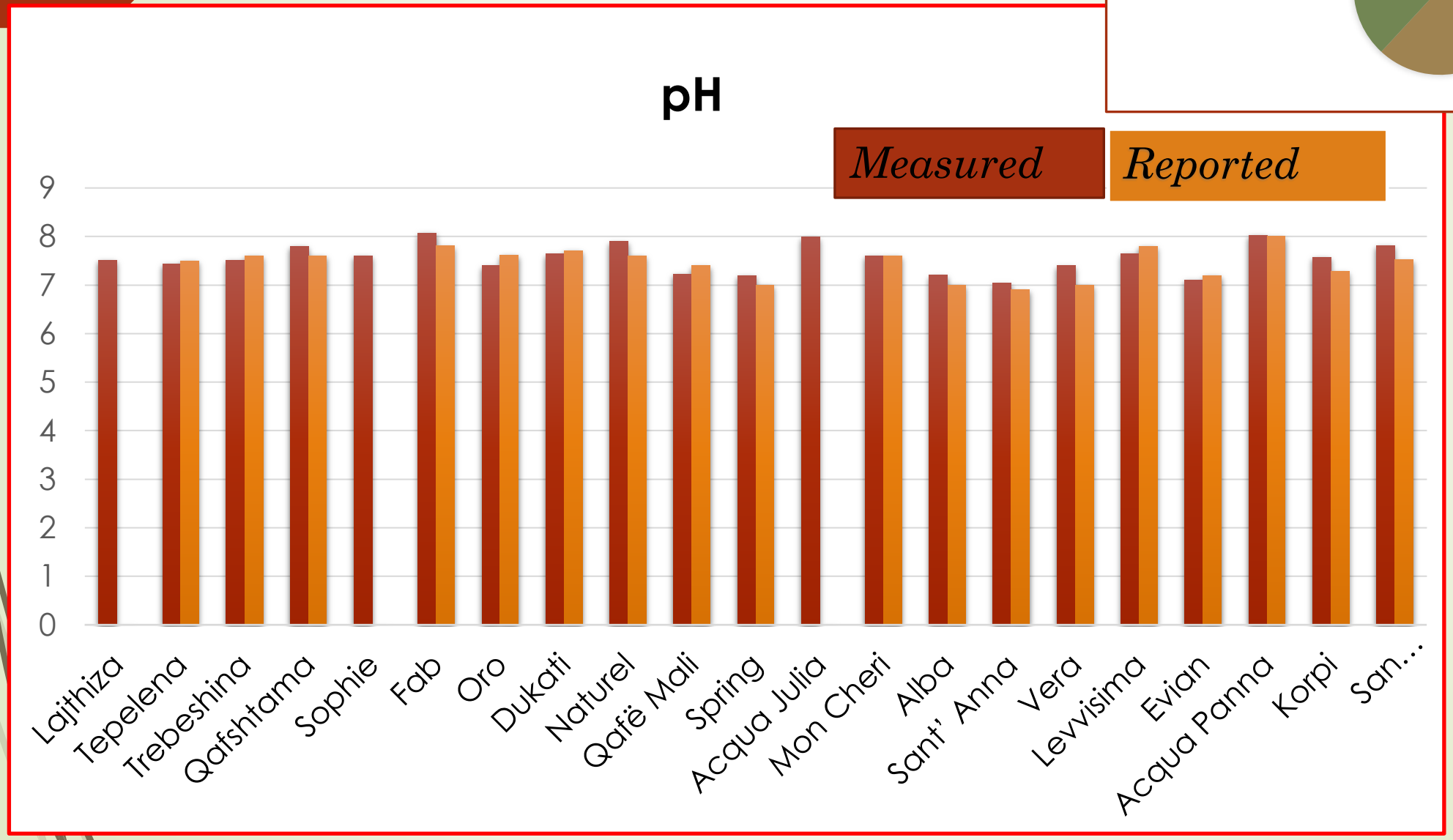
14%
lower
33%


pH
Measured
Reported
9
8
7
6
5
4
3
2
1
0
Lajthiza
Tepelena
Trebeshina
Qafshtama
Sophie
Fab
Oro
Dukati
Naturel
Qafë Mali
Spring
Acqua Julia
Mon Cheri
Alba
Sant' Anna
Vera
Levvisima
Evian
Acqua Panna
Korpi
San…

Conductivity

Gives a idea of amount of dissolved material in the water. Conductivity value range from ***29*** µS/cm (Sant` Anna brand) to ***636*** µS/cm (Vera brand), with an overall value of ***166.44*** µS/cm.

This fluctuation in EC is attributed to soil source, lithology and geological origin of source that produced of each bottled water.

All the water brands have conductivity values within the International standard limit.

Bottled water	Conductivity µS/cm
Lajthiza	103
Tepelena	207
Trebeshina	480
Qafshtama	157
Sophie	98
Fab	117
Oro	209
Dukati	388
Naturel	499
Qafë Mali	133
Spring	249
Acqua Julia	118
Mon cheri	501
Alba	192
Sant' Anna	**29**
Vera	**636**
Levvisima	118
Evian	513
Acqua Panna	217
Korpi	422
San Benedetto	419

Total dissolved solids

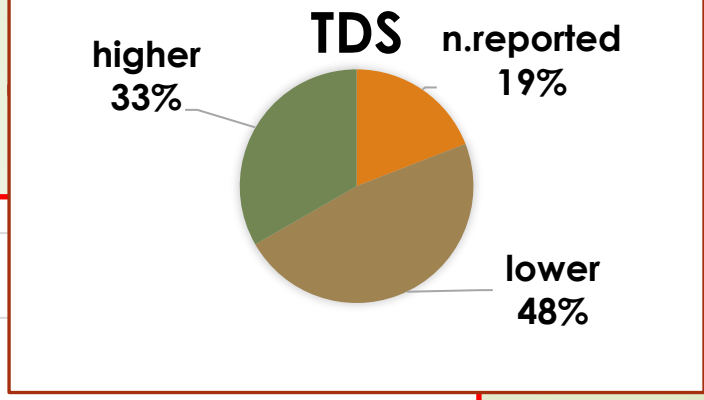
The palatability of drinking water has been rated by panels of tasters in relation to its TDS level as follows:

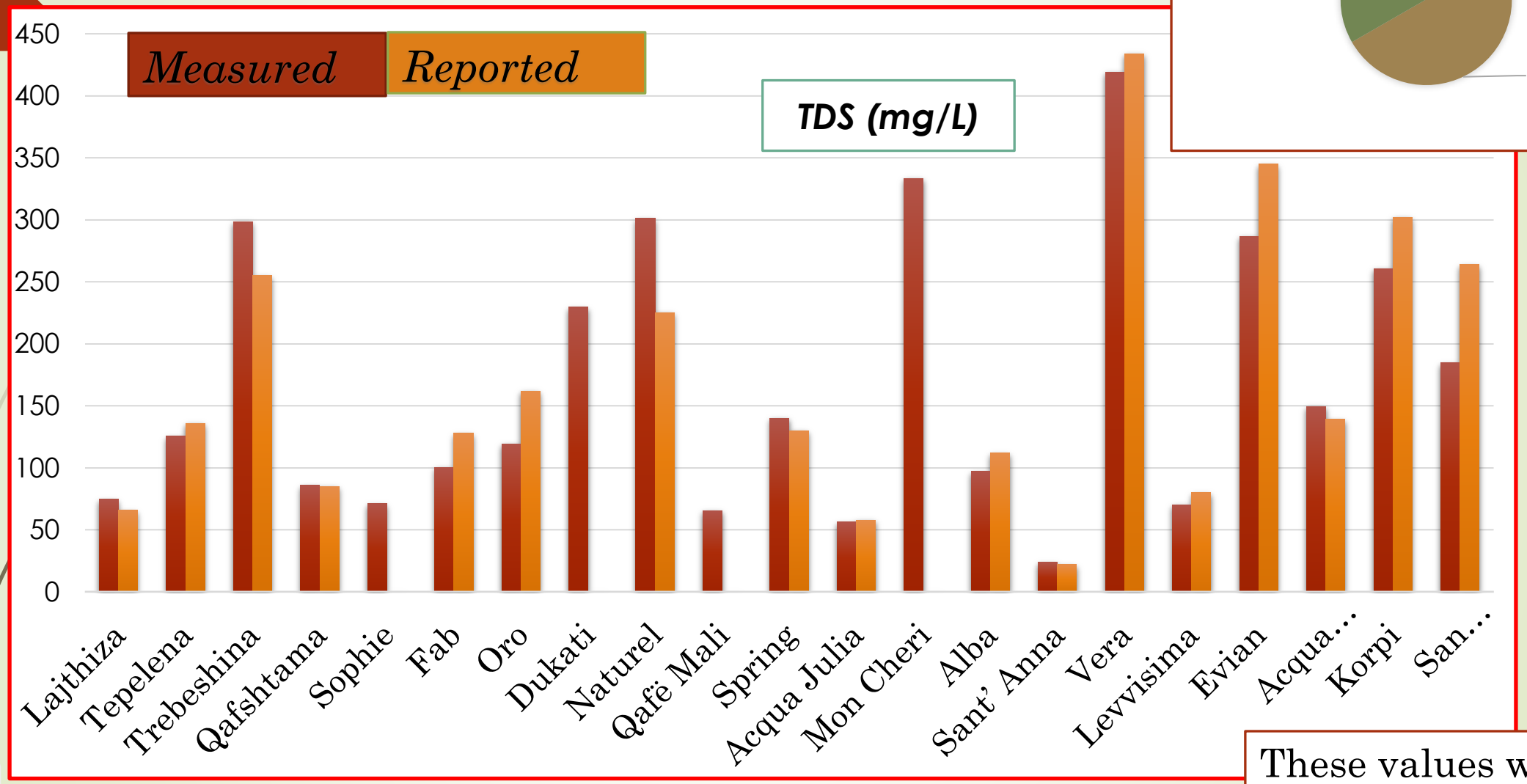
- excellent, less than 300 mg/L;
- good - 300 and 600 mg/L;
- fair - between 600 and 900 mg/L;
- poor - between 900 and 1200 mg/L;
- unacceptable - greater than 1200 mg/L.

Total dissolved solid (TDS) values of sample varied from 24.09 (Sant´ Anna brand) to 419.2 mg/l (Vera brand), with an overall value of 166.4 mg/l.

These values were within the WHO and IBWA standards.

Bottled water	TDS mg/L
Lajthiza	74.8
Tepelena	125.6
Trebeshina	298.8
Qafshtama	86
Sophie	71.2
Fab	100.4
Oro	119.6
Dukati	229.6
Naturel	301.2
Qafë Mali	65.6
Spring	140
Acqua Julia	56.4
Mon cheri	333.2
Alba	97.2
Sant' Anna	24.09
Vera	419.2
Levvisima	70.4
Evian	286.8
Acqua Panna	149.6
Korpi	260.8
San Benedetto	184.8





These values were within the WHO and IBWA standards.

Total hardness

Hardness is a key water parameter and its control is important to assure proper water quality.

The maximum allowable limit of TH for drinking purpose is 500 mg/L (WHO, 2008), while the most desirable limit is 80-100 mg/L.

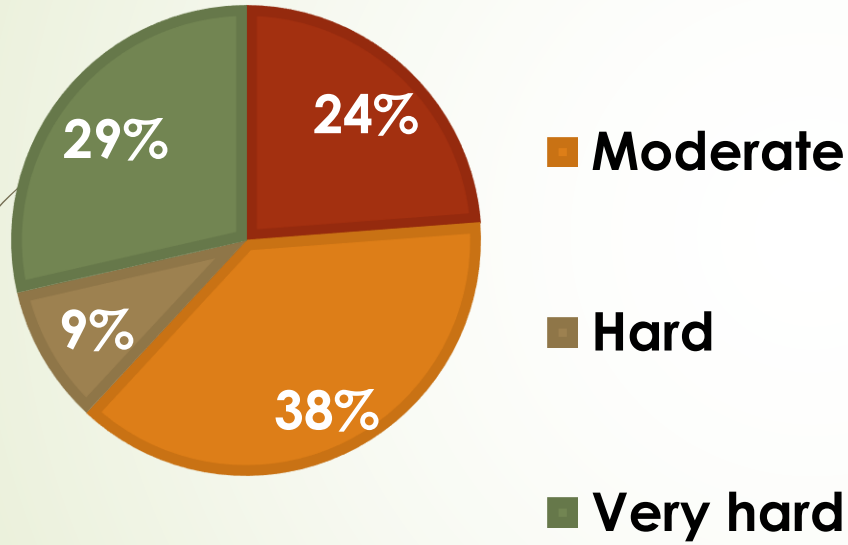
Based on this criteria the studied samples range from 9.02 (Sant Anna brand) to 385.2 mg/L (Vera brand) with an average value of 136.7 mg/L.

The epidemiological studies demonstrated that water hardness may protect against certain diseases.

$CaCO_3$ (mg/L)	Hardness
0 to 60 mg/L	Soft water
60 to 120 mg/L	Moderately hard water
120 to 180 mg/L	Hard water
>180 mg/L	Very hard water

Water samples	Concentration mg $CaCO_3$/L	German Degrees	English degrees	French Degrees	Hardness as Classification
Lajthiza	47.9	2.88	3.35	4.78	Soft water
Tepelena	119.9	7.2	8.40	11.99	Moderately hard water
Trebeshina	203.4	12.18	14.24	20.34	Very hard water
Qafshtama	92.9	5.58	6.50	9.29	Moderately hard water
Sophie	48.6	2.9	3.402	4.86	Soft water
Fab	106.2	6.36	7.434	10.62	Moderately hard water
Oro	117	7.02	8.19	11.7	Moderately hard water
Dukati	192.6	11.58	13.48	19.26	Hard water
Naturel	203.9	12.24	14.27	20.40	Very hard water
Qafë Mali	48.6	2.9	3.40	4.86	Soft water
Spring	120.6	7.26	8.44	12.06	Moderately hard water
Acqua Julia	60.5	3.6	4.23	6.04	Soft water
Mon Cheri	207	12.42	14.49	20.7	Very hard water
Alba	72.5	4.38	5.08	7.25	Moderately hard water
Sant' Anna	9.02	0.54	0.63	0.9	Soft water
Vera	385.2	23.1	26.96	38.52	Very hard water
Levvisima	61.2	3.66	4.28	6.12	Moderately hard water
Evian	284.4	17.04	19.40	27.72	Very hard water
Acqua Panna	97.2	0.6	6.80	9.72	Moderately hard water
Korpi	223.2	13.38	15.62	22.32	Very hard water
San Benedetto	169.2	10.2	11.84	16.92	Hard water

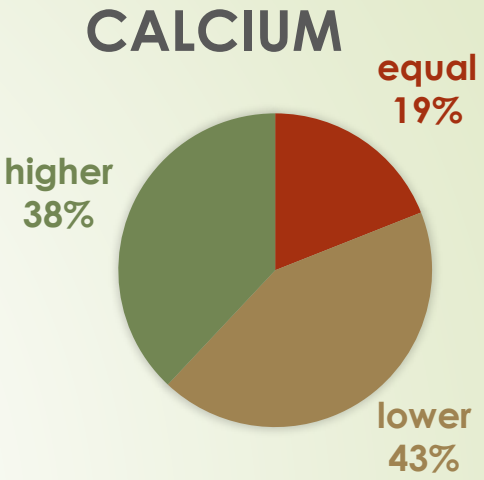
TOTAL HARDNESS



- Five brands were classified as soft waters;
- Eight brands were classified as moderate hard waters;
- Two brands were classified as hard waters;
- Six brands were classified as very hard waters.

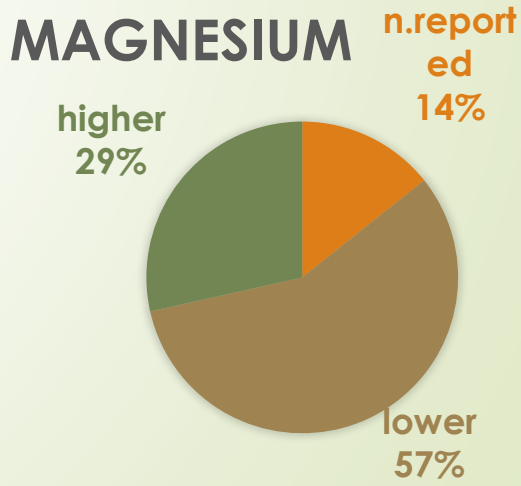
- **Calcium**

Natural water sources typically contain concentrations of up to 10 mg/L Ca. Concentrations of Ca ranged between 2.88 (Sant Anna brand) to 115.4 mg/L (Vera brand) with an average value of 44.51 mg/L. All the studied water brands have Ca levels falling within the international standard limits.



- **Magnesium**

Concentrations of Mg range from 0.44 to 23.5 mg/L with an average value of 6.1 mg/L. All the water brands have Mg levels well within WHO and IBWA standard limits.



Water sample	Ca (mg/L)	Mg (mg/L)
Lajthiza	16.3	1.7
Tepelena	46.5	0.87
Trebeshina	76.3	3.06
Qafshtama	3.09	20.7
Sophie	16.8	1.62
Fab	41.1	0.87
Oro	41.2	3.50
Dukati	57.3	11.98
Naturel	74.2	4.51
Qafë Mali	15.1	2.62
Spring	47.1	0.74
Acqua Julia	23.3	0.57
Mon Cheri	75.8	4.24
Alba	8.64	12.4
Sant' Anna	**2.88**	**0.44**
Vera	**115.4**	**23.5**
Levvisima	23.3	0.74
Evian	74.9	21.9
Acqua Panna	33.8	3.06
Korpi	87.8	0.87
San Benedetto	54	8.32

Calcium is used to built bones and teeth. A deficiency over a long period may lead to osteoporosis. It is also used for coagulation of the blood and regulates heart activity. Calcium deficiency increases the risk of high blood pressure and heart attack.

The recommended Ca daily intake for adults ranges between 700 and 1000 mg (Scientific Committee for Food, 1999; Committee on Dietary Reference Intake, 2007).

DRICa

$$DRI_{Ca} = \frac{C_{Ca} * 2liters}{1000\,{}^{mg}/_{day}} * 100$$

Magnesium is essential for bones and cells, especially for muscular cells. It helps to maintain the muscular and nervous equilibrium. It is also used for building bones and tendons and in the construction of many enzymes.
Epidemiological studies suggest that consumption of Mg may reduce the frequency of sudden death.
The recommended magnesium daily intake for an adult is about 300-400 mg (Scientific Committee for Food, 1999; Committee on Dietary Reference Intake, 2007).

DRI_{Mg}

$$DRI_{Mg} = \frac{C_{Mg} * 2liters}{365\,{}^{mg}/_{day}} * 100$$

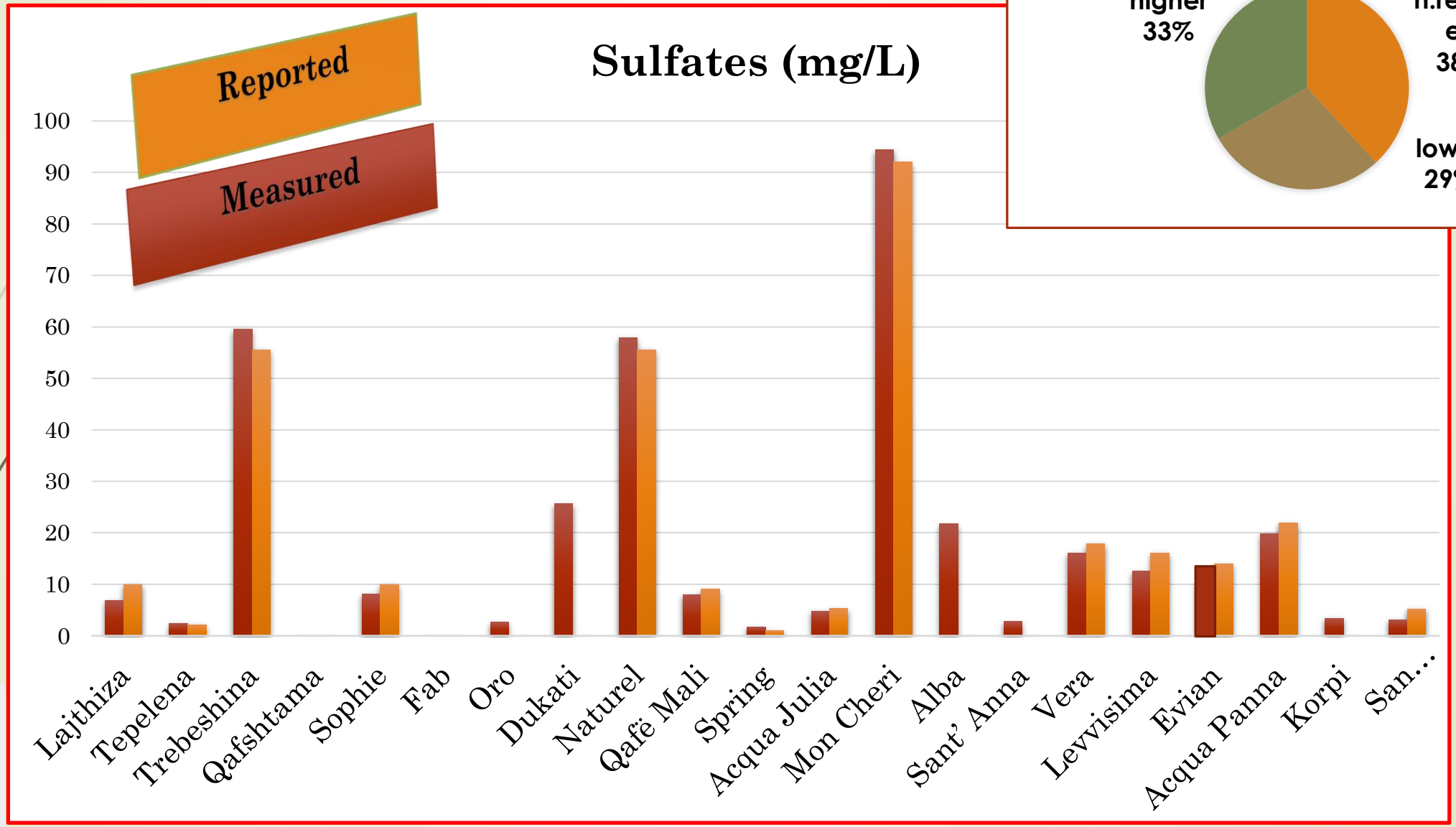
Bottled water	DRI Ca %	DRI Mg %
Lajthiza	3.25	0.96
Tepelena	9.31	0.47
Trebeshina	15.3	1.67
Qafshtama	0.62	11.34
Sophie	3.36	0.89
Fab	8.21	0.48
Oro	8.21	1.92
Dukati	11.46	6.56
Naturel	14.83	2.47
Qafë Mali	3.02	1.44
Spring	9.4	0.41
Acqua Julia	4.65	0.31
Mon cheri	15.16	2.32
Alba	1.73	6.78
Sant' Anna	***0.57***	***0.24***
Vera	***23.09***	***12.70***
Levvisima	4.65	0.41
Evian	14.98	11.98
Acqua Panna	6.77	1.68
Korpi	17.57	0.48
San Benedetto	10.81	4.56

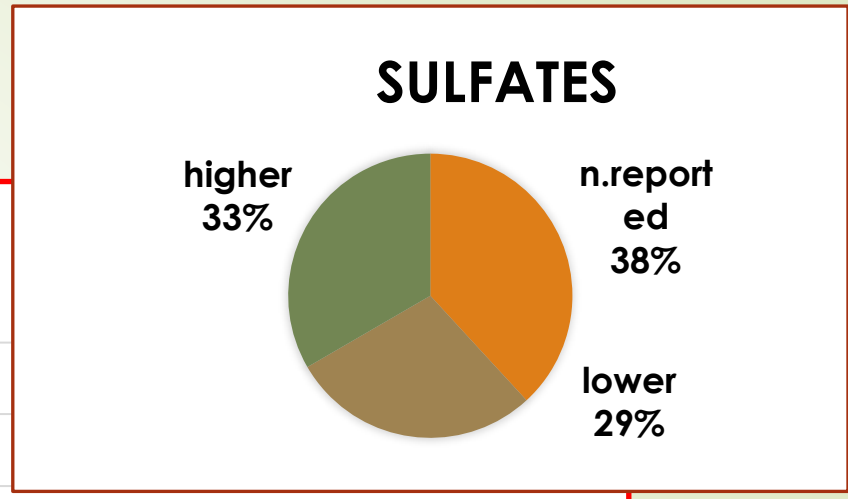
Dietary Reference Intakes of Ca^{2+} and Mg^{2+} (DRIs) was evaluated based on the levels of these two elements

SULFATES

Sulfate ion is generally harmless, except its effect on taste. The major physiological effects resulting from the ingestion of large quantities of sulfate are catharsis, dehydration and gastrointestinal irritation. The SO_4 concentrations in all the water samples are within the international standards for drinking water.

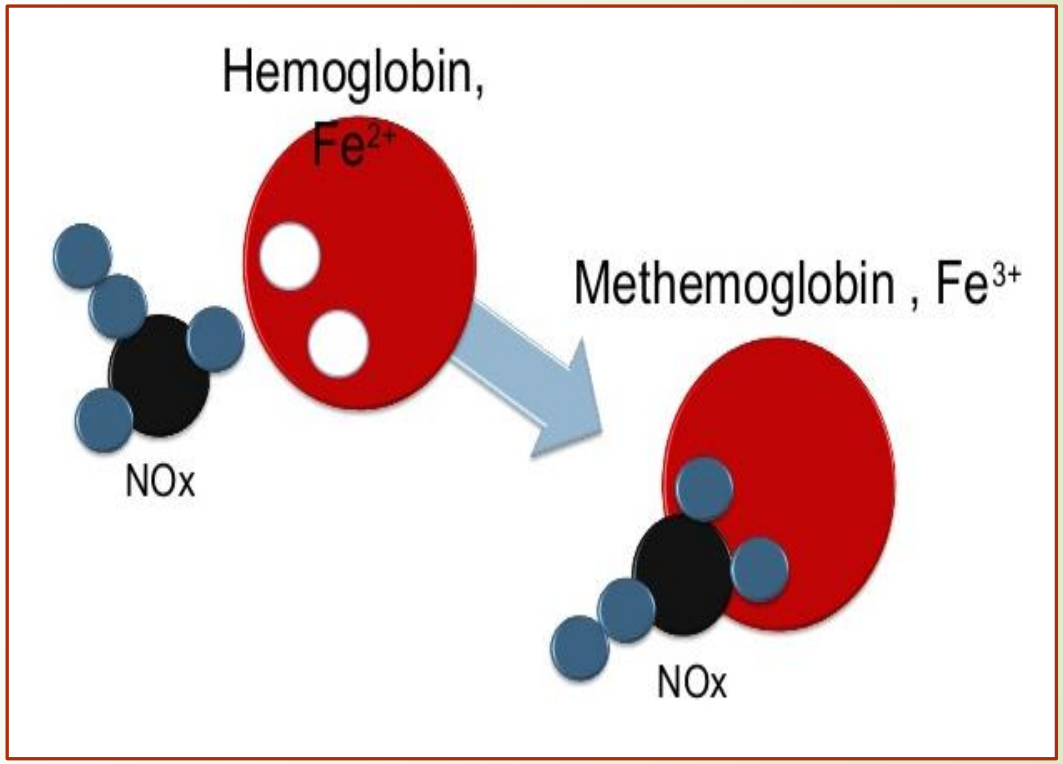
Water brand	SO4 (mg/L)
Lajthiza	10.08
Tepelena	2.38
Trebeshina	59.5
Qafshtama	**<1.5**
Sophie	11.13
Fab	**<1.5**
Oro	2.63
Dukati	25.63
Naturel	57.88
Qafë Mali	8
Spring	1.75
Acqua Julia	4.8
Mon Cheri	**99.38**
Alba	21.75
Sant' Anna	2.75
Vera	16.13
Levvisima	12.63
Evian	10.63
Acqua Panna	19.88
Korpi	3.38
San Benedetto	3.13

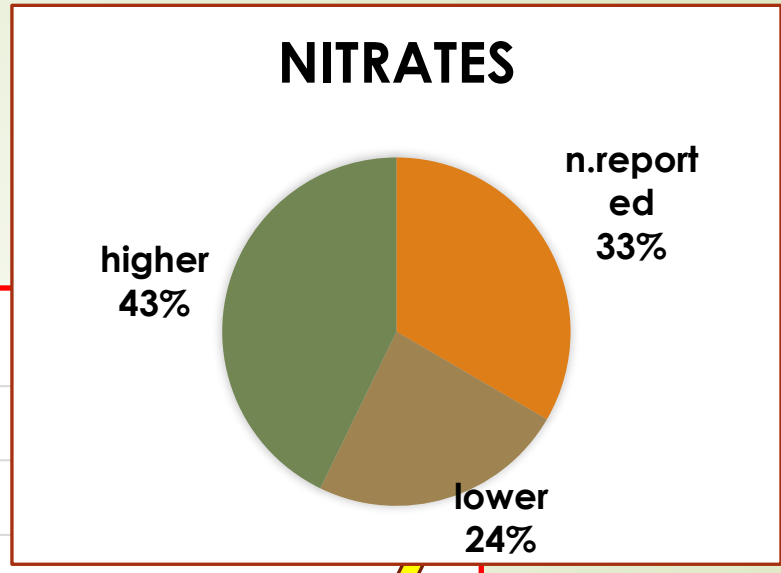

Sulfates (mg/L)
Reported
Measured
100
90
80
70
60
50
40
30
20
10
0
Lajthiza
Tepelena
Trebeshina
Qafshtama
Sophie
Fab
Oro
Dukati
Naturel
Qafë Mali
Spring
Acqua Julia
Mon Cheri
Alba
Sant' Anna
Vera
Levvisima
Evian
Acqua Panna
Korpi
San…

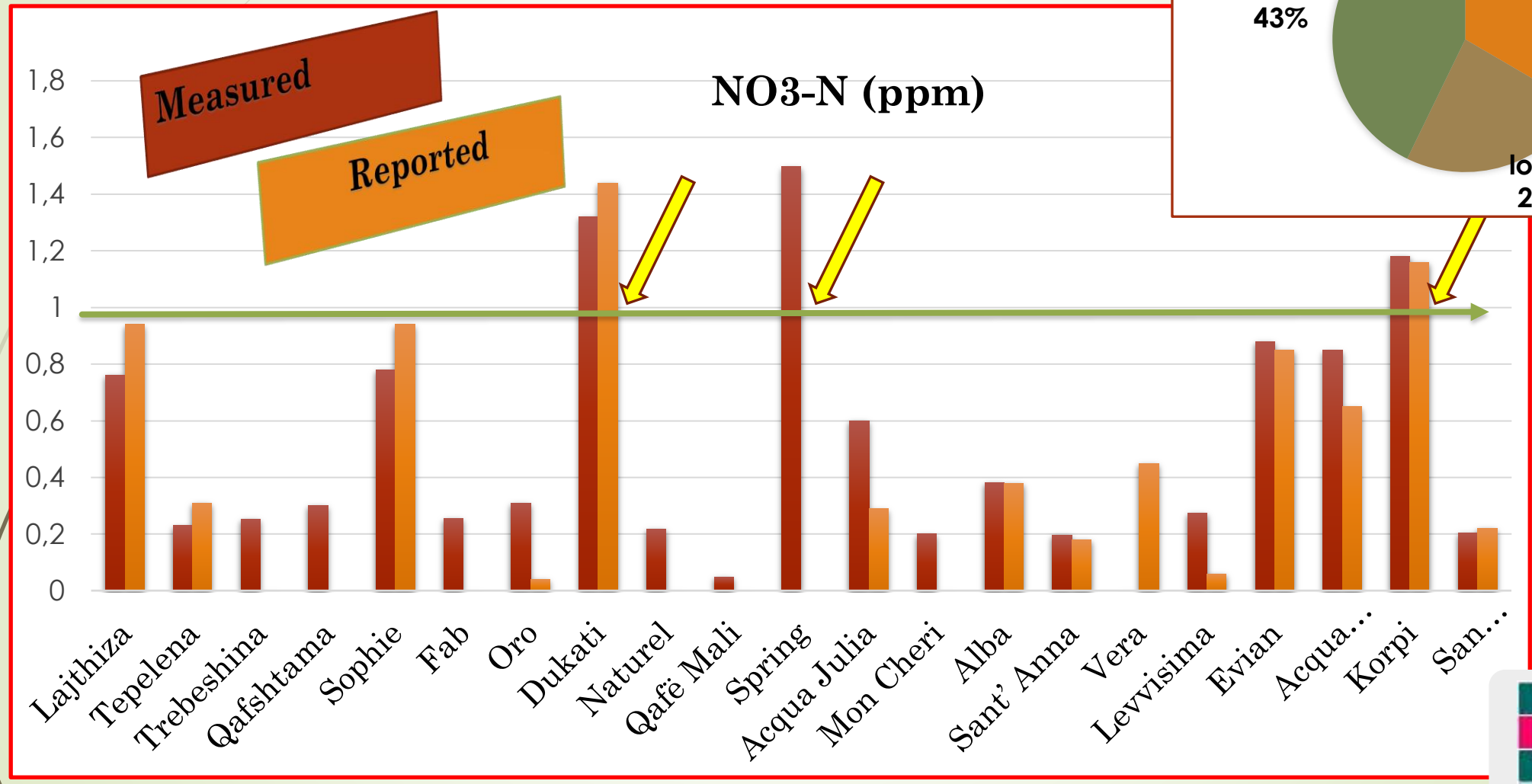

SULFATES
higher
33%
n.report
ed
38%
lower
29%

NITRATES

The primary health concern regarding NO_3 is the formation of methemoglobinemia, a so-called 'bluebaby syndrome'.
NO_3 can change to NO_2 in the stomach of infants, which can then oxidize hemoglobin to methemoglobin, making it difficult to transport oxygen around the body .
In Italy, a limit of 1 mg/L NO_3 - N has been recommended for the water destined to infants and pregnant woman.




NITRATES
n.reported
33%
higher
43%
lower
24%


Measured
Reported
NO3-N (ppm)
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
Lajthiza
Tepelena
Trebeshina
Qafshtama
Sophie
Fab
Oro
Dukati
Naturel
Qafë Mali
Spring
Acqua Julia
Mon Cheri
Alba
Sant' Anna
Vera
Levvisima
Evian
Acqua…
Korpi
San…

CONCLUSION

The physical and chemical contents of the studied water brands are found within the accepta limits set for drinking water by International Bottled Water Association (IBWA, 2004) and World Health Organization (WHO, 2008).

Bicarbonate, calcium, TDS and magnesium ions represented about 42.8, 43, 47.6 and 57.2 percent of studied sample contents lower values than label amount, respectively. Sulphate, pH and nitrate were about 33.3, 38.1, and 42.8 % respectively higher than label values.

Classification of the water brands based on Total Hardness (TH) shows that a majority of the studied samples fall in *moderate hard water category*.

The DRI of Ca^{2+} varied from 0.6 - 23.08 % (average 10,73 %); the DRI of Mg^{2+} varied from 0.31-11.98 % (average 3,31%).

Bottled water that contain more than 1 mg/L NO_3 –N are not recommended for the water destined to infants and pregnant women.

Results of this study may be useful for guiding the consumers in their choices for suitable brands.