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Nitrate and Nitrite Levels of Natural Spring and Mineral Water in Van, Turkey

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Abstract: This study was performed to determine nitrate and nitrite levels of packaged natural spring and mineral water consumed in Van city of Turkey. A total of 200 water samples, belonging to 10 different companies, each of 100 pet spring water and 100 bottled mineral water samples were used as material. Nitrate and nitrite levels were measured by the spectrophotometric method. According to the results both nitrate and nitrite were found to be present in all water samples. Mean nitrate and nitrite concentrations were 3.66±0.028 and 0.045±0.003 mg L^{-1} in the spring water and 3.52±0.011 and 0.025±0.001 mg L^{-1} in the mineral water, respectively. Finally; nitrate and nitrite levels in water samples were in accordance with the related national and international regulations and considered safe for consuming.

Key words: Water, spring, mineral, nitrate, nitrite, Van

INTRODUCTION

Demand for water increases day after day based on the facts of climate change, rapid population increase and industrialization. In Turkey, annual usable water amount per capita is 1,750 m^3 and water potential is 3,690 m^3. Countries with >10,000 m^3 water amounts per capita are considered rich in terms of water whereas as Turkey falls within the countries not considered as such. Additionally, water scarcity is denser in some regions due to unplanned urbanization and domestic migrations. Under such conditions, it is quite a high possibility to encounter with serious problems of water scarcity in the future.

Underground water sources are highly utilized in Turkey for providing potable water. However, such sources are contaminated by domestic and industrial wastewater discharged directly into natural environment without treatment, leakages originating from drainage systems and solid wastes, agricultural pesticides, chemical fertilizer residues and other contaminators. Underground water is more fragile towards contamination compared to surface water.

Capacity for change and dilution in such waters which are usually utilized without any treatment is quite limited. It takes long years for contaminated aquifers to get cleaned through natural processes. Therefore, the impact of contamination lasts longer. Spring water and mineral water are natural water which develops through mixing of meteorological water and magma originated water (juvenile) under the ground in different proportions during water cycle. Such water has different characteristics than others.

They cause various elements and substances contained within the soil to dissolve during circulation under the ground. They are also in a protected state from biological and chemical contaminators during formation process. They are qualified as safe water at their sources, it is important in terms of public health that such quality does not change during bottling phase and within the period between after bottling and consumption. Mineral water is also used for therapeutic purposes for certain substances and minerals it contains. However, some portion of such substances has negative effects on human health or water quality. Therefore, the upper limit values should not exceed the values indicated in standards.

Nitrates are naturally present in all sources of water. Higher levels in water can indicate contamination whether from human or animal waste, fertilizers, septic tanks, decaying plants, sewage disposal systems and erosion of natural deposits (WHO, 2007). Excessive nitrate levels in drinking water can cause methemoglobinemia or blue-baby syndrome a condition in infants which the blood has diminished ability to take of oxygen, potentially causing brain damage or death (Beatson, 1978; Fan and Steinberg, 1996). Infants may suffer from acute nitrite toxicity if they

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are fed formula prepared from water containing high (>10 ppm) nitrates (Self and Qwaskom, 1998). Others at risk from excess nitrates in drinking water are pregnant women, individuals with reduced gastric acidity and persons with genetically controlled deficiencies of the enzymes glucose 6 phosphate dehydrogenase or methemoglobin reductase (Avery, 1999).

Nitrate itself is not a direct toxicant but it is the conversion of nitrate to nitrite which causes the problems. In the human stomach, nitrites can react with secondary and tertiary amines or amides to form N-nitro so, compounds which are probably carcinogenic in humans (Yang *et al*., 1998). World Health Organization (WHO) has determined daily acceptable nitrate and nitrite amounts for adults as 0-5 and 0-0.4 mg kg^{-1}, respectively (WHO, 2006). In this study were investigated the nitrate and nitrite levels of bottled natural spring water and mineral water consumed in Turkey and their compliance with national and international standards.

MATERIALS AND METHODS

Natural spring water and mineral water consumed in Turkey and produced by different firms were examined in terms of nitrate and nitrite. For this purpose, natural water in 100 units of plastic bottles (1.5 L) and mineral water in 100 units of glass bottles (200 mL) were used as the material subject to examination.

Water samples were collected periodically from sales points in Van city during August to October 2009 period. Samples were taken to laboratory in a short time and went under analysis within the same day. All samples were kept at room temperature (20-25°C) until the analysis are finalized. Spectro- photometric (Shimadzu UV-1800, Japan) method was used for measurement of nitrate and nitrite levels (APHA, 1995).

Statistical analysis: Data obtained from the study were evaluated via one way Analysis of Variance (One-way ANOVA). Duncan test was used for determination of variances between group averages. Statistical analysis was executed with SAS packaged software (SAS, 1998).

RESULTS AND DISCUSSION

Bottled water constitutes an alternative source for meeting daily potable water needs. Production of bottled water has shown a rapid progress in Turkey also just like in all over the world. Out of 247 facilities producing bottled water within Turkey, about 199 produce spring water, 12 produce potable water and 36 produce mineral water. Annual bottled water consumption per capita in Turkey is 78 L, such an amount is quite lower compared to European levels. Factors such as increases in population and income levels and changes in consumer preferences increase the consumption amount. Fruit flavored products also had an impact on such increase in recent years. Nitrates and nitrites are substances formed up widely during natural nitrogen cycle.

Major factors effective in nitrogenous substances getting mixed in water include domestic wastes, industrial wastes containing nitrogen (wool, food, leather, beer and milk industries) organic substances, slaughterhouse wastes and nitrogenous fertilizers used for agriculture being carried with irrigation water or rain water. The possibility of such substances to be contained in water and the amounts contained have increased in recent years based on rapid population increase and industrialization.

In this study, bottled natural spring water and mineral water produced by different firms and consumed widely in Turkey were examined in terms of nitrate and nitrite levels. Nitrate and nitrite levels determined in bottled spring water and mineral water and the results of statistical analysis were shown in Table 1 and 2.

According to analysis findings, different nitrate and nitrite levels were determined in all natural spring water and mineral water examined. Nitrate and nitrite levels were determined as 3.40-4.48 and 0.005-0.120 mg L^{-1}, respectively in spring water and as 3.42-3.84 and 0.011-0.040 mg L^{-1}, respectively in mineral water. Average values were found to be higher in spring water. When label information is taken into account, nitrate and nitrite levels were found to be unindicted for 90% of bottled spring water (90/100, 1 firms) and 10% of bottled mineral water (10/100, 1 firm). Furthermore, nitrate and nitrite levels indicated in the labels were found to be inconsistent with the analysis results for 10% of spiring water (1 firm) and 90% of mineral water (9 firms) (Table 1 and 2).

In studies made in different years in Turkey, nitrate levels were found to be between 0-58.3 mg L^{-1} and nitrite levels between 0.1-1.32 mg L^{-1} (Alisarli *et al*., 2009). Nitrate and nitrite levels in well water analyzed were found to be as 0-243.61 mg L^{-1} and 0-2.8 mg L^{-1}, respectively. Kawther and Suaad (2007) found vnitrate levels between 1-5 ppm in bottled mineral water samples with 9 different brands obtained from Riyadh and various regions of Saudi Arabia.

Pip (2000) determined an average nitrate level of 0.65±0.12 mg L^{-1} (range <0.01-4.1 mg L^{-1}) in bottled spring water consumed in Manitoba region of Canada. Velghe and Claeys (1985) determined an average nitrate level of 7.16±9.39 mg L^{-1} (range 0.2-26.8 mg L^{-1}) in natural

Table 1: Nitrate levels of bottled spring water and mineral water (mg L^{-1})

	Pet spring water				Bottled mineral water		
Firm	n	X±SX	Min-Max	Firm	n	X±SX	Min-Max
1	10	3.50±0.019^{d}	(3.42-3.62)	1	10	3.46±0.016^{e}	(3.42-3.59)
2	10	3.47±0.008$^{d, e}$	(3.45-3.51)	2	10	3.56±0.022^{c}	(3.52-3.75)
3	10	3.45±0.012$^{d, e}$	(3.40-3.51)	3	10	3.50±0.018^{d}	(3.45-3.57)
4	10	3.45±0.009^{e}	(3.40-3.48)	4	10	3.78±0.014^{a}	(3.71-3.84)
5	10	3.77±0.005^{c}	(3.75-3.78)	5	10	3.46±0.009^{e}	(3.42-3.51)
6	10	4.30±0.025^{a}	(4.20-4.48)	6	10	3.48±0.019$^{d, e}$	(3.42-3.59)
7	10	3.45±0.007$^{d, e}$	(3.43-3.48)	7	10	3.44±0.005^{e}	(3.43-3.46)
8	10	3.96±0.027^{b}	(3.79-4.09)	8	10	3.60±0.005^{b}	(3.57-3.62)
9	10	3.76±0.011^{c}	(3.71-3.81)	9	10	3.46±0.009^{e}	(3.42-3.51)
10	10	3.48±0.012$^{d, e}$	(3.42-3.54)	10	10	3.44±0.006^{e}	(3.42-3.46)
Total	100	3.66±0.028	(3.40-4.48)	Total	100	3.52±0.011	(3.42-3.84)

$^{a, b, c, d, e}$Variances between averages shown with different uppercase indices is important ($p<0.05$)

Table 2: Nitrite levels of bottled spring water and mineral water (mg L^{-1})

	Pet spring water				Bottled mineral water		
Firm	n	X±SX	Min-Max	Firm	n	X±SX	Min-Max
1	10	0.013±0.003^{d}	(0.005-0.034)	1	10	0.021±0.003^{c}	(0.011-0.034)
2	10	0.019±0.003^{d}	(0.011-0.034)	2	10	0.021±0.003^{c}	(0.011-0.034)
3	10	0.017±0.003^{d}	(0.005-0.029)	3	10	0.030±0.002$^{a, b}$	(0.023-0.040)
4	10	0.017±0.002^{d}	(0.011-0.029)	4	10	0.031±0.002^{a}	(0.023-0.040)
5	10	0.076±0.003^{b}	(0.069-0.087)	5	10	0.024±0.002$^{b, c}$	(0.017-0.034)
6	10	0.094±0.004^{a}	(0.081-0.120)	6	10	0.024±0.002$^{b, c}$	(0.017-0.034)
7	10	0.033±0.002^{c}	(0.023-0.040)	7	10	0.022±0.002^{c}	(0.017-0.029)
8	10	0.089±0.002^{a}	(0.081-0.098)	8	10	0.022±0.002^{c}	(0.017-0.029)
9	10	0.076±0.003^{b}	(0.064-0.087)	9	10	0.022±0.002^{c}	(0.017-0.029)
10	10	0.019±0.004^{d}	(0.005-0.040)	10	10	0.033±0.001^{a}	(0.029-0.040)
Total	100	0.045±0.003	(0.005-0.120)	Total	100	0.025±0.001	(0.011-0.040)

$^{a, b, c, d, e}$Variances between averages shown with different uppercase indices is important ($p<0.05$)

mineral water they analyzed. Nitrate levels in natural mineral water consumed in various regions in Turkey were determined to be between 1.8-13.1 mg L^{-1} by Erbahadir; 0.02-9.41 mg L^{-1} by Padil; 0.20-24.06 mg L^{-1} by Gunduz; 0.01-4.84 mg L^{-1} by Soyuyuce and 1.09-13.20 mg L^{-1} by Cemek *et al.* (2007).

Nitrite levels in the same mineral water samples were determined to be between 0-0.0625 mg L^{-1} by Soyuyuce; 0.008-0.087 mg L^{-1} by Cemek *et al.* (2007). The results of this study were within the reference values. Nitrate levels of natural spring and mineral water were evaluated to be as 50 mg L^{-1} in national and international standards (CAC, 2009; WHO, 2006).

Nitrite levels were evaluated to be as 0.5 and 3 mg L^{-1} (WHO, 2006) in spring water and 0.1 mg L^{-1} (CAC, 2009) in mineral water.

According to the research findings, nitrate and nitrite levels determined in the analyzed natural spring and mineral water samples were in compliance with the limit values indicated by these standards.

CONCLUSION

As a result, it is determined that bottled natural spring and mineral water from various firms and analyzed were determined to be compliant with the standards in terms if nitrate and nitrite levels and they do not constitute any risk for public health. However, the facts that a part of the examined samples not bearing label information or not being consistent with the existing label information will create problems in terms of consumer rights and product safety. Therefore, we think that inspection of product safety must be introduced as an obligation.

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