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Safety evaluation of bottled water and water taken from local intake

Introduction

The man's water requirement ranges from 1.5 to 2.5 l/day. Water for drinking should be safe for consumer's health and so it should show the right quality. Drinking water as a foodstuff is most often supplied via the water supply network or drawn from the well. Especially in small towns and villages water is most often drawn from underground waters, and very frequently occurs an increased concentration of mineral substances, mainly iron, manganese and organic compounds.

According to the FAO/WHO *Expert Committee on Food Additives* (JECFA) [JECFA, 2002] fixed daily intake of an adult of nitrates on the level of 0÷3.7 mg and nitrites 0÷0.7 mg kg⁻¹ and 28÷43 mg Cl⁻ body mass. Acceptable daily intake (ADI) by an adult of 70 kg cannot exceed 260 mg of nitrates and 49 mg nitrites and 2÷3 g chlorides.

The quality of water for consumption is standardized and controlled and so the evaluation of its applicability for consumption is covered by numerous research [Kot *et al.* 2000; Rogozińska, Pobereżny, 2001; Kot, 2001; Wichrowska *et al.*, 2001; Soylak *et al.* 2002; Michalik, 2008; Blicharska *et al.*, 2010]. They are provided for in *Annexes to Regulation of Minister of Health* of April 20, 2010 changing *Regulation* on the quality of drinking water for man [Regulation of MH, 2010]. They consider the WHO guidelines [WHO *Guidelines for Drinking-Water Quality*, 2011], but mostly they comply with *Directive of the Council of the European Union* [Council *Directive 98/83/EC*, 1998] which defines e.g. the parameters of the maximum concentration of the substances harmful to health; e.g. chlorides, nitrates, sodium, etc; chemical properties, as well as bacteriological properties [Wilson, Trollip, 2009]. Natural mineral water is an underground water drawn with one or a few water intake stations (wells and/or sources), originally chemically and microbiologically pure, with a stable mineral composition and the properties of physiological importance, with a favourable effect on human health. Natural spring water does not differ in its properties and mineral composition from the water for human consumption, defined by the collective water supply regulations, whereas table water is the water received after adding natural spring water, natural mineral water or mineral salts, containing one or more nutrients of physiological importance, like sodium, magnesium, calcium, chlorides, sulphates, bicarbonates. A specific group of bottled waters is made up by curative waters. The acceptance of those waters is the competence of the *National Institute of Public Health - National Institute of Hygiene* which keeps them registered. Bottled in spa towns, natural mineral waters meet the requirements of curative waters, however, due to a complicated and costly procedure connected with a formal acceptance of the waters as curative waters, they are sold as natural mineral waters. Curative waters are prepared for the market and packaged only in 4 spa towns; Krynica-Zdrój, Polanica-Zdrój, Szczawno-Zdrój and Wysowa-Zdrój.

The aim of the present research has been to determine nitrates and chlorides content for mineral and spring waters as well as the tap water from the *Municipal Water and Sewage Service* (MWiK) in Bydgoszcz and own water intake station – the well located in the *Lower Vistula River*.

Materials and methods

The research was performed over 2012-2013. Under *Regulation of Minister of Health* [Regulation MH, 2007] on the quality of water

for human consumption, samples of tap water from MWiK in Bydgoszcz and own water intake station; the well located in the *Lower Vistula River Valley*, for research were taken four times per year. Bottled waters were tested 4 times every half year and demonstrated at least half-year use-by date.

The analysis involved:

- the content of chlorides Cl⁻. Determination of chloride was assayed by [Clarke, 1950];
- content of nitrates NO₃⁻. Determination of nitrates were assayed with the ion-selective method with the use of multifunctional device *Elmetron*. 10 ml of water was measured and transferred to the flask of 250 cm³. The electrodes were placed in the sample no more than 2 mm deep and the result was read in ppm. It was converted into mg·dm⁻³ considering the amount of the sample taken.

Results and discussion

Nitrates occurred in all the waters tested (except for distilled water – the reference sample). Their concentration fell below 18.81 mg·dm⁻³. The highest concentration was recorded for bottled water *Arca North* (18.81 mg·dm⁻³), however, the value was much below the maximum norm which is 50 mg·dm⁻³ [Annex 1 to Regulation MH, 2011], followed by tap water (17.00 mg·dm⁻³) as well as the water from own water intake station (16.01 mg·dm⁻³).

Waters recommended for babies should contain no more than 10 mg·dm⁻³ [Annex 5 to Regulation MH, 2011], and in one of the waters tested with the approval by the *Mother and Child Institute* was noted quite a high level of the maximum content (8.10 mg·dm⁻³) as compared with other waters.

The natural source of nitrates is the nitrogen cycle which occurs in the environment, related to e.g. plant decomposition. However, the most problematic are anthropogenic sources; e.g. municipal and industrial sewage, artificial and natural fertilisers as well as acid rains and dusts, which provide considerable amounts of nitrates to the environment [Orzeł and Biernat, 2012]. Directly they are not hazardous for humans, however, in the alimentary canal they can be transformed into harmful nitrites [Orzeł, Biernat 2012] the maximum concentration of which in drinking water is 0.5 mg/L [Annex 1 to Regulation MH, 2010].

Chlorides. A good solubility of hydrochloric acid salt, namely chlorides as well as their common occurrence in nature make the chloride ion occur in all the natural waters. Inconsiderable amounts of chloride ions are found in mountain and rain waters. Chlorides can penetrate to natural waters from: the soil, natural salt deposits, with sewage, with animal-origin waste.

While evaluating the content of chlorides in water, it is essential to determine their origin, namely whether they are of natural origin or whether their presence is a result of water pollution. In the latter case, chloride ions are accompanied by considerable amounts of nitrate compounds. Salty taste of water depends on the kind of salts which occur in water. The taste is caused by the presence of sodium chloride in water ([Brzozowska, 2010].

A high concentration of chloride ions increases water corrosiveness. The concentration of chlorides above 250 mg/L is harmful to plants. According to the sanitary and epidemiology requirements, the content of chlorides in drinking water should not exceed 250 mg/L, if those are chlorides of natural origin. Chlorides of another origin than the natural ones can make water undrinkable.

Tab. 1. Content of nitrates and chlorides (mean for reps \pm SD)

Water sample studied	Content of nitrates [mg · dm ⁻³]	Content of chlorides [mg · dm ⁻³]
	Limit 50 (10) [*] [mg · dm ⁻³]	Limit 250 [mg · dm ⁻³]
<i>Ostromecko</i> – still natural mineral water, mid-mineralised	1.79 \pm 0.12	34.81 \pm 4.11
<i>Muszymianka</i> – natural mineral water, CO ₂ low-saturated, highly mineralized; magnesium-calcium	0.29 \pm 0.03	11.05 \pm 0.45
<i>Kropla Beskidu</i> – still natural mineral water, low-mineralized	2.87 \pm 0.21	2.02 \pm 0.25
<i>Cisowianka</i> – natural mineral water moderately mineralized; low-sodium	3.45 \pm 0.55	2.54 \pm 0.44
<i>Mama i Ja</i> – still natural spring water for babies, pregnant women and mothers provided with the approval by the <i>Mother and Child Institute</i>	2.51 \pm 0.82	9.12 \pm 0.62
<i>Nestle Aquarel</i> – still natural spring water recommended for babies, pregnant women and mothers provided with the approval by the <i>Mother and Child Institute</i>	1.80 \pm 0.30	5.65 \pm 0.15
<i>Żywiec Zdrój</i> – still natural spring water recommended for babies, pregnant women and mothers provided with the approval by the <i>Mother and Child Institute</i>	8.10 \pm 0.15	4.71 \pm 0.01
<i>Górska Natura</i> – still spring water	5.28 \pm 0.08	2.15 \pm 0.05
<i>Arka-North</i> – still natural spring water	18.81 \pm 2.51	32.10 \pm 0.02
Tap water – <i>Municipal Water and Sewage Service (MWiK)</i> , Bydgoszcz	17.00 \pm 1.51	175.0 \pm 1.32
Water from own water intake station – the well located in the <i>Lower Vistula River Valley</i>	16.01 \pm 2.02	146.0 \pm 21.0
Distilled water	0.00	0.00

* refers to the natural mineral waters drawn on the territory of the Republic of Poland

SD – standard deviation for the mean for reps over years; LSD ($\alpha=0.05$) = 2.58 (content of nitrates); LSD ($\alpha=0.05$) = 13.49 (content of chlorides)

Most chlorides were contained in tap water (175 mg · dm⁻³), followed by the water from own water intake station (146 mg · dm⁻³), and among bottled waters – *Ostromecko* (34.81 mg · dm⁻³) and *Arka-North* (32.10 mg · dm⁻³), nevertheless the limit is 250 mg · dm⁻³ [*Regulation MH, 2010*] (the water which contains more than 200 mg · dm⁻³ should be marked as containing chlorides [*Annex 5 to Regulation MH, 2011*], whereas the water adequate for baby food preparation should contain no more than 20 mg · dm⁻³ [*Annex 5 to Regulation MH, 2011*]). The limits were met by all the waters tested with the approval by the *Mother and Child Institute* as well as *Kropla Beskidu*, *Cisowianka*, *Górska Natura*.

Conclusions

The water samples tested did not exceed the norms provided for in *Regulations of Minister of Health* in terms of the content of nitrates and chlorides which were most numerous in tap water.

Nevertheless there a high level of the maximum content of nitrates in spring waters, including one recommended by the *Mother and Child Health Institute*, was noted.

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