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ORIGINAL ARTICLE

# NATURAL MINERAL BOTTLED WATERS AVAILABLE ON THE POLISH MARKET AS A SOURCE OF MINERALS FOR THE CONSUMERS. PART 2: THE INTAKE OF SODIUM AND POTASSIUM

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## ABSTRACT

**Background.** Natural mineral waters are purchased and consumed according to consumer preferences and possible recommendations. The choice of appropriate water should take into account not only the general level of mineralization but also the content of individual components, including electrolytes such as sodium and potassium. Sodium is necessary to ensure the proper physiological functions of the body. It is defined as a health risk factor only when its excessive intake occurs. Potassium acts antagonistically towards sodium and calcium ions, contributes to a reduction of the volume of extracellular fluids and at the same time reduces muscle tension and permeability of cell membranes. The demand for sodium and potassium is of particular importance in people expending significant physical effort, where an increased electrolyte supply is recommended.

**Objective.** The aim of the study was to estimate the content of sodium and potassium in natural mineral waters available in the Polish market and to evaluate the intake of those components with the commercially available mineral waters by different groups of consumers at the assumed volume of their consumption.

**Material and Methods.** The research material consisted of natural mineral waters of forty various brands available on the Polish market. The examined products were either produced in Poland or originated in other European countries. Among the products under examination, about 30% of the waters were imported from Lithuania, Latvia, the Czech Republic, France, Italy and Germany. A sample for analyses consisted of two package units of the examined water from different production lots. Samples for research were collected at random. The study was conducted with the same samples in in which calcium and magnesium content was determined, which was the subject of the first part of the study [6].

The content of sodium and potassium was determined using the emission technique (acetylene-air flame), with the use of atomic absorption spectrometer – ICE 3000 SERIES – THERMO – England, equipped with a GLITE data station, with wavelengths of 589.0 nm and 766.5 nm, respectively.

**Results.** The obtained research results indicate a high differentiation of the content of both sodium and potassium in natural mineral waters available on the Polish market, particularly in medium- and highly-mineralized waters. The consumption of 1 liter of low-mineralized natural mineral water ensures recommendations concerning the amount of sodium intake only in a limited scope, while in case of products of medium and high level of mineralization, it is much diversified. On the other hand, potassium supply with one liter of natural mineral water may ensure no more than several percent of the recommended daily intake of this component.

**Conclusions.** The high diversification of sodium content in natural mineral waters available on the Polish market should encourage the analysis of their composition to avoid health disorders in a given group of consumers. The natural mineral waters examined in the study, at the assumed volume of their daily consumption, are not a good source of potassium for the population groups under analysis.

**Key words:** *natural mineral water, minerals, sodium, potassium, daily intake*

## STRESZCZENIE

**Wprowadzenie.** Naturalne wody mineralne są nabywane i spożywane przez konsumentów według ich preferencji oraz ewentualnych zaleceń. Dobór odpowiedniej wody powinien uwzględniać nie tylko ogólny stopień mineralizacji, lecz również zawartość poszczególnych składników, w tym elektrolitów takich jak sód i potas. Sód jest niezbędny dla prawidłowego fizjologicznego funkcjonowania organizmu, jako czynnik stanowiący ryzyko zaburzeń zdrowia definiowany jest dopiero wówczas, gdy odnotowuje się jego nadmierne spożycie. Potas działa antagonistycznie do jonów sodu i wapnia, powoduje

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obniżenie objętości płynów zewnątrzkomórkowych i jednocześnie zwiększa napięcie mięśniowe i przepuszczalność błon komórkowych. Zapotrzebowanie na sód i potas ma szczególne znaczenie w grupie osób wykonujących znaczący wysiłek fizyczny, gdzie wskazana jest większa podaż elektrolitów.

**Cel.** Celem badań było oszacowanie rzeczywistej zawartości sodu i potasu w naturalnych wodach mineralnych występujących na polskim rynku oraz ocena pobrania tych składników z badanych produktów przez różne grupy konsumentów przy założonej ilości ich spożycia.

**Materiał i metody.** Materiał badawczy stanowiły naturalne wody mineralne 40 różnych marek dostępne na polskim rynku. Badane produkty były wyprodukowane w Polsce oraz pochodziły z innych krajów europejskich. Wśród badanych produktów około 30% stanowiły wody pochodzące z Litwy, Łotwy, Czech, Francji, Włoch i Niemiec. Próbkę do badań stanowiły dwa opakowania badanej wody z różnych partii produkcyjnych. Próbki do badań pobierane były losowo. Badania przeprowadzono na tym samym materiale badawczym, na którym dokonano oznaczeń wapnia i magnezu, co było przedmiotem pierwszej części pracy [6].

Zawartość sodu i potasu oznaczono techniką emisyjną (płomień acetylen-powietrze), przy użyciu spektrometru absorpcji atomowej – ICE 3000 SERIES - THERMO - Anglia, wyposażonego w stację danych GLITE, stosując odpowiednio długości fali: 589,0 nm, 766,5 nm.

**Wyniki.** Uzyskane wyniki badań wskazują na duże zróżnicowanie zawartości zarówno sodu, jak i potasu w naturalnych wodach mineralnych występujących na polskim rynku, szczególnie tych średnio- i wysokozmineralizowanych. Spożycie 1 litra naturalnych wód mineralnych niskozmineralizowanych pozwala w niewielkim stopniu realizować zalecenia dotyczące ilości spożycia sodu, a w przypadku produktów o średnim i wysokim stopniu mineralizacji jest to bardzo zróżnicowane. Natomiast dostarczanie potasu z taką ilością naturalnej wody mineralnej może stanowić co najwyżej kilka procent zalecanej dziennej ilości tego składnika.

**Wnioski.** Duże zróżnicowanie zawartości sodu w naturalnych wodach mineralnych występujących na polskim rynku powinno skłaniać do analizy ich składu w celu uniknięcia zaburzeń zdrowia u danej grupy konsumentów. Badane naturalne wody mineralne w założonej wielkości dziennego spożycia nie są dobrym źródłem potasu dla analizowanych grup populacyjnych.

**Słowa kluczowe:** *naturalna woda mineralna, składniki mineralne, sód, potas, dzienne pobranie*

## INTRODUCTION

Numerous studies conducted in various countries indicate a high diversity in the composition of natural mineral waters [1, 3, 5, 14]. The importance of bottled waters in a diet results from the occurrence of such mineral components in their content as calcium, magnesium, sodium, potassium or the presence of carbohydrates, which regulate the acid-base balance in the body. Additionally, the ionized form of mineral components in water affects their good assimilability [15, 18, 16, 17]. Evaluation of natural bottled waters available in the Polish market as a source of calcium and magnesium was the subject of the first part of the study in this regard [6]. As the results of that part of the study indicate, natural mineral waters available in the market are characterized by a varied content of calcium and magnesium and even a very high level of product mineralization does not always guarantee significant amounts of these components. Although water can be the source of many mineral components, those occurring in the amounts above 15% of the recommended daily allowance are of significant importance [25, 26]. Natural mineral waters are purchased and consumed according to consumer preferences and recommendations. The choice of appropriate water should take into account not only the general level of mineralization, but also its content of individual components, including electrolytes such as sodium and potassium.

The concentration of $K^+$ and $Na^+$ ions in intracellular and extracellular spaces is a particularly important element for maintaining water and electrolyte homeostasis and the acid-base balance of the body. Changes in the concentration of sodium cations, the concentration of which is lower inside the cell than in the extracellular fluid, are a crucial factor for water and electrolyte balance disorders. $Na^+$ ions are the most significant and the dominant part of mineral components of blood serum and their normal concentration is estimated within the range of 136-145 mmol/L. Both too high and too low sodium content in blood serum can be detrimental to human health. A sodium content below 120 mmol/L can cause hyponatraemia, which is accompanied by nausea, lack of appetite, headaches, orientation disorders and, in extreme cases, tremors and coma. The health condition of the body in which the sodium concentration in blood serum is higher than 145 mmol/L is described as hypernatraemia and an increase in sodium concentration up to 160mmol/l can result in death [8, 9, 10, 13].

Sodium ions are a necessary element of water exchange between cells and intercellular substances, they also actively participate in the transport of nutrients (amino acids, glucose) through cellular membranes.

Sodium is necessary for the proper physiological functioning of the body and is defined as a risk factor for health disorders only when its excessive intake is recorded. It has been demonstrated that

a lowering of blood tension as a result of reducing the amount of sodium in the diet is a linear relation, proven in the interventional U.S. study known as DASH (Dietary Approaches to Stop Hypertension), evaluating the effect of sodium intake on blood pressure. The results of that study helped to prepare dietary recommendations for the prevention and treatment of blood hypertension [22].

Potassium acts antagonistically to sodium and calcium ions, contributes to a reduction of the volume of extracellular fluids while reducing muscle tension and the permeability of cellular membranes. The concentration of $K^+$ ions is much higher inside the cell than in the extracellular fluid. The extracellular fluid contains only 2% of the systemic potassium and the concentration of $K^+$ ions in body cells and extracellular spaces is precisely regulated since it guarantees proper nervous and muscular conduction. $K^+$ ions participate in the regulation of osmotic pressure and pH of the cell and they are also responsible for sending nervous impulses and for muscle contractions, as well as for proper metabolism of proteins and carbohydrates [9, 13, 23]. Low potassium level (hypokalaemia) is diagnosed when the potassium concentration in blood serum is below 3.4 mmol/l, which results in weakness, disorders of the nervous and muscular system functions, general fatigue, constipation, abnormal heart rhythms and kidney dysfunctions. Chronic potassium deficiency can lead to higher blood pressure and diseases of cardiovascular and urinary systems [2, 9]. Hyperkalaemia – an elevated concentration of potassium in blood serum – describes the condition when the concentration of $K^+$ ions is higher than 5.5 mmol/l. It results in irregularities in the functioning of the muscular and nervous systems and slowed heart rate [8, 9, 13].

The demand for sodium and potassium is of particular importance among people expending significant physical effort, where an increased electrolyte supply is recommended. The increased secretion of sweat, particularly when a physical effort is made at high temperatures, can lead instead to changes in the water content and the concentration of electrolytes in body fluids, resulting in an increase in their osmotic pressure. Sodium prevents rapid dehydration of the body. It is also worth emphasizing that an excessive supply of hypertonic fluids, provided during intensive physical effort, provokes the occurrence of hypertonic overhydration, characterized by an increased concentration of sodium ions in blood plasma, followed by an increase in osmolality and the volume of extracellular fluid and a reduction of the volume of intracellular fluid. The intake of chlorine-sodium waters during physical effort and at high temperatures allows for a reduction of dehydration and has a favourable effect on the performance and well-being of the body [8, 9, 23].

Early childhood is a period when proper dietary habits are developed, including the important habit of consuming water. For infants and children below the age of 3, for whom reduced sodium intake is advised, bottled spring waters or natural mineral waters with low sodium, low mineral and low sulphate level are recommended [23, 24]. Among the youngest consumers and young people, an excessive sodium consumption is often recorded [7, 11, 19, 20], which additionally indicates the need to consume low-sodium waters.

The aim of the study was to estimate the real content of sodium and potassium in natural mineral water available on the Polish market and to evaluate the intake of those components with the examined products by different groups of consumers at the assumed volume of their consumption.

The aim of the study was achieved by determining:

- the real content of sodium and potassium in the examined products,
- the percentage of intake of sodium and potassium with natural mineral water in the recommended daily intake in various age groups.

## MATERIAL AND METHODS

The study material consisted of natural mineral waters of 40 various brands available on the Polish market. The examined products were produced in Poland or originated from other European countries. 30% of the examined products were waters imported from such countries as Lithuania, Latvia, the Czech Republic, France, Italy and Germany. A sample for the tests consisted of two package units of the examined water from different production lots. Samples for the research were collected at random. The research was conducted using the same research material for which calcium and magnesium was determined, which was the subject of the first part of the study [6].

The content of sodium and potassium was determined using the emission technique (acetylene-air flame), with the use of an atomic absorption spectrometer – ICE 3000 SERIES – THERMO – England, equipped with a GLITE data station, with wavelengths of 589.0 nm and 766.5 nm, respectively. Determinations were carried out in the AAS laboratory, in which the above methods were validated. The applied concentrations of Na and K standard solutions provided the measurement range of the analytical method, which was characterized by the linearity of calibration curves. The limits of the measurement range (µg/ml) assumed for sodium and potassium, the formula ($y = ax + b$) and the coefficient of calibration curve ($R^2$ regression), respectively, were as follows:

| | | | |
|---|---|---|---|
| Na | 0.5-4.0 | y=22.284+11.985 | 0.9982 |
| K | 2.0-20.0 | y=4.6449x+9.2497 | 0.9891 |

The determinations used:

- Na and K models: standards of concentration 1 mg/cm$^3$ dissolved with 0.1 M solution of $HNO_3$ – by *J.T. Baker*, Holland,
- de-ionized water with resistivity >18.2 MΩ. cm obtained with the use of a water de-ionizer by SYNERGY - MILLIPORE – France.

The reliability of the analytical methods was assessed based an analysis of the certified reference material (Institute of Nuclear Chemistry and Technology). The following results were obtained for:

- sodium (mg/kg) - certified value -24.7±3.2, determined content - 25.1±2.9, recovery (%) - 101.6
- potassium (g/kg) - certified value -17.0±1.2, determined content - 16.8±1.4, recovery (%) - 98.8.

The intake of mineral waters was evaluated according to the norms of sodium and potassium intake, established at the level of adequate intake (AI) for and sex (Table 1) [16]. Additionally, the daily consumption of natural mineral water was assumed at the level of one liter. The evaluation did not take into account factors affecting the bioavailability of components in the body, as it was not the subject of the research.

The statistical analysis was carried out using Statistica 12 software (StatSoft, USA).

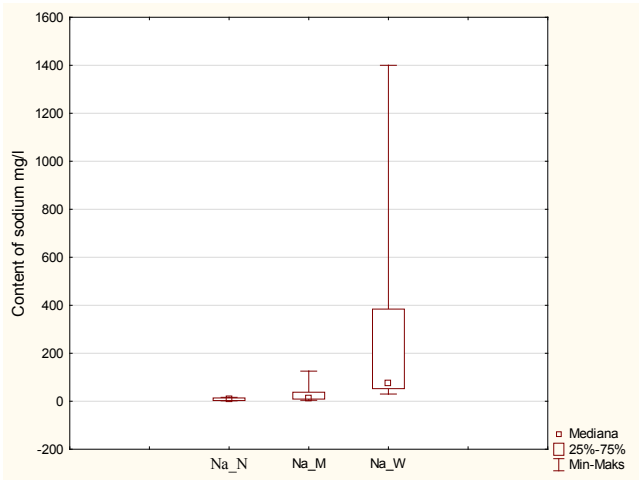
Table 1. Norms for electrolytes established at the level of adequate intake (AI) [Jarosz, 2012]

| Group (sex, age/years) | Potassium (mg/d) | sodium (mg/d) |
|---|---|---|
| | AI | AI |
| Children | | |
| 1-3 | 2400 | 750 |
| 4-6 | 3100 | 1000 |
| 7-9 | 3700 | 1200 |
| Boys | | |
| 10 – 12 | 4100 | 1300 |
| 13 – 15 | 4700 | 1500 |
| 16 - 18 | 4700 | 1500 |
| Men | | |
| 19 – 30 | 4700 | 1500 |
| 31 – 50 | 4700 | 1500 |
| 51 – 65 | 4700 | 1400 |
| 66 – 75 | 4700 | 1300 |
| ≥ 75 | 4700 | 1200 |
| Girls | | |
| 10 – 12 | 4100 | 1300 |
| 13 – 15 | 4700 | 1500 |
| 16 - 18 | 4700 | 1500 |
| Woman | | |
| 19 – 30 | 4700 | 1500 |
| 31 – 50 | 4700 | 1500 |
| 51 – 65 | 4700 | 1400 |
| 66 – 75 | 4700 | 1300 |
| ≥ 75 | 4700 | 1200 |

## RESULTS AND DISCUSSION

*Sodium and potassium content in natural mineral waters available on the market*

The natural mineral waters available in the Polish market are characterized by a varied level of mineralization, which is determined by the general content of mineral component. While analysing the dietary quality of this group of products, one criteria is the content of individual components, including the amount of sodium and potassium. As regards the group of low-mineralized natural mineral waters (which accounted for about ¼ of the examined products) all of them were characterized by low sodium content (Table 2). The amount of this component ranged from about 2 to about 16 mg in one liter. The physiological effects of such waters on the human body, as one of the criteria for classifying them as natural mineral waters, results exactly from the low content of sodium (below 20 mg/l). Diversification of the sodium content in this group of products was strongly lower than in medium- and highly-mineralized waters [Figure 1a]. The waters with a low mineralization level also featured the lowest diversification of potassium content, with values ranging from 0.59 to 3.42 mg/L (Table 2).




N – low-mineralized natural mineral water
S – medium-mineralized natural mineral water
W – high-mineralized natural mineral water

Figure 1a. Content of sodium in natural mineral water

The content of sodium in products with medium and high levels of mineralization was definitely higher (Table 2, Figure 1a), with sodium levels ranging from 4.6 to 808.40mg/l and from 31.38 to 1400.05 mg/L, respectively. These waters, as compared to low-mineralized waters, were also characterized by a high diversification of the potassium content (Table 2, Figure 1b). Among these waters, it is also possible to find products with a potassium ion content below 1mg/L, as well as products for which this value exceeded 50

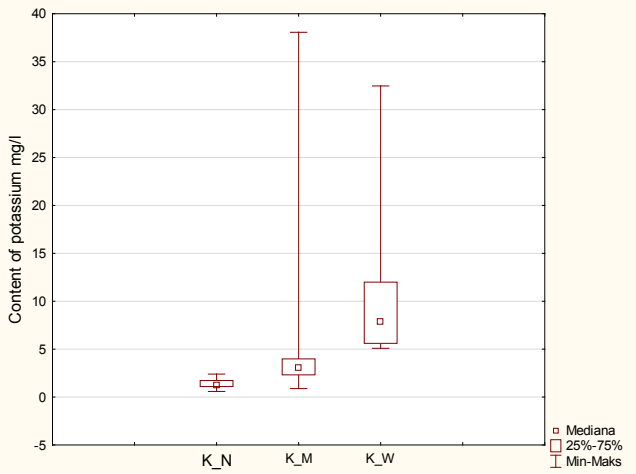
mg/l. The previous characteristics of natural mineral waters available on the market also indicate the high variability of sodium and potassium ions in the group of cations found in natural mineral waters [12].

Table 2. Sodium and potassium content in natural mineral waters, (mg/L)

| Trade name of product | Content of minerals, mg/L | |
|---|---|---|
| | Na | K |
| Low-mineralized natural mineral waters | | |
| Artic | 7.65 | 1.53 |
| Bolle | 3.43 | 1.14 |
| Dobrowianka | 1.94 | 1.06 |
| Evian | 6.35 | 1.18 |
| Fonta de Medici | 16.32 | 1.92 |
| Kropla Beskidu | 11.70 | 1.29 |
| Neptunas | 2,48 | 0.59 |
| Salinger | 15.91 | 3,42 |
| Vilsa | 16.09 | 2.40 |
| Medium-mineralized natural mineral waters | | |
| Augustowianka | 125.41 | 10.68 |
| Cisowianka | 9.91 | 4.06 |
| Everest | 11.02 | 3.02 |
| Food & Joy Natural Mineral Water | 38.53 | 4.10 |
| Grodziska Tesco | 15.08 | 2.90 |
| Jurajska | 9.22 | 3.91 |
| Kinga Pienińska | 4.06 | 3.82 |
| Krystynka | 808.40 | 13.07 |
| Magnesja | 4,50 | 1.52 |
| Nałęczowianka | 8.94 | 3.70 |
| Naturalna Woda Min. Sudety (Carrefour) | 37.88 | 3.06 |
| Naturalna woda mineralna Kaufland | 37.68 | 1.92 |
| Perrier | 10.11 | 0.89 |
| Polanica Tesco | 36.36 | 3.16 |
| Polaris | 11.92 | 2.79 |
| San Pellegrino | 28.86 | 2.66 |
| Ustronianka | 5.19 | 1.32 |
| Veroni Mineral | 8.13 | 2.88 |
| Wielka Pieniawa | 57.00 | 38.07 |
| Wielka Wieniecka | 15.18 | 1.98 |
| Zdroje Piwniczna | 82.01 | 5.11 |
| High-mineralized natural mineral waters | | |
| Borjomi | 1400.05 | 32.47 |
| Darida | 1071.5 | 13.91 |
| Kryniczanka | 52.72 | 6.50 |
| Muszyna Skarb Życia | 31.38 | 5.61 |
| Muszyna Tesco Cechini | 30.10 | 5.09 |
| Muszynianka | 73.41 | 7.88 |
| Naturalna Woda Mineralna Piotr i Paweł | 63.65 | 9.19 |
| Staropolanka | 110.55 | 53.09 |

*Percentage of sodium and potassium intake with natural mineral water in the daily intake of these components in different population groups.*

The evaluation of body demand for sodium and potassium is difficult due to a lack of clear data and research results which would make it possible to determine the recommended daily allowance (RDA) or estimated average requirement (EAR). Consequently, the norms of sodium and potassium intake were established at the level of appropriate intake (AI).




N - low-mineralized natural mineral water
S – medium-mineralized natural mineral water
W- high-mineralized natural mineral water

Figure 1b. Content of potassium in natural mineral water

The analysis of sodium intake with low-mineralized waters (Table 3) showed that for all population groups under analysis, this type of natural mineral water is not a significant source of sodium in a diet. An adequate intake of sodium was provided to the highest extent in the group of children aged 1-3 years (Vilsa, Salinger, Fronta de Medici waters) and when determined as a percentage of AI coverage it amounted to 2.12-2.18. For other population groups, it was low and provided about 1% of the referential values.

The intake of 1 liter of medium-mineralized mineral water (Table 4) ensures, depending on the product, very good or poor satisfaction of the recommendations concerning dietary sodium intake. A high sodium content was found in "Krystynka" water, the consumption of which, pursuant to the research assumptions, provides almost 54% of AI for women and men. An equally high percentage of meeting the recommendations was observed in population groups of girls and boys, and among children aged 1-3, the supply of 1 litre of this water provides almost 108% of AI, for children aged 4-6 years it provides 81%, and for 7-9-year-old children it provides 67.37%. Other medium-mineralized mineral waters examined satisfy the recommendation at the level between a few and twenty percent (Augustowianka,

Zdroje Piwniczna, Wielka Pieniawa) and in an amount equal to or less than 1% AI established for individual population groups (Veroni Mineral, Ustronianka, Magnesja, Jurajska).

Table 3. Percentage of daily intake of sodium with low-mineralized natural mineral water at the assumed consumption of 1 liter of water, %.

| Trade name of product | Children | | | Girls | | | Boys | | | Woman | | | Men | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Age (years) | | | | | | | | | | | | | | |
| | 1-3 | 4-6 | 7-9 | 10-12 | 13-15 | 16-18 | 10-12 | 13-15 | 16-18 | 19-30 | 31-50 | 51-65 | 19-30 | 31-50 | 51-65 |
| Artic | 1,02 | 0,77 | 0,64 | 0,59 | 0,51 | 0,51 | 0,59 | 0,51 | 0,51 | 0,51 | 0,51 | 0,54 | 0,51 | 0,51 | 0,54 |
| Bolle | 0,46 | 0,34 | 0,29 | 0,26 | 0,23 | 0,23 | 0,26 | 0,23 | 0,23 | 0,23 | 0,23 | 0,25 | 0,23 | 0,23 | 0,25 |
| Dobrowianka | 0,26 | 0,19 | 0,16 | 0,15 | 0,13 | 0,13 | 0,15 | 0,13 | 0,13 | 0,13 | 0,13 | 0,14 | 0,13 | 0,13 | 0,14 |
| Evian | 0,85 | 0,63 | 0,53 | 0,49 | 0,42 | 0,42 | 0,49 | 0,42 | 0,42 | 0,42 | 0,42 | 0,45 | 0,42 | 0,42 | 0,45 |
| Fonta de Medici | **2,18** | 1,63 | 1,36 | 1,26 | 1,09 | 1,09 | 1,26 | 1,09 | 1,09 | 1,09 | 1,09 | 1,17 | 1,09 | 1,09 | 1,17 |
| Kropla Beskidu | 1,56 | 1,17 | 0,98 | 0,90 | 0,78 | 0,78 | 0,90 | 0,78 | 0,78 | 0,78 | 0,78 | 0,84 | 0,78 | 0,78 | 0,84 |
| Neptunas | 0,33 | 0,25 | 0,21 | 0,19 | 0,16 | 0,16 | 0.19 | 0,16 | 0,16 | 0,16 | 0,16 | 0,18 | 0,16 | 0,16 | 0,18 |
| Salinger | **2,12** | 1,59 | 1,33 | 1,22 | 1,06 | 1,06 | 1,22 | 1,06 | 1,06 | 1,06 | 1,06 | 1,14 | 1,06 | 1,06 | 1,14 |
| Vilsa | **2,14** | 1,61 | 1,34 | 1,24 | 1,07 | 1,07 | 1,24 | 1,07 | 1,07 | 1,07 | 1,07 | 1,15 | 1,07 | 1,07 | 1,15 |

Table 4. Percentage of daily intake of sodium with medium-mineralized natural mineral water at the assumed consumption of 1 liter of water, %.

| Trade name of product | Children | | | Girls | | | Boys | | | Woman | | | Men | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Age (years) | | | | | | | | | | | | | | |
| | **1-3** | **4-6** | **7-9** | **10-12** | **13-15** | **16-18** | **10-12** | **13-15** | **16-18** | **19-30** | **31-50** | **51-65** | **19-30** | **31-50** | **51-65** |
| Augustowianka | **16,72** | **12,54** | **10,45** | **9,65** | **8,36** | **8,36** | **9,65** | **8,36** | **8,36** | **8,36** | **8,36** | **8,96** | **8,36** | **8,36** | **8,96** |
| Cisowianka | 1,32 | 0,99 | 0,83 | 0,76 | 0,66 | 0,66 | 0,76 | 0,66 | 0,66 | 0,66 | 0,66 | 0,71 | 0,66 | 0,66 | 0,71 |
| Everest | 1,47 | 1,10 | 0,92 | 0,85 | 0,73 | 0,73 | 0,85 | 0,73 | 0,73 | 0,73 | 0,73 | 0,79 | 0,73 | 0,73 | 0,79 |
| Food&Joy Natural Mineral Water | 5,14 | 3,85 | 3,21 | 2,96 | 2,57 | 2,57 | 2,96 | 2,57 | 2,57 | 2,57 | 2,57 | 2,75 | 2,57 | 2,57 | 2,75 |
| Grodziska Tesco | 2,01 | 1,51 | 1,26 | 1,16 | 1,01 | 1,01 | 1,16 | 1,01 | 1,01 | 1,01 | 1,01 | 1,08 | 1,01 | 1,01 | 1,08 |
| Jurajska | 1,23 | 0,92 | 0,77 | 0,71 | 0,61 | 0,61 | 0,71 | 0,61 | 0,61 | 0,61 | 0,61 | 0,66 | 0,61 | 0,61 | 0,66 |
| Kinga Pienińska | 0,54 | 0,41 | 0,34 | 0,31 | 0,27 | 0,27 | 0,31 | 0,27 | 0,27 | 0,27 | 0,27 | 0,29 | 0,27 | 0,27 | 0,29 |
| Krystynka | | **80,84** | **67,37** | **62,18** | **53,89** | **53,89** | **62,18** | **53,89** | **53,89** | **53,89** | **53,89** | **57,74** | **53,89** | **53,89** | **57,74** |
| Magnesja | 0,60 | 0,45 | 0,38 | 0,35 | 0,30 | 0,30 | 0,35 | 0,30 | 0,30 | 0,30 | 0,30 | 0,32 | 0,30 | 0,30 | 0,32 |
| Nałęczowianka | 1,19 | 0,89 | 0,75 | 0,69 | 0,60 | 0,60 | 0,69 | 0,60 | 0,60 | 0,60 | 0,60 | 0,64 | 0,60 | 0,60 | 0,64 |
| Natural mineral water Sudety (Carrefour) | 5,05 | 3,79 | 3,16 | 2,91 | 2,53 | 2,53 | 2,91 | 2,53 | 2,53 | 2,53 | 2,53 | 2,71 | 2,53 | 2,53 | 2,71 |
| Natural mineral water Kaufland | **5,02** | **3,77** | **3,14** | **2,90** | **2,51** | **2,51** | **2,90** | **2,51** | **2,51** | **2,51** | **2,51** | **2,69** | **2,51** | **2,51** | **2,69** |
| Perrier | 1,35 | 1,01 | 0,84 | 0,78 | 0,67 | 0,67 | 0,78 | 0,67 | 0,67 | 0,67 | 0,67 | 0,72 | 0,67 | 0,67 | 0,72 |
| Polanica Tesco | 4,85 | 3,64 | 3,03 | 2,80 | 2,60 | 2,60 | 2,80 | 2,42 | 2,42 | 2,42 | 2,42 | 2,60 | 2,60 | 2,60 | 2,60 |
| Polaris | 1,59 | 1,19 | 0,99 | 0,92 | 0,79 | 0,79 | 0,92 | 0,79 | 0,79 | 0,79 | 0,79 | 0,85 | 0,79 | 0,79 | 0,85 |
| San Pellegrino | 3,48 | 2,89 | 2,41 | 2,22 | 1,92 | 1,92 | 2,22 | 1,92 | 1,92 | 1,92 | 1,92 | 2,06 | 1,92 | 1,92 | 2,06 |
| Ustronianka | 0,69 | 0,52 | 0,43 | 0,40 | 0,35 | 0,35 | 0,40 | 0,35 | 0,35 | 0,35 | 0,35 | 0,37 | 0,35 | 0,35 | 0,37 |
| Veroni Mineral | 1,08 | 0,81 | 0,68 | 0,63 | 0,54 | 0,54 | 0,63 | 0,54 | 0,54 | 0,54 | 0,54 | 0,58 | 0,54 | 0,54 | 0,58 |
| Wielka Pieniawa | **7,60** | **5,70** | **4,75** | **4,38** | **3,80** | **3,80** | **4,38** | **3,80** | **3,80** | **3,80** | **3,80** | **4,07** | **3,80** | **3,80** | **4,07** |
| Wielka Wieniecka | 2,02 | 1,52 | 1,27 | 1,17 | 1,01 | 1,01 | 1,17 | 1,01 | 1,01 | 1,01 | 1,01 | 1,08 | 1,01 | 1,01 | 1,08 |

Table 5. Percentage of daily intake of sodium with high-mineralized natural mineral water at the assumed consumption of 1 liter of water, %.

| Trade name of product | Children | | | Girls | | | Boys | | | Woman | | | Men | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Age (years) | | | | | | | | | | | | | | |
| | **1-3** | **4-6** | **7-9** | **10-12** | **13-15** | **16-18** | **10-12** | **13-15** | **16-18** | **19-30** | **31-50** | **51-65** | **19-30** | **31-50** | **51-65** |
| Borjomi | **186,73** | **140,00** | **116,67** | **107,70** | **93,34** | **93,34** | **107,70** | **93,34** | **93,34** | **93,34** | **93,34** | **100,00** | **93,34** | **93,34** | **100,00** |
| Darida | **142,87** | **107,15** | **89,29** | **82,42** | **71,43** | **71,43** | **82,42** | **71,43** | **71,43** | **71,43** | **71,43** | **76,54** | **71,43** | **71,43** | **76,54** |
| Kryniczanka | **7,03** | **5,27** | **4,39** | 4,06 | 3,51 | 3,51 | 4,06 | 3,51 | 3,51 | 3,51 | 3,51 | 3,77 | 3,51 | 3,51 | 3,77 |
| Muszyna Skarb Życia | 4,18 | 3,14 | 2,62 | 2,41 | 2,09 | 2,09 | 2,41 | 2,09 | 2,09 | 2,09 | 2,09 | 2,24 | 2,09 | 2,09 | 2,24 |
| Muszyna Tesco Cechini | 4,01 | 3,01 | 2,51 | 2,32 | 2,01 | 2,01 | 2,32 | 2,01 | 2,01 | 2,01 | 2,01 | 2,15 | 2,01 | 2,01 | 2,15 |
| Muszynianka | **9,79** | **7,34** | **6,12** | **5,65** | 4,89 | 4,89 | 5,65 | 4,89 | 4,89 | 4,89 | 4,89 | 5,24 | 4,89 | 4,89 | 5,24 |
| Naturalna Woda Mineralna Piotr i Paweł | **8,49** | **6,37** | **5,30** | **4,98** | 4,24 | 4,24 | 4,98 | 4,24 | 4,24 | 4,24 | 4,24 | 4,55 | 4,24 | 4,24 | 4,55 |
| Staropolanka | **14,73** | **11,06** | **9,21** | **8,50** | **7,37** | **7,37** | **8,50** | **7,37** | **7,37** | **7,37** | **7,37** | **7,90** | **7,37** | **7,37** | **7,90** |
| Wysowianka | **51,20** | **38,40** | **32,00** | **29,53** | **25,60** | **25,60** | **29,53** | **25,60** | **25,60** | **25,60** | **25,60** | **27,43** | **25,60** | **25,60** | **27,43** |
| Źródła Muszyny | **15,93** | **11,95** | **9,96** | **9,19** | **7,96** | **7,96** | **9,19** | **7,96** | **7,96** | **7,96** | **7,96** | **8,53** | **7,96** | **7,96** | **8,53** |

Table 6. Percentage of daily intake of potassium with low-mineralized natural mineral water at the assumed consumption of 1 liter of water, %.

| Trade name of product | Children | | | Girls | | | Boys | | | Woman | | | Men | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Age (years) | | | | | | | | | | | | | | |
| | **1-3** | **4-6** | **7-9** | **10-12** | **13-15** | **16-18** | **10-12** | **13-15** | **16-18** | **19-30** | **31-50** | **51-65** | **19-30** | **31-50** | **51-65** |
| Artic | 0,06 | 0,05 | 0,04 | 0,04 | 0,03 | 0,03 | 0,04 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 |
| Bolle | 0,05 | 0,04 | 0,03 | 0,03 | 0,02 | 0,02 | 0,03 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 |
| Dobrowianka | 0,04 | 0,03 | 0,03 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 |
| Evian | 0,05 | 0,04 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 |
| Fonta de Medici | 0,08 | 0,06 | 0,05 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 |
| Kropla Beskidu | 0,54 | 0,04 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 |

The highly-mineralized waters examined (Table 5) are a generally good or very good source of sodium (Borjomi, Darida waters) satisfying 70-100% of the recommendations or even significantly exceeding them in population groups of children aged 10-12. It should also be emphasized that highly-mineralized waters can be low in sodium and ensure specific AI at a level below 5% for most population groups. The study by *Rychlik* [21] carried out with the participation of 11-13-year-old students of Warsaw schools proved that mineral and spring waters consumed by the youth covered sodium intake norms specified for this group at the level of 0.9-1.2%. The research carried out among students of the Warsaw University of Life Sciences and the Cardinal Wyszyński University in Warsaw [4] demonstrated that sodium intake with bottled water was at the level of about 1% of the referential value and potassium intake was about 0.04% AI, regardless of the university type.

The examined natural mineral waters in the assumed amount of daily consumption are not a good source of potassium for all population groups under analysis. For highly-mineralized waters (Table 8), the highest satisfaction of recommendations can be obtained through the supply of Staropolanka and Borjomi waters (from 0.69% AI for women, men, girls and boys aged 13-15 and 16-18 years old to 1.35% and 2.21% AI for children aged 1-3), while among medium-mineralized waters (Table 7), the best source of potassium is Wielka Pieniawa water, satisfying

1.58% of the recommended levels of AI for 1-3-year-old children, to 0.81 – 0.93% of the referential values for women, men, girls and boys.

Low-mineralized natural mineral waters (Table 6), at the assumed daily intake of 1 liter, satisfy dietary recommendations concerning potassium supply in a diet in the amount of tenths or hundreds of a percentage of referential values for individual population groups. The highest values (obtained for Salinger water) were at the level of 0.07% with reference to AI for women, men, boys and girls and up to 0.14% with reference to AI for children aged 1-3.

Table 7. Percentage of daily intake of potassium with medium-mineralized natural mineral water at the assumed consumption of 1 liter of water, %.

| Trade name of product | Children | | | Girls | | | Boys | | | Woman | | | Men | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Age (years) | | | | | | | | | | | | | | |
| | **1-3** | **4-6** | **7-9** | **10-12** | **13-15** | **16-18** | **10-12** | **13-15** | **16-18** | **19-30** | **31-50** | **51-65** | **19-30** | **31-50** | **51-65** |
| Augustowianka | 0,44 | 0,34 | 0,29 | 0,26 | 0,23 | 0,23 | 0,26 | 0,23 | 0,23 | 0,23 | 0,23 | 0,23 | 0,23 | 0,23 | 0,23 |
| Cisowianka | 0,17 | 0,13 | 0,11 | 0,10 | 0,08 | 0,08 | 0,10 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 |
| Everest | 0,13 | 0,09 | 0,08 | 0,07 | 0,06 | 0,06 | 0,07 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 |
| Food&Joy Natural Mineral Water | 0,17 | 0,13 | 0,11 | 1,00 | 0,09 | 0,09 | 1,00 | 0,09 | 0,09 | 0,09 | 0,09 | 0,09 | 0,09 | 0,09 | 0,09 |
| Grodziska Tesco | 0,12 | 0,09 | 0,08 | 0,07 | 0,06 | 0,06 | 0,07 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 |
| Jurajska | 0,16 | 0,13 | 0,11 | 0,09 | 0,08 | 0,08 | 0,09 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 |
| Kinga Pienińska | 0,15 | 0,12 | 0,10 | 0,09 | 0,08 | 0,08 | 0,09 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 |
| Krystynka | 0,54 | 0,42 | 0,35 | 0,31 | 0,28 | 0,28 | 0,31 | 0,28 | 0,28 | 0,28 | 0,28 | 0,28 | 0,28 | 0,28 | 0,28 |
| Magnesja | 0,06 | 0,05 | 0,04 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 |
| Nałęczowianka | 0,15 | 0,12 | 0,10 | 0,09 | 0,08 | 0,08 | 0,09 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 | 0,08 |
| Natural mineral water Sudety (Carrefour) | 0,13 | 0,10 | 0,08 | 0,07 | 0,06 | 0,06 | 0,07 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 |
| Naturalna woda mineral. Kaufland | 0,08 | 0,06 | 0,05 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 |
| Perrier | 0,03 | 0,03 | 0,02 | 0,02 | 0,01 | 0,01 | 0,02 | 0,01 | 0,01 | 0,01 | 0,01 | 0,01 | 0,01 | 0,01 | 0,01 |
| Polanica Tesco | 0,13 | 0,10 | 0,09 | 0,07 | 0,06 | 0,06 | 0,07 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 |
| Polaris | 0,12 | 0,09 | 0,08 | 0,07 | 0,06 | 0,06 | 0,07 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 |
| San Pellegrino | 0,11 | 0,09 | 0,07 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 |
| Ustronianka | 0,05 | 0,04 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 | 0,03 |
| Veroni Mineral | 0,12 | 0,09 | 0,08 | 0,07 | 0,06 | 0,06 | 0,07 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 | 0,06 |
| Wielka Pieniawa | **1,58** | **1,23** | **1,03** | 0,93 | 0,81 | 0,81 | 0,93 | 0,81 | 0,81 | 0,81 | 0,81 | 0,81 | 0,81 | 0,81 | 0,81 |
| Wielka Wieniecka | 0,08 | 0,06 | 0,05 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 |

Table 8. Percentage of daily intake of potassium with high-mineralized natural mineral water at the assumed consumption of 1 liter of water, %.

| Trade name of product | Children | | | Girls | | | Boys | | | Woman | | | Men | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Age (years) | | | | | | | | | | | | | | |
| | **1-3** | **4-6** | **7-9** | **10-12** | **13-15** | **16-18** | **10-12** | **13-15** | **16-18** | **19-30** | **31-50** | **51-65** | **19-30** | **31-50** | **51-65** |
| Borjomi | **1,35** | **1,05** | 0,88 | 0,79 | 0,69 | 0,69 | 0,79 | 0,69 | 0,69 | 0,69 | 0,69 | 0,69 | 0,69 | 0,69 | 0,69 |
| Darida | 0,58 | 0,45 | 0,38 | 0,34 | 0,30 | 0,30 | 0,34 | 0,30 | 0,30 | 0,30 | 0,30 | 0,30 | 0,30 | 0,30 | 0,30 |
| Kryniczanka | 0,27 | 0,21 | 0,18 | 0,16 | 0,14 | 0,14 | 0,16 | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 | 0,14 |
| Muszyna Skarb Życia | 0,23 | 0,18 | 0,15 | 0,13 | 0,12 | 0,12 | 0,13 | 0,12 | 0,12 | 0,12 | 0,12 | 0,12 | 0,12 | 0,12 | 0,12 |
| Muszyna Tesco Cechini | 0,21 | 0,16 | 0,14 | 0,12 | 0,11 | 0,11 | 0,12 | 0,11 | 0,11 | 0,11 | 0,11 | 0,11 | 0,11 | 0,11 | 0,11 |
| Muszynianka | 0,33 | 0,25 | 0,21 | 0,19 | 0,17 | 0,17 | 0,19 | 0,17 | 0,17 | 0,17 | 0,17 | 0,17 | 0,17 | 0,17 | 0,17 |
| Naturalna Woda Mineralna Piotr i Paweł | 0,38 | 0,30 | 0,25 | 0,22 | 0,19 | 0,19 | 0,22 | 0,19 | 0,19 | 0,19 | 0,19 | 0,19 | 0,19 | 0,19 | 0,19 |
| Staropolanka | **2,21** | **1,71** | **1,43** | **1,29** | **1,13** | **1,13** | **1,29** | **1,13** | **1,13** | **1,13** | **1,13** | **1,13** | **1,13** | **1,13** | **1,13** |
| Wysowianka | 0,50 | 0,39 | 0,32 | 0,29 | 0,26 | 0,26 | 0,29 | 0,26 | 0,26 | 0,26 | 0,26 | 0,26 | 0,26 | 0,26 | 0,26 |

## CONCLUSIONS

1. The high diversification of the sodium content in natural mineral waters available on the Polish market should encourage an analysis of their composition in order to avoid health disorders in a given group of consumers.
2. The examined natural mineral waters in the assumed amount of daily consumption are not a good source of potassium for the population groups under analysis.

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**Conflict of interest**
*The authors declare no conflict of interest.*

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