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ORIGINAL ARTICLE

QUALITY OF DRINKING WATER FROM THE AGRICULTURAL AREA TREATED WITH PITCHER WATER FILTERS

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ABSTRACT

Background. Home methods of drinking water treatment through filtration have recently become quite popular.

Objective. The aim of the study was to compare chemical composition of unfiltered water with water filtered in households with pitcher water filters. Obtained results were discussed in view of the effect of analysed chemical components of water on human health.

Material and methods. Water samples were taken from water works supplies and from home dug wells from the agricultural area. Unfiltered water and water filtered through filters filled with active carbon and ion-exchanging resin and placed in a pitcher were analysed. Electrolytic conductivity, pH, hardness and the concentrations of calcium, magnesium, nitrate, phosphate and chloride ions were determined in water samples. Results of analyses were statistically processed.

Results. As a result of water filtration, the concentration of phosphates significantly increased and the concentrations of calcium, magnesium, electrolytic conductivity and pH decreased. No changes were noted in the concentration of chloride ions. Filtering water decreased the concentration of nitrates in dug wells samples.

Conclusions. Using water purification devices is justified in the case of water originating from home dug wells contaminated with nitrates when, at the same time, consumers' diet is supplemented with calcium and magnesium. Filtration of water from water works supplies, controlled by sanitary inspection seems aimless.

Key words: *water filtration, calcium, magnesium, nitrates, phosphates, chlorides, acidity*

STRESZCZENIE

Wprowadzenie. Sposoby uzdatniania wody pitnej w gospodarstwie domowym przez filtrację stały się ostatnio bardzo popularne.

Cel. Celem badań było porównanie składu chemicznego wody niefiltrowanej z wodą filtrowaną w gospodarstwach domowych za pomocą filtrów dzbankowych. Wyniki badań zostały omówione w aspekcie wpływu analizowanych składników chemicznych wody na zdrowie człowieka.

Materiał i metody. Próbki wody pobierano z ujęć wodociągowych oraz ze studni kopanych na terenach rolniczych. Analizowano próbki wody niefiltrowanej i filtrowanej za pomocą filtrów dzbankowych, wypełnionych węglem aktywnym i żywicą jonowymienną. W próbkach wody oznaczano: przewodność elektrolityczną, pH, twardość i stężenie jonów wapnia, magnezu, azotanów, fosforanów oraz chlorków. Wyniki analizy opracowano statystycznie.

Wyniki. W wyniku filtrowania wody odnotowano znaczący wzrost stężenia fosforanów oraz obniżenie stężenia wapnia, magnezu, przewodnictwa elektrolitycznego i pH. Nie stwierdzono zmian w stężeniu jonów chlorkowych. W próbkach wody filtrowanej pochodzącej ze studni kopanych stwierdzono zmniejszenie stężenia azotanów w porównaniu z próbkami wody niefiltrowanej.

Wnioski. Wykorzystanie urządzeń do filtrowania wody jest uzasadnione w przypadku wody zanieczyszczonej azotanami, pochodzącej z studni kopanych, przy jednoczesnym uzupełnianiu diety konsumentów wapniem i magnezem. Filtracja wody z ujęć wodociągowych, kontrolowanych przez inspekcję sanitarną wydaje się bezcelowa.

Słowa kluczowe: *filtracja wody, wapń, magnez, azotany, fosforany, chlorki, kwasowość*

INTRODUCTION

Water and substances contained therein are essential for proper functioning of human organism. Drinking water should have a composition favourable for human health and be devoid of harmful substances. Basic inorganic components in water are calcium, magnesium, sodium, potassium and bicarbonate ions. They are considered the main components in typical natural waters and constitute over 90% of dissolved substances [3]. Water quality and the content of inorganic components depend on the type of substratum. The following values

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were adopted as a geochemical background for natural ground waters in Poland: pH 6.5 - 8.5, conductivity 200 - 700 µS/cm, Ca 2 - 200 mg/l, Mg 0.5 - 30 mg/l, NO_3^- 0 - 5 mg/l, Cl^- 2 - 60 mg/l, PO_4^{3-} 0.01 - 1.0 mg [22]. For 70% of people in Poland ground waters are the source of drinking water [26]. These are mainly deep waters situated under impermeable rocky formations and unaffected by anthropogenic pollution. Part of Poland's inhabitants, mainly from rural areas, use home dug wells fed with ground waters. In the year 2013, 76.6% of rural population were supplied in water from water works, the rest used water mainly from home wells [26]. Water from dug wells often situated near farm buildings is exposed to pollution and, compared with water from deep intakes, contains more nitrates, phosphates, chlorides and has a higher total hardness [2, 10, 20].

Water from water works in Poland is controlled by the State Sanitary Inspection and its consumption should not pose health risk. The order of the Minister of Health on the assessment of drinking water quality [24] imposes an obligation on the State Sanitary Inspection to issue the areal assessments of water quality to fulfil the demands determined in the order and to estimate health risk of the consumers. Legal regulations, being in effect since 2010 and agreed with the EU norms, guarantee that drinking water meets the highest standards [31]. Water from home wells, however, is not monitored by sanitary services and, in some cases, its systematic consumption may pose a risk for consumers' health, mainly due to nitrate concentrations that exceed the obligatory standards [2, 20, 27].

Various methods of water treatment through filtration are used to improve its quality [12, 21, 29, 30]. Filtration of water reduces both organic and inorganic (e.g. heavy metals) pollutants [1], removes pharmaceuticals [7, 21, 28] and decreases water hardness [12], but it also changes microbiological composition of water [30]. Home methods of drinking water treatment through filtration have recently become quite popular. The two most popular methods of water purification are reverse osmosis and pitcher filters equipped with replacement filters filled with active carbon and ion-exchanging resin. Studies on the quality of drinking water filtered in home intakes with reverse osmosis showed that the process decreased water hardness but did not efficiently remove nitrates [15].

This study was aimed at estimating the effect of water filtering in households though pitcher filters on changes in the chemical properties of water with main focus on such parameters as conductivity, pH, water hardness, concentrations of magnesium, calcium, chlorides, nitrates and phosphates. Water samples from water works and from home dug wells located in an agricultural area were analysed. The results obtained were used to assess the influence of water filtration on chemical properties of water and discussed in the context of human health.

MATERIAL AND METHODS

Water samples were randomly collected from 33 localities situated in an agricultural area in north-eastern Poland. Intakes of water works (n=18) were situated deeper than 100 m below ground. Samples from dug wells (n=15) were collected from the depth varying from 7 to 12 m. Each water sample was analysed before (sample A) and after (sample B) filtration. Filtered water samples were purified with filters filled with active carbon and ion-exchanging resin and placed in a pitcher. According to the information obtained in households, the filters had been used from 1 to 3 weeks.

Water samples were analysed for selected chemical parameters. Conductivity was measured with a conductivity meter and pH was determined with a digital pH meter. Water hardness and the concentrations of calcium and magnesium were determined complexometrically with EDTA as a titrant and eriochrome black and murexid as indicators. Concentrations of chloride ions were determined with the argentometric method. Nitrates concentration was determined with the use of disulfonic acid. Phosphates were measured with the molybdenum blue method. Nitrates and phosphates were determined spectrophotometrically at wavelengths of 410 and 700 nm, respectively. The applied methods of samples analyses were in accord with the recommendations given in the Regulation of the Minister of Environment [23]. All spectrophotometric analyses were performed with Shimadzu UV-VIS 1800 spectrophotometer (produced in Japan). All the analyses were repeated three times and the arithmetic mean of the three measurements was used for further interpretation of data.

The results of the analyses were statistically processed. Data distribution was checked with *Shapiro-Wilk* test, t-*Student* test or *Wilcoxon* test were used to compare means or medians of determined parameters. Comparisons of water components between the two types of water intakes were made with non-parametric *Mann-Whitney* U test. Statistical calculations were performed with Statistica 10 software.

RESULTS

Analysed water parameters varied significantly. Electrolytic conductivity varied from 52.0 to 1305.0 µS/cm, pH from 4.71 to 8.29, water hardness from 11.60 to 569.9 mg $CaCO_3$/l, calcium concentration from 2.40 to 168.3 mg/l, magnesium concentration from 0.0 to 36.47 mg/l, the concentration of nitrates from 0.040 to 104.0 mg/l, concentration of phosphates from 0.016 to 3.801 mg/l, and the concentration of chlorides from 2.00 to 185.0 mg/l (Tables 1, 2). Most analysed parameters had non-normal distribution (Table 3), therefore, in such cases median values were used in data interpretation.

Table 1. Descriptive statistics of selected parameters in unfiltered (A) and filtered (B) water with the division into water taken from water works supply

Parameter	Unit	Mean	Median	Range (min. – max.)	Lower - upper quartile	Interval quartile	SD
Conductivity A	µS/cm	448.9	469.5	143.0 -700.0	373.0 - 550.0	177.0	148.9
Conductivity B		283.9	273.5	52.00 - 534.0	181.0 - 364.0	183.0	134.4
Acidity A	pH	7.154	7.100	6.760 - 7.700	6.990 - 7.280	0.290	0.272
Acidity B		6.604	6.445	5.480 - 7.620	6.000 - 7.290	1.290	0.664
Hardness A	mg $CaCO_3$/l	240.8	251.76	90.00 - 339.9	219.9 - 290.0	249.9	73.16
Hardness B		87.76	79.01	11.60 - 247.9	36.20 - 123.0	236.4	59.50
Ca^{2+} A	mg/l	77.75	82.96	20.04 - 113.8	67.33 - 92.99	25.66	26.36
Ca^{2+} B		25.22	24.45	2.405 - 56.11	9.700 - 36.87	27.17	16.27
Mg^{2+} A		11.37	11.43	0.970 - 25.28	8.265 - 13.90	5.635	5.009
Mg^{2+} B		6.038	4.132	0.000 - 26.25	1.440 - 9.724	8.284	6.441
NO_3^- A		1.890	2.201	0.505 - 4.982	0.864 - 2.230	1.366	1.226
NO_3^- B		2.017	1.653	0.040 - 8.414	0.514 - 2.315	1.801	2.026
PO_4^{3-} A		0.175	0.138	0.016 - 0.656	0.050 - 0.246	0.196	0.165
PO_4^{3-} B		0.388	0.319	0.020 - 1.694	0.142 - 0.479	0.337	0.387
Cl^- A		23.12	16.000	4.000 - 100.1	11.00 - 26.00	15.00	22.35
Cl^- B		21.95	15.500	2.000 - 92.10	11.00 - 25.00	14.00	21.61

Table 2. Descriptive statistics of selected parameters in unfiltered (A) and filtered (B) water with the division into water taken from dug wells

Parameter	Unit	Mean	Median	Range (min. – max.)	Lower - upper quartile	Interval quartile	SD
Conductivity A	µS/cm	608.3	528.0	250.0 -1305.0	444.0 - 703.0	259.0	308.3
Conductivity B		375.6	338.0	41.00 - 981.0	216.0 - 535.0	319.0	241.9
Acidity A	pH	7.177	7.250	6.450 - 8.290	6.750 - 7.390	0.640	0.486
Acidity B		6.065	5.810	4.710 - 7.700	5.650 - 6.550	0.900	0.811
Hardness A	mg $CaCO_3$/l	303.9	285.9	125.0 - 569.9	234.0 - 379.9	444.9	108.1
Hardness B		107.6	91.90	12.00 - 308.0	64.00 - 122.0	296.0	80.05
Ca^{2+} A	mg/l	101.4	96.19	48.10 - 168.3	80.16 - 116.2	36.00	32.35
Ca^{2+} B		29.20	24.85	4.810 - 73.75	17.64 - 44.08	26.44	18.59
Mg^{2+} A		12.39	9.724	1.220 - 36.47	5.834 - 16.29	10.46	9.083
Mg^{2+} B		8.438	5.340	0.000 -30.14	2.100 - 11.18	9.080	8.965
NO_3^- A		35.88	26.48	0.208 - 104.0	0.841 - 62.40	61.56	36.78
NO_3^- B		16.08	6.100	0.159 - 78.78	2.750 - 22.05	19.30	21.32
PO_4^{3-} A		0.770	0.430	0.063 - 3.639	0.279 - 1.039	0.760	0.922
PO_4^{3-} B		1.074	0.772	0.150 -3.801	0.459 - 1.204	0.744	0.918
Cl^- A		41.01	20.00	8.000 - 185.0	15.00 - 37.00	22.00	46.19
Cl^- B		33.38	18.00	6.000 - 118.0	14.00 - 37.50	23.50	33.16

Table 3. Statistical data on the normal distribution of measured water parameters

Parameter	Water works supply (n=18)		Dug wells (n=15)	
	W	*p*	*W*	*p*
Conductivity A	0.959	0.576	0.818	0.008
Conductivity B	0.973	0.855	0.938	0.359
Acidity A	0.937	0.257	0.952	0.554
Acidity B	0.933	0.222	0.876	0.041
Hardness A	0.889	0.037	0.932	0.290
Hardness B	0.918	0.122	0.859	0.024
Ca^{2+} A	0.904	0.067	0.975	0.927
Ca^{2+} B	0.942	0.314	0.906	0.116
Mg^{2+} A	0.919	0.124	0.859	0.024
Mg^{2+} B	0.798	0.001	0.831	0.009
NO_3^- A	0.854	0.009	0.856	0.021
NO_3^- B	0.806	0.001	0.743	< 0.001
PO_4^{3-} A	0.830	0.004	0.672	< 0.001
PO_4^{3-} B	0.758	< 0.001	0.786	0.002
Cl^- A	0.699	< 0.001	0.664	< 0.001
Cl^- B	0.738	< 0.001	0.733	< 0.001

Water samples from water works and from dug wells were similar in conductivity, pH, water hardness and the concentrations of magnesium and chlorides but differed markedly in the concentration of nitrates and phosphates. In the water from dug wells there was 12 times more nitrates and 3 times more phosphates than in the water from water works. Water from wells was a bit richer in calcium ions compared with samples from waterworks, yet the difference was statistically insignificant (Tables 1, 2 and 4).

Table 4. Analysed water parameters in relation to the type of water intake (comparison with *Mann-Whitney* U test)

Parameter	Sum of ranks - water supply	Sum of ranks - dug wells	*U*	*Z*	*p*
Conductivity A	274.0	287.0	103.0	-1.139	0.255
Conductivity B	278.0	283.0	107.0	-0.994	0.320
Acidity A	301.0	260.0	130.0	-0.163	0.871
Acidity B	370.0	191.0	71.00	2.296	0.022
Hardness B	267.0	294.0	96,00	-1,392	0,164
Hardness A	295.0	266.0	124,0	-0,380	0,704
Ca^{2+} A	254.5	306.5	83.50	-1.844	0.065
Ca^{2+} B	294.5	266.5	123.5	-0.398	0.691
Mg^{2+} A	322.5	238.5	118.5	0.578	0.563
Mg^{2+} B	291.0	270.0	120.0	-0.524	0.600
NO_3^- A	237.0	324.0	66.00	-2.477	0.013
NO_3^- B	228.0	333.0	57.00	-2.802	0.005
PO_4^{3-} A	208.0	353.0	37.00	-3.525	< 0.001
PO_4^{3-} B	216.0	345.0	45.00	-3.236	0.001
Cl^- A	263.0	298.0	92.00	-1.536	0.124
Cl^- B	269.5	291.5	98.50	-1.302	0.193

Significant correlations ($p<0.05$, $n=15$) between water hardness and the concentration of nitrates ($R_s=0.650$) and chlorides ($R_s=0.612$) were found in the water from dug wells. Similarly, meaningful correlations were found between the concentrations of nitrates and calcium ($R_s=0.650$) and between the concentration of chlorides and calcium ($R_s=0.556$). No such correlations were noted for water from water works.

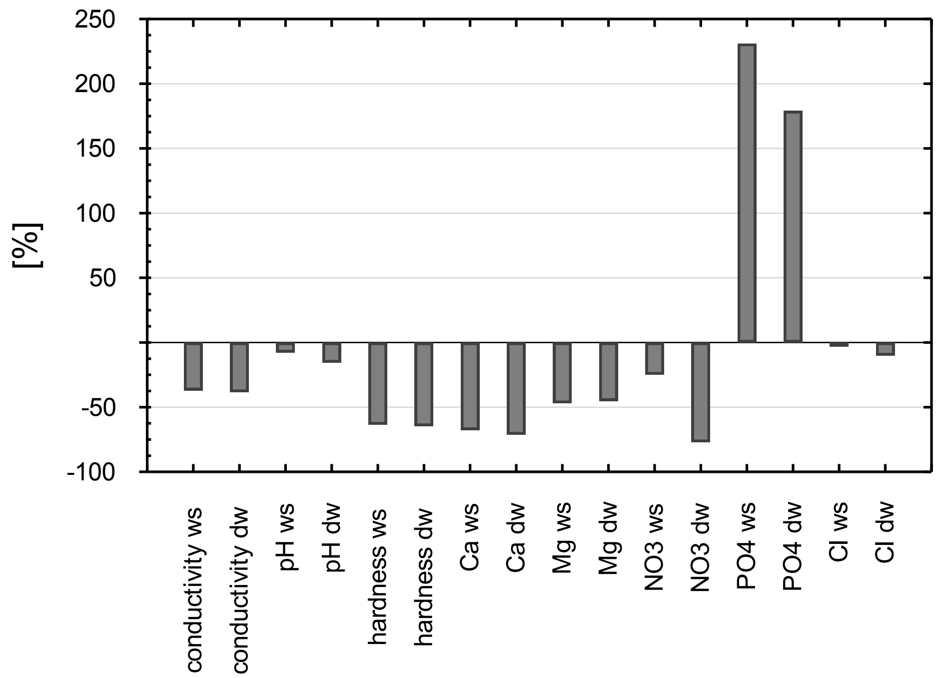

Figure 1. Percentage changes in values of chosen chemical parameters as a result of water filtration with household pitcher water filters (ws - water supply, dw - dug wells)

Table 5. Comparison of analysed water parameters in unfiltered (A) and filtered (B) water samples

Water works supply (n=18)				
Parameter	*t*	*df*	*p*	Statistical test
Conductivity A & B	7.050	17	< 0.001	t-*Students*
Acidity A & B	4.394	17	< 0.001	
Ca^{2+} A & B	8.333	17	< 0.001	
	T	*Z*	*p*	
Hardness A & B	0.00	3.725	< 0.001	*Wilcoxon*
Mg^{2+} A & B	7.500	3.396	< 0.001	
NO_3^- A & B	63.00	0.979	0.327	
PO_4^{3-} A & B	27.00	2.548	0.011	
Cl^- A &B	43.50	1.829	0.067	
Dug wells (n=15)				
Parameter	*T*	*Z*	*p*	Statistical test
Conductivity A & B	1.000	3.351	< 0.001	*Wilcoxon*
pH A & B	3.000	3.237	0.001	
Hardness A & B	1.00	3.351	< 0.001	
Mg^{2+} A & B	6.000	3.067	0.002	
NO_3^- A & B	7.000	3.010	0.002	
PO_4^{3-} A & B	0.000	3.408	< 0.001	
Cl^- A & B	28.00	1.817	0.069	
	t	*df*	*p*	t-*Students*
Ca^{2+} A & B	12.75	14	< 0.001	

With the exception of phosphates, higher concentrations of the studied parameters were found in unfiltered than in filtered water. In water samples from both water works and dug wells, filtration process decreased electrolytic conductivity by more than 35% and calcium concentrations by about 70%. Concentrations of magnesium ions decreased by 45% in water from water works and by 64% in water from dug wells. Water pH decreased due to filtration, which was particularly visible in water from dug wells. In these water samples filtration decreased nitrate concentration by almost 80% and about 25% in samples from water works. In both types of water samples, filtration did not significantly affect chloride concentrations but markedly increased the concentration of phosphates (Figure 1, Tables 1, 2 and 5).

DISCUSSION

Values of physical and chemical parameters in samples of water from water works fell within the range given as a geochemical background for ground water in Poland [22]. In the samples of water from dug wells, however, the geochemical background values were exceeded in 80% of samples for nitrates and in 27% of samples for phosphates and electrolytic conductivity. These results suggest that water from dug wells is largely exposed to pollutant inflow and statistically significant correlations between water components indicate that the pollutants are of municipal origin or come from animal breeding [10]. Noteworthy, water from individual intakes is not the subject to sanitary control in Poland and, in some cases, its quality may pose a threat to consumers' health, mainly because of high nitrate concentrations. Nitrates may cause methaemoglobinemia in infants and little children and diseases of alimentary tract and hypertension in adults. Long exposure to high nitrate concentrations may be carcinogenic [4, 8, 14]. The maximal allowable concentration of nitrates in drinking water in Poland is 50 mg/l [24]. The concentration of nitrates in ground water below 5 mg/l is natural and does not pose a risk for consumers' health. The process of filtration does not affect significantly the concentration of nitrate ions in water. Lack of significant changes in nitrate concentration after filtration through membrane filters was also noted by *Van der Bruggen* et al. [29]. Changes in the concentration of nitrates were, however, significant in water taken from wells. This water with its concentration of nitrates over ten times higher than in deep water intakes may be markedly improved after filtration.

Drinking water is an important source of calcium and magnesium in diet [5, 9]. The results of presented analyses of randomly collected water samples showed that filtration of water in households decreased water hardness and the concentrations of calcium and magnesium. It also led to water acidification. The revealed effects of filtration on water properties may have unfavourable consequences for the health of consumers.

Both calcium and magnesium participate in many physiological processes in human organism at subcellular, cellular and tissue level. Their deficit leads to hypocalcemia and hypomagnesemia [6, 17, 18, 19]. Chronic hypocalcemia may result in osteoporosis [17, 18]. Moreover, hypocalcemia increases the risk of cerebral stroke and leads to an increase of blood pressure [11]. Magnesium deficit in human organism contributes to diseases of blood circulation system, disturbs heartbeat rhythm, causes vertigo and muscle spasms [6, 25]. Larsson et al. [16] underlined that high magnesium intake may reduce the occurrence of colorectal cancer in women. In view of presented literature data one can hardly agree with a common belief that home filtration of water may improve its quality. *Rubenowitz* et al. [25] clearly indicate the correlation between the concentration of magnesium and the calcium to magnesium ratio in drinking water and health risk associated e.g. with heart diseases.

Filtration increased phosphate concentration in water. This was true for both water from water works and from dug wells. Systematic uptake of higher amounts of phosphates in drinking water may result in symptoms described e.g. by *Kemi* et al. [13] and *Maziarska* and *Pasternak* [17], including unfavourable effects on bone metabolism and disturbed calcium-phosphate equilibrium. Filtration of water markedly decreased its pH. Acidification of water after filtration is an effect of calcium and magnesium sorption on ion-exchanging resin and their replacement by hydrogen ions.

The results of presented analyses of randomly collected ground water samples showed that using filters decreased the concentrations of calcium and magnesium, substantially decreased pH value and increased phosphate concentrations. Water from deep intakes contains natural concentrations of nitrate ions and is the subject of control by sanitary services. Improving its quality by filtration is fruitless. Filtration of water may only decrease the risk of exposure to high nitrate concentrations in the case of water from dug wells polluted by these substances.

CONCLUSIONS

1. The improvement of water quality with home methods when the water is supplied by water works and analysed by sanitary services seems pointless.
2. In the case of dug wells, using water purification devices decreases health risk subsequent to the intake of nitrates with water.
3. Due to the lowered calcium and magnesium concentrations in water treated with pitcher water filters, it is advisable to supplement diet with these elements.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. *Ahmedna M., Marshall W.E., Husseiny A.A., Rao R.M., Goktepe I.*: The use of nutshell carbons in drinking water filters for removal of trace metals. Water Res 2004;38:1062–1068. doi:10.1016/j.watres.2003.10.047
2. *Bilek M., Rybakowa M.*: Nitrates and nitrites content in the samples taken from the dug and drilled wells from the area of Podkarpacie region as a methemoglobinemia risk factors. Prz Lek 2014;71(10):520–522.
3. *Derkowska-Sitarz M., Adamczyk-Lorenc A.*: Influence of mineral components dissolved in drinking waters on human organism. Pr Nauk Inst Górn Politech Wrocł 2008;123(34) 39–48.
4. *Fewtrell L.*: Drinking-water nitrate, methemoglobinemia, and global burden of disease: a discussion. Environ Health Persp 2004;112(14):1371–1374. doi: 10.1289/ehp.7216
5. *Gątarska A., Tońska E., Ciborska J.*: Natural mineral bottled Walters available on the Polish market as a source of minerals for the consumer. Part 1. Calcium and magnesium. Rocz Panstw Zakl Hig 2016; 67(1): 1-8.
6. *Grzebisz W.*: Magnesium - food and human health. J Elementol 2011;16(2):299–323. doi: 10.5601/jelem.2011.16.2.13
7. *Huerta-Fontela M., Galceran M.T., Ventura F.*: Occurrence and removal of pharmaceuticals and hormones through drinking water treatment. Water Res 2011;45:1432–1442. doi:10.1016/j.watres.2010.10.036
8. *Jamaludin N., Sham S.M., Ismail S.N.S.*: Health risk assessment of nitrate exposure in well water of residents in intensive agriculture area. Am J Appl Sci. 2013;10(5):442–448. doi:10.3844/ajassp
9. *Januszko O., Madej D., Postaleniec E., Brzozowska A., Pietruszka B., Kałuża J.*: Minerals intake from drinking water by young women. Rocz Panstw Zakl Hig 2012;63(1):43-50.
10. *Jaszczyński J., Sapek A., Chrzanowski S.*: Chemical indices of drinking water from wells in farms situated in the buffer zone of the Biebrza National Park. Woda Środ Obsz Wiej. 2006;62(18):129–142.
11. *Jorde R., Bonaa K.H.*: Calcium dairy products, vitamin D intake and blood pressure: the Tromsø study. Am J Clin Nutr 2000; 6:1530–1535.
12. *Karakulski K., Gryta M., Morawski A.*: Membrane processes used for potable water quality improvement. Desalination. 2002;145:315–319.
13. *Kemi V.E., Kärkkäinen M.U.M., Lamberg-Allardt Ch.J.E.*: High phosphorus intakes acutely and negatively affect Ca and bone metabolism in a dose-dependent manner in healthy young females. Brit J Nutr 2006;96,545–552. doi: 10.1079/BJN20061838
14. *Knobeloch L., Salna B., Hogan A., Postle J., Anderson H.*: Blue babies and nitrate contaminated well water. Environ Health Perspect 2000;108:675–678.
15. *Królak E., Raczuk J., Biardzka, E.*: Do water filters improve the quality of potable water? J Elementol 2015;20(1):149–159. doi: 10.5601/jelem.2013.18.4.541
16. *Larsson S.C., Bergkvist L., Wolk A.*: Magnesium intake in relation to risk of colorectal cancer in women. JAMA. 2005; 293(1):86–89. doi:10.1001/jama.293.1.86

17. *Maziarska A., Pasternak K.*: Calcium and phosphorus in medicine and treatment. J Elementol 2013;18(3):529–539. doi: 10.5601/jelem.2013.18.3.16
18. *Morr S., Cuartas E., Alwattar B., Lane J.M.*: How much calcium is in your drinking water? A survey of calcium concentrations in bottled and tap water and their significance for medical treatment and drug administration. HSSJ. 2006;2:130–135. doi: 10.1007/s11420-006-9000-9
19. *Pasternak K., Kocot J., Horecka A.*: Biochemistry of magnesium. J Elementol 2010;15(3):601–616.
20. *Raczuk J.*: Nitrogen compounds in the well water of Sokołów Podlaski district. Rocz Panstw Zakl Hig 2006;57(1):49–56. (in Polish)
21. *Radjenovic´ J., Petrovic´ M., Venturac F., Barcelo D.*: Rejection of pharmaceuticals in nanofiltration and reverse osmosis membrane drinking water treatment. Water Res 2008;42:3601–3610. doi:10.1016/j.watres.2008.05.020
22. Regulation of the Minister of Environment of 23 July 2008 on the criteria and monitoring of the assessment of groundwater Dz.U.2008 no. 143 item 896 (in Polish).
23. Regulation of the Minister of Environment of 15 November 2011 on the forms and monitoring of surface water and groundwater Dz.U.2011 no. 258 item 1550. (in Polish)
24. Regulation of the Minister of Health of 13 November 2015 on the quality of water intended for consumption. Dz.U.2015, item 1989 (in Polish).
25. *Rubenowitz E., Molin I., Axelsson G., Rylander R.*: Magnesium in drinking water in relation to morbidity and mortality from acute myocardial infarction. Epidemiology 2000;11(4):416–421.
26. Statistical Information and Elaborations. Environment. Central Statistical Office, Warsaw, 2014.
27. *Su X., Wang H., Zhang Y.*: Health risk assessment of nitrate contamination in groundwater: a case study of an agricultural area in northeast China. Water Resour Manag 2013;27:3025–3034. doi: 10.1007/s11269-013-0330-3
28. *Ternes T.A., Meisenheimer M., McDowell D., Sacher F., Brauch H.J., Haist-Gulde B., Preuss G., Wilme U., Zulei-Seibert N.*: Removal of pharmaceuticals during drinking water treatment. Environ Sci Technol 2002;36:3855–3863. doi: 10.1021/es015757k
29. *Van der Bruggen B., Everaert K., Wilms D., Vandecasteele C.*: Application of nanofiltration for removal of pesticides, nitrate and hardness from ground water: rejection properties and economic evaluation. J Membrane Sci 2001;193(2):239–248. doi: 10.1016/S0376-7388(01)00517-8
30. *Velten S., Boller M., Köster O., Helbing J., Weilenmann H.U., Hammes F.*: Development of biomass in a drinking water granular active carbon (GAC) filter. Water Res 2011;45(19):6347–6354. doi:10.1016/j.watres.2011.09.017
31. *Wojtyła-Buciora P., Marcinkowski J.T.*: Estimation of health risk resulting from excessive chemical parameters in drinking water. Probl Hig Epidemiol 2010;91(1):137–142.

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