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Dorota KALEMBASA[1], Dawid JAREMKO[1], Marcin BECHER[1], Krzysztof PAKUŁA[1] and Kamil STEFAŃSKI[1]

CHEMISTRY OF TAP WATER IN SELECTED LOCALITIES ON SOUTH PODLASIE LOWLAND

CHEMIZM WODY WODOCIĄGOWEJ W WYBRANYCH MIEJSCOWOŚCIACH NIZINY POŁUDNIOWOPODLASKIEJ

Abstract: The aim of this paper is presentation of results of chemical composition of tap water in selected localities on South Podlasie Lowland. Samples of water were taken from water treatment station and taps situated in various parts of Lukow, Sokolow Podlaski and selected localities in Lochow, Wierzbno and Mokobody commune. Quarterly investigations covered analysis of water reaction (pH) by potentiometric method, electrical conductivity (EC) by electrochemical method and total concentration of 26 elements by inductively coupled plasma atomic emission spectrometry (ICP-AES). It was found that untreated waters being the source of tap water in selected localities on South Podlasie Lowland contained excessive iron and manganese amounts, that were efficiently removed during the treatment. Concentration of analyzed elements in treated water did not exceed the permissible limits and quality of analyzed tap water changed a little during its transport due to the secondary contamination.

Keywords: tap water chemistry, ICP-AES, quality indicators of tap water

„There is no life without water. It is a treasure indispensable to all human activity. Fresh water resources are not inexhaustible. It is essential to conserve, control, and wherever possible, to increase them. The quality of water must be maintained at levels suitable for the use to be made of it and, in particular, must meet appropriate public health standards. Conservation of water calls for intensified scientific research, training of specialists and public information services". European Water Charter proclaimed in Strasbourg, May 6, 1968 considers that collective action on a European scale on water problems is necessary. On a local scale, underground water resources and quality are of great importance to public health and local economy. These waters are main reservoir of drinking water for people, water for industry, agriculture, food production and food processing. Water intended for these purposes must comply with the requirements presented in appropriates legal acts [1, 2]. Among these requirements important role play physicochemical indexes of water quality. Physical, chemical, and biochemical processes affecting the quality of water supplied to the receivers occur in tap water distribution systems. The water quality often gets worse during its flow from the intake and treatment point to the receiving point (tap). Chemically and biologically instable waters are mostly exposed to the secondary contamination, because they make a corrosion of metal elements of the water distribution system and internal installations. The aim of this paper is presentation of results of chemical composition of tap water in selected localities on South Podlasie Lowland.

[1] Department of Soil Science and Agricultural Chemistry, Siedlce University of Natural Sciences and Humanities, ul. B. Prusa 14, 08-110 Siedlce, phone 25 643 12 87(88), email: kalembasa@uph.edu.pl

Material and methods

Samples of water were taken from water treatment stations (untreated and treated water) and taps situated in various parts of Lukow (15 samples), Sokolow Podlaski (8 samples), selected localities in Lochow commune (7 samples), Wierzbno commune (9 samples) and Mokobody commune (15 samples). Quarterly investigations covered analysis of water reaction (pH) by potentiometric method, electrical conductivity (EC) by electrochemical method and total concentration of 26 elements by inductively coupled plasma atomic emission spectrometry (ICP-AES) [3]. The study was carried out with the Optima 3200RL by Perkin Elmer. The optics of the instrument consists of a high resolution, Echelle-based polychromator, a segmented-array charge-coupled device (SCD) detects the light. A cross-flow nebuliser with GemTips was used throughout the study. The working parameters of the apparatus were: RF power - 1300 W, plasma argon flow rate - 15 dm^3/min, auxiliary argon flow rate - 0.5 dm^3/min, nebuliser argon flow rate - 0.8 dm^3/min, sample flow rate - 1.5 cm^3/min, integration time - 30 s. The element detection limits at the analytical wavelengths are presented in Table 1. For the calibration of the elements, multielement standards were mixed from single element stock solutions (Fluka). All samples as well as standards and the blank were acidified to contain 2% nitric acid in the final solution. Acid used was Riedel-de Haën. 18 MΩ water was used for dilution and calibration blank.

Table 1

Analytical wavelengths of analyzed elements and method detection limits

Element	Wavelength [nm]	Detection limit [mg·dm^{-3}]
P	213.617	0.05
K	766.490	0.005
Ca	317.933	0.006
Mg	285.213	0.002
Na	330.237	0.8
S	181.975	0.06
Fe	238.204	0.002
Al	394.401	0.02
Mn	257.610	0.0004
Co	228.616	0.001
Mo	202.031	0.001
B	249.677	0.0004
Li	670.784	0.001
Ti	334.940	0.001
Ba	233.527	0.006
Sr	421.552	0.0001
V	290.880	0.001
Se	196.026	0.05
Sn	189.927	0.08
As	188.979	0.02
Pb	220.353	0.008
Cd	228.802	0.0009
Cr	267.716	0.001
Cu	327.393	0.005
Zn	206.200	0.008
Ni	231.604	0.002

Results and discussion

Performed studies revealed that water samples from analyzed water supply systems were characterized by stable acidity and specific conductivity, and values of these parameters met the requirements of legal acts and WHO recommendations [1, 2, 4]. Concentrations of 13 analyzed elements (P, Pb, Cd, Ni, As, Cr, Sn, Al, Co, Mo, Ti, V, Se) were below detectable limits for methods presented in Table 1, while concentrations of other analyzed elements are presented in Tables 2 and 3.

Table 2

Physicochemical parameters of untreated, treated and mean, minimal, maximal values in tap water supply systems in Lukow, Sokolow Podlaski, Lochow, Wierzbno and Mokobody commune

		pH	EC	Ca	Mg	K	Na	S
		-	[$\mu S \cdot cm^{-1}$]	[$mg \cdot dm^{-3}$]				
Lukow	untreated	7.4	329	68.3	6.19	1.97	3.63	0.42
	treated	7.3	312	64.6	5.95	1.85	3.37	0.31
	mean	7.4	338	66.0	6.02	1.89	3.56	0.34
	min	7.3	311	65.0	5.93	1.85	3.37	0.28
	max	7.6	345	67.4	6.11	2.33	3.73	0.48
	SD*	0.1	8	0.8	0.05	0.12	0.12	0.05
	RSD*	0.9	2.4	1.2	0.9	6.3	3.2	13.8
Sokolow Podlaski	untreated	7.3	535	97.6	15.5	2.05	8.82	0.97
	treated	7.3	510	95.6	15.1	1.92	8.25	1.17
	mean	7.3	522	95.0	15.1	1.90	8.11	1.31
	min	7.2	508	92.5	14.9	1.86	7.96	1.01
	max	7.6	544	98.4	15.9	1.97	8.27	1.46
	SD	0.1	12	1.7	0.3	0.04	0.11	0.14
	RSD	1.8	2.2	1.7	2.1	2.2	1.4	11.0
Lochow	untreated	7.0	407	69.1	8.84	1.71	6.53	3.41
	treated	7.1	402	69.1	8.88	1.60	6.48	3.39
	mean	7.0	399	69.4	8.94	1.59	6.58	3.27
	min	7.0	397	69.0	8.85	1.56	6.45	2.73
	max	7.1	403	70.1	9.08	1.64	6.83	3.55
	SD	0.1	2	0.4	0.09	0.03	0.13	0.33
	RSD	0.8	0.5	0.6	1.0	1.9	2.0	10.1
Wierzbno	untreated	7.3	536	92.0	15.4	1.58	4.83	2.92
	treated	7.6	482	90.5	15.6	1.67	4.59	2.79
	mean	7.5	491	88.6	15.3	1.72	5.06	2.89
	min	7.4	472	82.8	13.9	1.66	4.66	2.65
	max	7.6	500	93.9	16.4	1.82	5.45	4.02
	SD	0.1	8	3.0	0.7	0.06	0.23	0.43
	RSD	0.9	1.6	3.4	4.4	3.4	4.6	14.8
Mokobody	untreated	7.9	571	-**	-	-	-	-
	treated	8.0	563	-	-	-	-	-
	mean	7.4	595	111	16.8	2.22	6.85	14.3
	min	6.5	560	99.5	14.8	1.38	4.88	8.53
	max	7.8	839	145	17.6	2.57	18.4	18.5
	SD	0.3	45	6.64	0.54	0.20	2.57	1.99
	RSD	3.8	7.5	6.0	3.2	9.2	37.5	14.0

* SD - standard deviation, RSD - relative standard deviation

** not analyzed

Table 3
Chemical parameters of untreated, treated and mean, minimal, maximal values in tap water supply systems in Lukow, Sokolow Podlaski, Lochow, Wierzbno and Mokobody commune

		Fe	Mn	B	Li	Ba	Sr	Cu	Zn
		[mg·dm^{-3}]							
Lukow	untreated	1.108	0.170	0.032	0.007	0.033	0.392	0.003	0.009
	treated	0.123	0.050	0.031	0.006	0.026	0.379	0.001	0.008
	mean	0.109	0.012	0.029	0.005	0.025	0.389	0.009	0.399
	min	0.099	0.006	0.028	0.004	0.022	0.382	0.003	0.100
	max	0.136	0.027	0.031	0.007	0.026	0.396	0.029	1.269
	SD*	0.011	0.007	0.001	0.001	0.001	0.004	0.008	0.307
	RSD*	9.7	52.2	2.3	16.1	3.4	1.1	90.9	76.8
Sokolow Podlaski	untreated	0.513	0.143	0.045	0.011	0.042	0.250	0.001	0.006
	treated	0.009	0.004	0.045	0.010	0.038	0.233	0.001	0.061
	mean	0.011	0.003	0.038	0.010	0.039	0.233	0.044	0.896
	min	0.005	0.002	0.035	0.009	0.037	0.223	0.003	0.353
	max	0.025	0.008	0.045	0.011	0.043	0.263	0.096	2.470
	SD	0.007	0.002	0.004	0.001	0.002	0.013	0.032	0.696
	RSD	66.0	61.4	9.8	7.3	5.2	5.4	73.6	77.7
Lochow	untreated	1.489	0.563	0.032	0.004	0.045	0.196	0.009	0.019
	treated	0.061	0.047	0.032	0.004	0.035	0.197	0.027	0.049
	mean	0.030	0.008	0.031	0.004	0.034	0.198	0.008	0.236
	min	0.017	0.002	0.031	0.004	0.032	0.195	0.005	0.105
	max	0.058	0.022	0.033	0.004	0.035	0.201	0.012	0.528
	SD	0.013	0.007	0.001	0.000	0.001	0.003	0.002	0.170
	RSD	44.3	86.1	2.7	2.9	3.2	1.3	26.6	72.2
Wierzbno	untreated	0.744	0.333	0.016	0.008	0.156	0.264	0.001	0.023
	treated	0.047	0.003	0.017	0.008	0.133	0.261	0.001	0.027
	mean	0.055	0.005	0.018	0.008	0.128	0.260	0.172	1.040
	min	0.047	0.002	0.017	0.007	0.100	0.240	0.004	0.202
	max	0.076	0.012	0.020	0.010	0.137	0.286	0.935	2.277
	SD	0.010	0.004	0.001	0.001	0.011	0.014	0.299	0.767
	RSD	18.1	78.2	4.6	9.1	8.8	5.2	173.3	73.7
Mokobody	untreated	1.85	0.153	-**	-	-	-	-	-
	treated	0.06	0.008	-	-	-	-	-	-
	mean	0.008	0.004	0.025	0.008	0.066	0.250	0.018	1.51
	min	0.003	0.001	0.017	0.002	0.028	0.173	0.002	0.123
	max	0.043	0.037	0.056	0.013	0.082	0.332	0.093	9.47
	SD	0.007	0.006	0.007	0.002	0.011	0.038	0.018	1.89
	RSD	79.7	130.3	28.0	29.1	16.3	15.3	102.1	125.2

* SD - standard deviation, RSD - relative standard deviation
** not analyzed

Concentrations of K, Ca, Mg, Na, S, B, Li, Ba, and Sr in water samples from intake points slightly varied and differed a little from those in untreated and treated water samples at the inlet to the water supply system. The greatest changes during the water transport along with quite large concentration differences were recorded for Fe, Mn, Cu, and Zn. It was found that mean iron concentration in untreated water samples from Lukow, Sokolow Podlaski, Lochow, Wierzbno and Mokobody exceeded permissible values amounting to 1.11, 0.513, 1.49, 0.744, 1.85 mg · dm^{-3}, respectively. The excessive quantities of the metal were removed during the treatment processes, when its concentration reductions were by

89, 98, 96, 94 and 97%. Treated water supplied to the system met requirements for that parameter. Water taken from the taps did not contain the excessive iron contents in any water supply system studied (Table 3). Also manganese concentration in water taken from underground layers excessive permissible norms amounting 0.170 mg · dm^{-3} in Lukow, 0.143 mg · dm^{-3} in Sokolow Podlaski, 0.563 mg · dm^{-3} in Lochow, 0.333 mg · dm^{-3} in Wierzbno and 0.153 mg · dm^{-3} in Mokobody. The demanganation process resulted in the decrease of manganese concentrations by 71, 97, 92, 99, 95%, respectively for the communes, which allowed for reaching lower value than permissible one. Water supplied to the distribution systems in Sokolow Podlaski, Wierzbno and Mokobody contained traces of manganese and its quality did not change during the transport. The element concentration was higher in water from treatment plant in Lukow and Lochow, but its decrease occurred due to the manganese compounds precipitation within water supply system. Waters from Lukow, Sokolow Podlaski, Lochow and Wierzbno contained traces of zinc (0.009, 0.006, 0.019, 0.023 mg · dm^{-3}, respectively). Mean zinc concentrations in water samples from the taps were higher (0.399, 0.896, 0.236, 1.04 mg · dm^{-3}); however they did not exceed values recommended by WHO. Quite broad range of these element concentrations in water samples from particular intake points was recorded, which was probably associated with the contamination due to materials, the terminal connections are made of. Mean copper concentrations in untreated water samples were from 0.002 to 0.009 mg · dm^{-3}. Water taken at intake points (taps) contained slightly more metal, namely in systems in Wierzbno and Sokolow Podlaski communes, but maximum values were much lower than permissible level. The differences of copper concentrations in samples resulted from copper installations in some intake points.

Conclusions

1. The underground waters being the source of tap water in selected localities on South Podlasie Lowland were characterized by good quality. They contained excessive iron and manganese amounts, that were efficiently removed during the treatment.
2. Quality of treated water supplied to the distribution systems in Lukow, Sokolow Podlaski, Lochow, Wierzbno and Mokobody met all norms for the quality indicators studied.
3. Quality of analyzed tap water changed a little during its transport due to the secondary contamination. No excessive concentrations of studied elements were recorded. The water quality slightly worsened in reference to zinc and copper contents, namely at intake points, where galvanized steel or copper pipes were the part of installations.

References

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CHEMIZM WODY WODOCIĄGOWEJ W WYBRANYCH MIEJSCOWOŚCIACH NIZINY POŁUDNIOWOPODLASKIEJ

Katedra Gleboznawstwa i Chemii Rolniczej, Uniwersytet Przyrodniczo-Humanistyczny w Siedlcach

Abstrakt: Celem niniejszej pracy jest przedstawienie wyników analizy składu chemicznego wody wodociągowej dostarczanej mieszkańcom wybranych miejscowości Niziny Południowopodlaskiej. Punkty pobrania próbek do badań wyznaczono na wyjściu ze stacji uzdatniania oraz w kurkach czerpalnych, położonych w różnych dzielnicach Łukowa i Sokołowa Podlaskiego, a także w różnych miejscowościach gmin Łochów, Wierzbno i Mokobody. Próbki wody pobierano w odstępach kwartalnych. W pobranych próbkach oznaczono odczyn (pH) wody metodą potencjometryczną, przewodnictwo właściwe metodą elektrochemiczną oraz stężenie K, Ca, Mg, Na, S, Fe, Mn, B, Li, Ba, Sr, Cu, Zn, Ni metodą optycznej spektrometrii emisyjnej ze wzbudzeniem w plazmie sprzężonej indukcyjnie (ICP-AES). Stężenie pierwiastków objętych badaniami na ogół nie przekraczało obowiązujących wartości dopuszczalnych. Sporadycznie odnotowano podwyższone wartości analizowanych parametrów w próbkach wody pobieranych w kurkach czerpalnych, wskazujące na zanieczyszczenie wody w systemie dystrybucji. W wodzie surowej stwierdzono ponadnormatywne stężenia żelaza i manganu, ale pierwiastki te były skutecznie usuwane w procesie uzdatniania.

Słowa kluczowe: chemizm wody wodociągowej, ICP-AES, wskaźniki jakości wody wodociągowej