DOI: 10.2428/ecea.2012.19(12)143 ECOL CHEM ENG A. 2012;19(12):1509-1517

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WATER CHEMISTRY OF SELECTED SOUTH PODLASIE LOWLAND RIVERS

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Abstract: In this paper results of the water quality investigations were presented. Samples of water were taken from four rivers in middle-eastern Poland: Kostrzyn, Mienia, Osownica and Wilga. Quarterly investigations covered analysis of water reaction, electrical conductivity, dissolved oxygen and biochemical oxygen demand, total concentration of twenty six elements by inductively coupled plasma atomic emission spectrometry (ICP-AES). The resulting data were processed statistically using arithmetic means, concentration ranges, standard deviations and relative standard deviations. Due to the effect of sample collection date on concentrations of analyzed elements, a single factor analysis of variance and Tukey post-hoc test were completed. It was found that the quality of water in the rivers was differential if selected water quality indicators were taken account. The values of this indicators were dependent on location of checkpoints, season and type of surrounding grounds cultivation. The quality of water in particular checkpoints was affected by anthropogenic sources of contamination: community waste from private possessions and sewage from fertilized arable land and greenlands.

Keywords: surface water quality, water quality indicators, sources of contamination, ICP-AES

Purity of surface and underground waters is very important from both an ecological and economic point of view. The decreasing extent of the use of surface water is a consequence of the quality of those waters which does not meet the standards set for water intended for consumption and for use in individual branches of the economy. The main factors which directly affect the diversity of chemical composition of surface waters are: geochemical properties of the drainage basin [1] and the amount of rainfall and methods of use of adjacent land [2–5]. The load of anthropogenic contamination introduced directly or as contaminated rainfall, can greatly affect the water quality. The chemical composition of the water also depends on seasonal changes of flow intensity, temperature, climate humidity and biological activity [6]. Water resources are frequently

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degraded by industrial, communal and agricultural pollutants being discharged to them [7, 8]. The ability of flowing water to regenerate varies and depends mainly on the presence and effect of anthropogenic factors. The knowledge of changes in soluble substance concentration helps to evaluate the natural chemical composition and the effect of human economic activities on the quality of surface waters.

The aim of the study was to evaluate the purity of the Kostrzyn, the Mienia, the Osownica and the Wilga rivers based on selected indicators of surface water quality as well as an interpretation of the spatial and seasonal changes in the water quality.

Materials and methods

Samples taken from the Kostrzyn (7 sampling sites), the Osownica (7), the Mienia (11) and the Wilga (10) rivers in the central-eastern part of Poland were used in the study. Water samples for analysis were taken seasonally at intervals of a quarter of a year in the years 2005/2006. The following were determined immediately after sampling: pH – by the potentiometric method with the use of a combined electrode and a 301 pH-meter, manufactured by Hanna Instruments; electrolytic conductivity – by the electrochemical method with an HI 2300 conductometer, manufactured by Hanna Instruments; concentration of dissolved oxygen – electrochemically with the use of an HI 9143 dissolved oxygen probe, manufactured by Hanna Instruments. The BOD_5 value was calculated from the results of determination of dissolved oxygen *in situ* and after a five-day period of incubation with an oxygen probe, without diluting the samples. Subsequently, 5 cm^3 of concentrated HNO_3 was added to 45 cm^3 of water and mineralised in a Multiwave microwave sample preparation system, manufactured by Anton Paar. The total content of 26 elements (P, K, Ca, Mg, Na, S, Fe, Al, Mn, Co, Mo, B, Li, Ti, Ba, Sr, V, Se, Sn, As, Pb, Cd, Cr, Cu, Zn, Ni) was determined by the ICP-AES method on an Optima 3200RL spectrometer, manufactured by Perkin Elmer. The method enabled simultaneous determination of the concentration of many elements at low levels of detectability and a relatively low effect of the sample matrix [9]. The results were worked out statistically by calculating arithmetic averages, concentration ranges, *standard deviations* (SD) and *relative standard deviation* (RSD) and performing a single-factor analysis of variance and Tukey's test at the levels of significance $\alpha = 0.05$ and $\alpha = 0.01$.

Results and discussion

The values of selected physical indexes of salinity and quality of waters corresponded generally to class I and II of surface water quality (Tables 1–4). The values corresponding to classes III, IV and V were recorded in the case of Fe, Mn and Al, but not for P and Cr. Elevated values of Cr content were found in the Wilga in spring and in the Kostrzyn in winter. This was probably a consequence of discharging communal wastewater. In the Kostrzyn, spot distribution of the pollution was observed and self-purification of the water took place down the river. The concentrations of Co, Mo, V, Se, Sn, As, Pb and Cd lay within the detection limits of the method and were equal to

Table 1

Statistical assessment of selected water quality indicators and analyzed elements contents in Kostrzyn River

Indicator	Spring					Summer					Autumn					Winter				
	mean	min	max	SD	RSD	mean	min	max	SD	RSD	mean	min	max	SD	RSD	mean	min	max	SD	RSD
pH	7.36	7.05	7.67	0.22	3	7.26	6.95	7.52	0.24	3	7.34	7.06	7.69	0.24	3	7.24	7.03	7.46	0.16	2
EC [$\mu S \cdot cm^{-1}$]	413	381	507	44	11	397	346	447	30	8	384	327	419	28	7	385	325	422	30	8
O_2 [$mg \cdot dm^{-3}$]	8.82	7.90	9.72	0.66	7	6.34	6.00	6.74	0.28	4	8.40	7.93	8.88	0.35	4	10.20	8.43	11.60	0.97	10
BOD_5 [$mg \cdot dm^{-3}$]	1.27	0.46	3.36	0.99	78	2.40	1.88	2.92	0.41	17	2.43	2.10	2.97	0.34	14	2.96	2.10	4.41	0.92	31
P [$mg \cdot dm^{-3}$]	0.124	0.098	0.176	0.026	21	0.285	0.232	0.461	0.084	29	0.142	0.117	0.164	0.016	11	0.061	0.008	0.088	0.027	45
K [$mg \cdot dm^{-3}$]	2.19	1.89	2.41	0.20	9	2.17	1.67	2.97	0.40	18	2.28	2.17	2.46	0.12	5	1.61	1.46	1.89	0.13	8
Ca [$mg \cdot dm^{-3}$]	55.6	51.2	60.4	3.5	6	68.4	65.7	74.6	3.1	5	61.9	59.6	64.0	1.4	2	59.5	56.4	62.0	2.0	3
Mg [$mg \cdot dm^{-3}$]	5.18	4.47	5.62	0.46	9	6.93	6.01	7.90	0.62	9	6.51	6.15	6.90	0.25	4	5.35	4.76	6.03	0.44	8
Na [$mg \cdot dm^{-3}$]	12.39	11.40	13.45	0.72	6	7.17	5.65	7.90	0.72	10	6.98	6.34	7.44	0.41	6	5.64	5.17	6.14	0.34	6
S [$mg \cdot dm^{-3}$]	12.79	11.81	13.61	0.67	5	10.91	9.41	13.70	1.42	13	5.43	3.75	6.91	1.04	19	11.50	9.99	13.88	1.36	12
Fe [$mg \cdot dm^{-3}$]	0.676	0.593	0.852	0.091	13	1.580	1.090	3.185	0.762	48	1.134	0.842	1.467	0.214	19	0.486	0.025	0.690	0.216	44
Al [$mg \cdot dm^{-3}$]	0.113	0.089	0.158	0.023	21	0.110	0.035	0.442	0.148	135	0.142	0.076	0.225	0.061	43	0.072	0.000	0.116	0.039	55
Mn [$mg \cdot dm^{-3}$]	0.135	0.109	0.183	0.027	20	0.220	0.122	0.424	0.098	45	0.140	0.118	0.161	0.015	10	0.130	0.053	0.179	0.041	31
B [$mg \cdot dm^{-3}$]	0.024	0.015	0.043	0.010	43	0.011	0.002	0.021	0.006	54	0.059	0.035	0.089	0.018	30	0.008	0.002	0.021	0.007	88
Li [$mg \cdot dm^{-3}$]	0.002	0.001	0.002	0.000	21	0.001	0.001	0.002	0.000	32	0.005	0.004	0.006	0.001	14	0.001	0.000	0.001	0.000	60
Ti [$mg \cdot dm^{-3}$]	0.000	0.000	0.000	0.000	188	0.001	0.000	0.009	0.003	248	0.002	0.000	0.005	0.002	66	0.001	0.000	0.004	0.001	97
Ba [$mg \cdot dm^{-3}$]	0.048	0.043	0.055	0.004	9	0.058	0.050	0.071	0.008	13	0.035	0.029	0.048	0.006	18	0.039	0.028	0.048	0.008	20
Sr [$mg \cdot dm^{-3}$]	0.121	0.103	0.141	0.017	14	0.184	0.168	0.202	0.011	6	0.127	0.125	0.132	0.002	2	0.111	0.097	0.124	0.010	9
Cr [$mg \cdot dm^{-3}$]	0.003	0.001	0.006	0.002	50	0.005	0.000	0.014	0.005	105	0.003	0.001	0.005	0.001	39	0.178	0.000	1.239	0.468	262
Cu [$mg \cdot dm^{-3}$]	0.008	0.007	0.009	0.000	4	< 0.004*					0.004	0.000	0.007	0.002	59	0.009	0.004	0.022	0.006	71
Zn [$mg \cdot dm^{-3}$]	0.066	0.049	0.091	0.018	27	0.016	0.000	0.035	0.012	77	0.004	0.000	0.011	0.005	116	0.064	0.000	0.123	0.045	70
Ni [$mg \cdot dm^{-3}$]	< 0.002*					0.034	0.000	0.228	0.086	251	< 0.002*									

* Content below the detection limit of the analytical method.

Table 2

Statistical assessment of selected water quality indicators and analyzed elements contents in Mienia River

Indicator	Spring					Summer					Autumn					Winter				
	mean	min	max	SD	RSD	mean	min	max	SD	RSD	mean	min	max	SD	RSD	mean	min	max	SD	RSD
pH	7.65	7.40	7.80	0.13	2	7.68	7.30	8.40	0.41	5	7.60	7.40	7.70	0.10	1	7.62	7.50	7.70	0.09	1
EC [$\mu S \cdot cm^{-1}$]	520	474	601	46	9	587	447	936	139	24	620	539	760	58	9	673	564	759	62	9
O_2 [$mg \cdot dm^{-3}$]	10.30	9.63	11.20	0.47	5	7.26	3.82	11.80	2.69	37	9.55	5.82	12.30	1.69	18	10.31	8.15	11.10	0.87	8
BOD_5 [$mg \cdot dm^{-3}$]	3.28	2.16	4.56	0.78	24	3.67	2.20	6.56	1.11	30	5.42	3.04	6.99	1.26	23	2.38	1.78	3.20	0.49	21
P [$mg \cdot dm^{-3}$]	0.275	0.111	0.501	0.144	52	0.969	0.198	4.625	1.242	128	0.534	0.073	1.946	0.575	108	0.319	0.023	0.667	0.266	83
K [$mg \cdot dm^{-3}$]	4.78	3.86	6.46	0.92	19	6.21	3.54	14.50	3.18	51	6.36	2.13	12.65	3.67	58	5.08	2.60	8.06	2.44	48
Ca [$mg \cdot dm^{-3}$]	62.7	57.0	66.1	3.1	5	83.3	66.2	114.0	15.7	19	83.7	68.0	102.5	12.9	15	83.3	67.9	106.2	11.7	14
Mg [$mg \cdot dm^{-3}$]	8.48	7.66	9.07	0.47	6	11.24	8.51	14.85	2.45	22	11.85	9.61	15.01	1.84	16	10.53	8.99	12.84	1.28	12
Na [$mg \cdot dm^{-3}$]	33.92	17.01	57.32	16.54	49	18.35	9.07	54.00	13.21	72	22.78	9.20	46.72	13.92	61	28.17	11.34	49.90	17.14	61
S [$mg \cdot dm^{-3}$]	13.86	10.85	16.45	2.15	16	13.58	8.52	19.55	2.94	22	19.36	14.39	28.08	3.82	20	18.60	14.80	22.01	2.51	13
Fe [$mg \cdot dm^{-3}$]	0.640	0.239	1.111	0.266	42	1.454	0.583	4.110	1.227	84	1.102	0.269	5.108	1.478	134	0.608	0.332	1.125	0.221	36
Al [$mg \cdot dm^{-3}$]	0.099	0.009	0.234	0.062	63	0.390	0.040	2.465	0.697	179	0.179	0.000	1.205	0.368	206	0.126	0.049	0.361	0.088	70
Mn [$mg \cdot dm^{-3}$]	0.145	0.062	0.224	0.051	35	0.745	0.122	3.050	1.108	149	0.221	0.052	1.094	0.298	135	0.155	0.089	0.263	0.044	28
B [$mg \cdot dm^{-3}$]	0.041	0.013	0.090	0.024	60	0.051	0.012	0.162	0.046	90	0.088	0.016	0.181	0.061	69	0.039	0.009	0.088	0.029	72
Li [$mg \cdot dm^{-3}$]	0.002	0.000	0.002	0.001	34	0.004	0.002	0.007	0.002	50	0.007	0.005	0.008	0.001	17	0.002	0.001	0.003	0.001	28
Ti [$mg \cdot dm^{-3}$]	0.004	0.001	0.011	0.003	78	0.006	0.000	0.046	0.013	223	0.002	0.000	0.017	0.005	228	0.001	0.000	0.005	0.002	141
Ba [$mg \cdot dm^{-3}$]	0.050	0.043	0.057	0.003	7	0.061	0.045	0.113	0.020	33	0.043	0.026	0.095	0.020	48	0.066	0.050	0.137	0.025	37
Sr [$mg \cdot dm^{-3}$]	0.188	0.162	0.211	0.018	10	0.173	0.143	0.207	0.020	12	0.152	0.123	0.179	0.017	11	0.137	0.103	0.159	0.019	14
Cr [$mg \cdot dm^{-3}$]	0.004	0.001	0.016	0.004	103	0.002	0.000	0.013	0.004	176	0.005	0.001	0.013	0.004	85	0.001	0.000	0.002	0.001	107
Cu [$mg \cdot dm^{-3}$]	0.000	0.000	0.005	0.001	332	< 0.004*					0.001	0.000	0.005	0.002	217	0.001	0.000	0.002	0.001	143
Zn [$mg \cdot dm^{-3}$]	0.001	0.000	0.015	0.005	308	0.019	0.001	0.045	0.015	80	0.002	0.000	0.010	0.004	222	0.006	0.000	0.030	0.009	142
Ni [$mg \cdot dm^{-3}$]	0.004	0.000	0.009	0.004	89	0.024	0.000	0.191	0.056	232	0.007	0.000	0.021	0.006	90	0.002	0.000	0.011	0.004	174

* Content below the detection limit of the analytical method.

Table 3

Statistical assessment of selected water quality indicators and analyzed elements contents in Osownica River

Indicator	Spring					Summer					Autumn					Winter				
	mean	min	max	SD	RSD	mean	min	max	SD	RSD	mean	min	max	SD	RSD	mean	min	max	SD	RSD
pH	7.44	7.25	7.98	0.25	3	7.39	7.20	7.69	0.16	2	7.42	7.35	7.54	0.07	1	7.56	7.23	7.87	0.19	3
EC [$\mu S \cdot cm^{-1}$]	379	322	420	31	8	465	432	487	18	4	432	412	452	14	3	421	347	457	36	9
O_2 [$mg \cdot dm^{-3}$]	9.07	8.68	9.36	0.23	3	5.87	5.61	6.15	0.20	3	7.51	7.04	8.12	0.42	6	10.12	8.94	11.46	0.79	8
BOD_5 [$mg \cdot dm^{-3}$]	1.69	0.71	2.94	0.82	48	1.55	0.86	2.48	0.69	44	2.89	2.50	3.23	0.29	10	2.38	1.69	3.39	0.60	25
P [$mg \cdot dm^{-3}$]	0.127	0.098	0.159	0.024	19	0.289	0.219	0.558	0.122	42	0.091	0.058	0.162	0.042	46	0.093	0.052	0.147	0.032	34
K [$mg \cdot dm^{-3}$]	2.97	2.65	3.21	0.22	7	2.76	2.28	3.22	0.33	12	2.47	2.17	2.75	0.22	9	2.13	1.91	2.52	0.20	10
Ca [$mg \cdot dm^{-3}$]	50.7	46.8	54.1	2.3	4	76.3	69.9	85.0	5.6	7	71.2	68.7	75.5	2.3	3	68.4	64.3	73.6	3.2	5
Mg [$mg \cdot dm^{-3}$]	6.23	5.75	6.52	0.28	5	11.35	10.07	12.95	1.14	10	9.81	8.64	11.22	0.86	9	8.38	7.64	9.89	0.79	9
Na [$mg \cdot dm^{-3}$]	12.30	10.78	13.31	0.91	7	6.17	5.05	9.06	1.41	23	5.15	4.88	5.51	0.20	4	5.79	5.09	6.88	0.56	10
S [$mg \cdot dm^{-3}$]	10.65	9.64	11.72	0.68	6	11.01	8.79	13.35	1.70	15	6.79	6.36	7.31	0.38	6	9.62	9.12	10.54	0.45	5
Fe [$mg \cdot dm^{-3}$]	0.670	0.552	0.971	0.145	22	2.251	1.335	5.320	1.367	61	0.898	0.533	1.549	0.462	51	0.950	0.534	1.491	0.332	35
Al [$mg \cdot dm^{-3}$]	0.172	0.131	0.234	0.034	20	0.352	0.188	0.819	0.216	61	0.075	0.000	0.345	0.130	173	0.121	0.062	0.172	0.042	35
Mn [$mg \cdot dm^{-3}$]	0.194	0.087	0.275	0.071	37	0.401	0.232	1.145	0.330	82	0.140	0.110	0.216	0.042	30	0.173	0.143	0.190	0.020	12
B [$mg \cdot dm^{-3}$]	0.036	0.020	0.050	0.014	40	0.012	0.002	0.029	0.010	77	0.035	0.016	0.081	0.024	69	0.015	0.001	0.050	0.022	144
Li [$mg \cdot dm^{-3}$]	0.003	0.003	0.003	0.000	5	0.005	0.004	0.006	0.001	13	0.006	0.006	0.007	0.001	9	0.002	0.002	0.003	0.001	22
Ti [$mg \cdot dm^{-3}$]	0.001	0.000	0.004	0.001	106	0.004	0.001	0.013	0.004	94	0.001	0.000	0.008	0.003	212	0.003	0.000	0.007	0.003	107
Ba [$mg \cdot dm^{-3}$]	0.058	0.051	0.072	0.007	12	0.093	0.075	0.128	0.018	19	0.051	0.040	0.061	0.009	18	0.065	0.057	0.077	0.008	12
Sr [$mg \cdot dm^{-3}$]	0.138	0.118	0.156	0.015	11	0.290	0.248	0.328	0.031	11	0.205	0.160	0.247	0.031	15	0.171	0.144	0.218	0.027	16
Cr [$mg \cdot dm^{-3}$]	0.005	0.002	0.015	0.005	98	0.011	0.003	0.024	0.009	79	0.003	0.001	0.005	0.002	47	0.000	0.000	0.001	0.000	256
Cu [$mg \cdot dm^{-3}$]	0.009	0.008	0.012	0.001	17	< 0.004*														
Zn [$mg \cdot dm^{-3}$]	0.071	0.037	0.104	0.024	34	0.034	0.015	0.069	0.020	60	0.006	0.000	0.017	0.007	127	0.015	0.000	0.056	0.021	136
Ni [$mg \cdot dm^{-3}$]	< 0.002*																			

* Content below the detection limit of the analytical method.

Table 4

Statistical assessment of selected water quality indicators and analyzed elements contents in Wilga River

Indicator	Spring					Summer					Autumn					Winter				
	mean	min	max	SD	RSD	mean	min	max	SD	RSD	mean	min	max	SD	RSD	mean	min	max	SD	RSD
pH	7.29	7.00	7.56	0.17	2	7.72	7.55	7.89	0.11	1	8.08	7.73	8.36	0.23	3	7.69	7.47	7.91	0.13	2
EC [$\mu S \cdot cm^{-1}$]	381	300	640	81	21	584	393	1185	197	34	528	499	591	28	5	536	433	628	53	10
O_2 [$mg \cdot dm^{-3}$]	10.74	9.61	12.25	0.58	5	9.54	7.03	10.90	0.97	10	10.22	9.40	11.15	0.59	6	10.75	9.78	11.20	0.39	4
BOD_5 [$mg \cdot dm^{-3}$]	5.19	4.38	6.55	0.67	13	5.40	3.16	10.01	2.45	45	4.27	3.53	5.02	0.50	12	6.09	2.89	10.27	2.36	39
P [$mg \cdot dm^{-3}$]	0.135	0.091	0.199	0.038	28	0.078	0.000	0.213	0.088	113	0.247	0.076	0.634	0.189	76	0.213	0.148	0.314	0.054	26
K [$mg \cdot dm^{-3}$]	3.50	2.42	6.56	1.69	48	4.03	3.08	5.38	1.00	25	3.48	2.79	4.81	0.86	25	3.40	3.19	3.83	0.22	7
Ca [$mg \cdot dm^{-3}$]	73.6	68.0	76.1	2.8	4	72.3	48.5	82.6	12.8	18	76.9	73.1	83.0	3.8	5	49.6	39.3	54.0	4.8	10
Mg [$mg \cdot dm^{-3}$]	9.20	8.62	9.56	0.37	4	9.81	9.54	10.33	0.30	3	9.09	8.37	9.85	0.48	5	5.45	4.41	5.90	0.53	10
Na [$mg \cdot dm^{-3}$]	14.42	7.69	34.52	11.51	80	14.99	9.13	28.34	8.68	58	16.16	9.70	29.32	8.49	53	5.71	4.34	7.83	1.38	24
S [$mg \cdot dm^{-3}$]	10.93	8.02	15.76	2.89	26	10.78	9.36	13.02	1.52	14	12.85	12.00	14.57	0.92	7	13.29	11.75	13.87	0.78	6
Fe [$mg \cdot dm^{-3}$]	1.154	0.504	2.705	0.741	64	0.330	0.185	0.567	0.162	49	1.466	0.941	2.317	0.553	38	0.632	0.417	0.971	0.226	36
Al [$mg \cdot dm^{-3}$]	< 0.05*					0.045	0.010	0.119	0.044	96	0.090	0.031	0.156	0.049	55	0.070	0.008	0.167	0.060	86
Mn [$mg \cdot dm^{-3}$]	0.228	0.153	0.296	0.047	20	0.099	0.041	0.193	0.059	59	0.336	0.253	0.416	0.059	18	0.131	0.093	0.162	0.027	20
B [$mg \cdot dm^{-3}$]	0.008	0.000	0.020	0.007	85	0.027	0.010	0.051	0.016	59	0.036	0.010	0.115	0.036	99	0.007	0.000	0.019	0.009	116
Li [$mg \cdot dm^{-3}$]	0.003	0.002	0.004	0.001	20	0.003	0.002	0.003	0.000	11	0.002	0.002	0.003	0.000	21	< 0.001*				
Ti [$mg \cdot dm^{-3}$]	0.001	0.000	0.005	0.002	170	0.001	0.000	0.004	0.002	228	0.001	0.000	0.004	0.002	125	0.003	0.000	0.007	0.003	91
Ba [$mg \cdot dm^{-3}$]	0.064	0.060	0.067	0.003	4	0.057	0.046	0.067	0.008	14	0.075	0.061	0.088	0.010	13	0.003	0.000	0.009	0.003	95
Sr [$mg \cdot dm^{-3}$]	0.275	0.239	0.327	0.029	11	0.234	0.215	0.279	0.024	10	0.228	0.197	0.263	0.021	9	0.095	0.078	0.108	0.012	13
Cr [$mg \cdot dm^{-3}$]	0.129	0.020	0.441	0.143	111	< 0.001*														
Cu [$mg \cdot dm^{-3}$]	< 0.004*					0.005	0.000	0.024	0.009	164	< 0.004*									
Zn [$mg \cdot dm^{-3}$]	0.025	0.005	0.054	0.017	68	0.002	0.000	0.009	0.004	173	0.018	0.000	0.079	0.031	173	0.050	0.012	0.101	0.037	75
Ni [$mg \cdot dm^{-3}$]	0.064	0.011	0.215	0.069	107	< 0.002*														

* Content below the detection limit of the analytical method.

0.001, 0.001, 0.001, 0.05, 0.004, 0.02, 0.008, 0.0009 mg · cm^{-3}, respectively. These elements are not shown in the Tables.

A single-factor analysis of variance showed the highly significant ($\alpha = 0.01$) effect of the date of sampling on the content of Ca (20 % of explained variance), Mg (21 %), Fe (11 %), B (17 %), Li (41 %), Ba (12 %), Sr (30 %) and Zn (18 %) and the significant effect ($\alpha = 0.05$) of the concentration of Mn (7 %). The results indicate a higher effect of the sampling site on the variance of concentration of the analysed elements than the sampling date. Higher average concentrations of each element were found in summer and autumn, which can be attributed to the diminiution of the river waters caused by the decreasing seasonal water levels (Table 5).

Table 5

Mean contents of analyzed elements and homogeneous groups of means

Sample collection date	Mean	Homogeneous groups of means		Sample collection date	Mean	Homogeneous groups of means		
Ca [mg · dm^{-3}]				Fe [mg · dm^{-3}]				
Spring	61.9	*		Winter	0.643	*		
Summer	65.9	*		Spring	0.803	*	*	
Autumn	75.0		*	Autumn	1.16		*	*
Winter	76.1		*	Summer	1.33			*
Mg [mg · dm^{-3}]				Li [mg · dm^{-3}]				
Spring	7.52	*		Winter	0.001	*		
Winter	7.58	*		Spring	0.002	*	*	
Autumn	9.54		*	Summer	0.003		*	
Summer	9.92		*	Autumn	0.005			*
B [mg · dm^{-3}]				Sr [mg · dm^{-3}]				
Winter	0.019	*		Winter	0.125	*		
Spring	0.027	*		Autumn	0.174		*	
Summer	0.030	*		Spring	0.183		*	*
Autumn	0.057		*	Summer	0.211			*
Ba [mg · dm^{-3}]				Zn [mg · dm^{-3}]				
Winter	0.044	*		Autumn	0.006	*		
Autumn	0.052	*		Summer	0.017	*	*	
Spring	0.055	*	*	Winter	0.031		*	*
Summer	0.065		*	Spring	0.039			*
Mn [mg · dm^{-3}]								
Winter	0.145	*						
Spring	0.172	*	*					
Autumn	0.213	*	*					
Summer	0.388		*					

In the case of Zn, this was observed in spring and in winter, which was probably caused by introducing anthropogenic pollutants, especially by discharging industrial, communal and agricultural sewage.

Conclusions

1. The water quality in the Kostrzyn, Mienia, Osownica and Wilga rivers varied in terms of the quality indicators under study. The values of selected indicators were affected by the location of the sampling site (geochemical properties of the drainage basin and the method of use of adjacent terrain) and, to a lesser extent, the sampling date (seasonal changes of the flow intensity, temperature, climate humidity and biological activity). The differences in concentrations of the indicators in water between different sampling sites are a consequence of pollution and the natural self-purification of water.

2. The overall concentration of the elements in the water of the rivers under study can be arranged in decreasing order:

– macroelements:
  Ca > S > Na > Mg > K > P (in the Kostrzyn);
  Ca > Na > S > Mg > K > P (in the Mienia and the Wilga);
  Ca > S > Mg > Na > K > P (in the Osownica);

– selected microelements and trace elements:
  Fe > Mn > Al > Sr > Ba > B > Li > Ti (in the Mienia);
  Fe > Mn > Sr > Al > Ba > B > Li > Ti (in the Kostrzyn, the Osownica and the Wilga).

3. The content of heavy metals in the rivers was low. The Pb and Cd content was lower than the detection limit of the method applied, therefore, the rivers can be included in class I and II of surface water quality. Elevated concentrations of the other metals were recorded sporadically, at sites affected by spot pollution sources.

4. An analysis of the chemical composition and selected indicators of water quality of the rivers under study indicates only a low degree of hazard to the aquatic environment. However, efforts should be made to minimize the effect that anthropogenic sources of pollution have on water quality, *eg* run-off from fertilized agricultural land, inflow of communal waste and uncontrolled discharge of industrial and agricultural waste.

References

[1] Kowalik P, Kulbik M. Wpływ pokrywy glebowej w zlewni na kształtowanie się obszarowego spływu niektórych zanieczyszczeń do wód powierzchniowych. Woda – Środowisko – Obszary Wiejskie. 2002;2,1(4):211-223.

[2] Koc J. Wpływ użytkowania terenu na jakość wód powierzchniowych obszarów rolniczych. In: Ochrona i wykorzystanie rolniczej przestrzeni produkcyjnej Polski. Puławy: Wyd IUNG; 1997;K(12/1).

[3] Koc J, Procyk Z, Szymczak S. Czynniki kształtujące jakość wód powierzchniowych obszarów wiejskich. Mat Sem IMUZ, Falenty. 1997;39:222-229.

[4] Koc J, Nowicki Z, Glińska K, Łachacz A. Kształtowanie się jakości wód w warunkach małej antropopresji na przykładzie zlewni strugi Ardung (Pojezierze Olsztyńskie). Zesz Nauk PAN "Człowiek i Środowisko". 2000;25:155-167.
[5] Grześkowiak M. Wpływ sposobu użytkowania terenu zlewni na skład chemiczny wód powierzchniowych w zlewni Wyskoci. Rocz AR, Poznań. 2001;21:79-85.
[6] Grabińska B, Koc J, Glińska-Lewczuk K. Wpływ użytkowania zlewni Narwi na zagrożenie wód związkami fosforu. Nawozy i Nawożenie. 2004;2(19):178-191.
[7] Rajda W, Natkaniec J. Wpływ wybranych form antropopresji na jakość wód powierzchniowych. Ann Warsaw Agricult Univ-SGGW, Land Reclam. 2001,31:65-74.
[8] Rossa L, Sikorski M. Odpływ wybranych substancji z obszarów zabudowy wiejskiej. Woda – Środowisko – Obszary Wiejskie. 2006;6,1(16):335-347.
[9] Boss CB, Fredeen KJ. Concepts, Instrumentation and Techniques in Inductively Coupled Plasma Optical Emission Spectrometry. Norwalk: Perkin-Elmer; 1999.

CHEMIZM WODY WYBRANYCH RZEK NIZINY POŁUDNIOWOPODLASKIEJ

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Abstrakt: W pracy przedstawiono wyniki badań jakości wód rzek w środkowo-wschodniej części Polski: Kostrzynia, Mieni, Osownicy i Wilgi. Próbki wody pobierano sezonowo w odstępach kwartalnych. Badano w nich odczyn, przewodnictwo właściwe, stężenie tlenu rozpuszczonego w wodzie i BZT_5 oraz zawartość 26 pierwiastków metodą ICP-AES. Uzyskane dane opracowano statystycznie podając średnie arytmetyczne, zakresy stężeń, odchylenie standardowe (SD) oraz względne odchylenie standardowe (RSD). Z uwagi na wpływ terminu pobrania próbki na zawartość pierwiastków przeprowadzono jednoczynnikową analizę wariancji. Stwierdzono, że jakość wód analizowanych rzek była zróżnicowana w zakresie badanych wskaźników jakości. Na wartość wybranych wskaźników wpływała głównie lokalizacja pobrania próbki wody, pora roku oraz sposób użytkowania terenów przyległych. Zróżnicowaną jakość pobieranej wody powodowały antropogenne źródła zanieczyszczeń, a przede wszystkim zrzuty ścieków komunalnych z prywatnych posesji i spływy z nawożonych terenów rolniczych. Sporadyczne występowanie podwyższonych wartości niektórych wskaźników miało charakter punktowy i zmniejszało się w dalszym biegu rzek.

Słowa kluczowe: jakość wód powierzchniowych, wskaźniki jakości, źródła zanieczyszczeń, ICP-AES