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## INFLUENCE OF LOW RETENTION RESERVOIR ON WATER QUALITY OF SUPRASŁ RIVER

### WPLYW ZBIORNIKA MAŁEJ RETENCJI NA JAKOŚĆ WÓD RZEKI SUPRASŁ

**Abstract:** Present research was aimed at evaluating the water quality in small retention reservoir localized within the agricultural catchment in Wasilkow. Three measurement points were selected during the study; their spatial distribution resulted from a possibility to record changes in physicochemical properties of water occurring in analyzed reservoir. Point No. 1 was localized near the inflow, No. 2 in the middle part, No. 3 at the water outflow of the reservoir. Physicochemical analyses of water included following determinations: apparent and real color, turbidity, oxidizability, (specific electrolytic) conductivity, acidity, Kjeldahl's organic nitrogen, ammonia, nitrates(III), nitrates(V), phosphates, total iron, and manganese. Analyses of water samples collected from the surface layer of the littoral were carried out once a month since May 2008 till March 2009. Determinations of water physicochemical parameters were made in accordance with obligatory methods and statistical processing of all achieved data was performed applying two-factorial variance analysis for particular dates and sampling points. Differences were verified using Tukey test.

A prominent seasonality of all examined parameters was observed when analyzing achieved results. Two-factorial variance analysis of mean values of apparent and real color, turbidity, oxidizability, (electrolytic) conductivity, acidity, phosphates, and manganese revealed significant differences between sampling dates, while sampling points had no considerable importance. The Tukey test also verified that significant differences between sampling dates and points were present in the case of nitrates(V), while for nitrates(III) no factor was significant. Only in the case of iron the sampling point appeared to be the most significant, whereas sampling dates were insignificant.

Waters supplying Wasilkow reservoir had more often much lower values of examined physicochemical parameters than those flowing into it, hence the quality of river water below the reservoir became much worse. Observations upon a spatial distribution of studied indicators revealed that reservoir in Wasilkow had no abilities to self-purification.

**Keywords:** low-retention reservoirs, water pollution, biogenic compounds, water quality

A term "small retention" began to function at the beginning of 70's of the twentieth century [1] and originally was identified with small water reservoirs. They included the

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smallest reservoirs localized along a watershed as well as reservoirs in central part of a catchment. It can be possible, particularly in the case of lowland catchments, because many river fragments, due to riverbed and river valley structure, are appropriate for localizing larger or smaller dam reservoirs. The river dams, resulting from artificial water damming, contribute to intensified sedimentation of substances carried by a river into the retention reservoir. Sometimes, loads are as huge that reservoir's life is only several tens of years. Specificity of retention reservoirs that consists in retaining the nutrients along with their insolation, make them ecosystems susceptible to eutrophication processes. The influence of the reservoir on water quality in a river below the dam is also important [2, 3].

Present research was aimed at evaluating the seasonality of water quality in small retention reservoir in Wasilkow and its influences on physicochemical parameters of river Suprasl water.

## Material and methods

Retention reservoir on Suprasl River (from 22+0.400 km to 22+0.800 km of the river course, average flow  $9.86 \text{ m}^3 \cdot \text{s}^{-1}$ ) localized in Wasilkow was the object of examination. The reservoir surface area is 12 ha, while the area of catchment supplying the reservoir amounts to 1448.2 km<sup>2</sup>. Catchment of Suprasl River above the water reservoir Wasilkow is mainly covered with forests, but also agriculturally managed areas. The weir was built in 1968 according to a technical design from 1963 by Central Office for Studies and Designs of Hydrological Engineering "Hydroprojekt" in Warsaw. At first, the reservoir had to serve as a surface water intake point to meet increasing needs of Bialystok citizens and industry, as well as it had to be used as a city bathing place.

Three measurement points were selected during the study; their spatial distribution resulted from a possibility to record changes in physicochemical properties of water occurring in analyzed reservoir. Point No. 1 was localized near the inflow, No. 2 in the middle part, No. 3 at the water outflow of the reservoir. Physicochemical analyses of water included following determinations: apparent and real color, turbidity, oxidizability, (specific electrolytic) conductivity, acidity, Kjeldahl's organic nitrogen, ammonia, nitrates(III), nitrates(V), phosphates, total iron, and manganese. Analyses of water samples collected from the surface layer of the littoral were carried out once a month since May 2008 till March 2009. Determinations of water physicochemical parameters were made in accordance to obligatory methods [4], and statistical processing of all achieved data was performed applying two-factorial variance analysis for particular dates and sampling points. The differences were verified using Tukey test at the significance levels of  $\alpha \leq 0.05$  and  $\alpha \leq 0.01$ .

## Results and discussion

Waters collected in May and June 2008 were characterized by the largest value of color and turbidity, which – according to Woyciechowska and Dojlido [5] – may have resulted from a transitional bottom washout. Another considerable increase of color and turbidity values occurred in February and March 2009, which could be attributed to a

supply of organic compounds after snow thawing. Decrease in color intensity was recorded in July 2008 and January 2009. It probably resulted from the oxidation of organic substances. On the base of two-factorial variance analysis of mean color and turbidity values (Table 1), significant differences between sampling dates were confirmed, while values of these indicators depending on the sample collecting points were statistically insignificant. It was observed that the spatial distribution of color and turbidity did not oscillate much, although values of these parameters slightly increased along with the water flowing through the reservoir. In the case of real color, they remained at the level close to inflowing water and water in the reservoir.

Average values of oxidizability depended only on the sampling date. The highest values of the indicator were recorded in January, when samples were collected from beneath the ice cover. It might prove a significant accumulation of organic matter that time. Higher values were found in water flow out of the reservoir rather than at point localized at the water inflow.

Values of (electrolytic) conductivity in waters of studied reservoir were significantly differentiated depending on the sampling dates. Taking into account the dates, mean values of water conductivity oscillated from  $266.7 \mu\text{S} \cdot \text{cm}^{-3}$  in January 2009 up to  $436.7 \mu\text{S} \cdot \text{cm}^{-3}$  in August 2008. Moreover, the highest and very similar values of (electrolytic) conductivity were measured in waters collected in June, July, and August 2008, which might be a result of an intensive recreational utilization of the reservoir. Fairly high (electrolytic) conductivity values were recorded in waters collected in September, October, November, and December 2008, which might be the result of intensive autumn rainfalls and associated surface runoffs, as well as possibility of releasing the inorganic substances from bottom sediments. Values of (electrolytic) conductivity for waters were similar at all measurement points.

Water acidity significantly varied depending on sampling dates and oscillated from pH 7.16 to pH 8.17, whereas sampling points had no significant effect. Considerable decrease of pH values at all sampling points was recorded in July 2008 and January 2009, while the highest pH values were found in May and June.

Significant differences (Table 2) in organic nitrogen, ammonia, and nitrates(V) contents in waters of analyzed reservoir in particular sampling dates were proven. The highest mean *total Kjeldahl's nitrogen* (TKN) value was recorded in waters collected in May, June, and August 2008. Another increase of organic nitrogen level was recorded in January 2009. The sampling localization did not affect the TKN contents. The water flow through the reservoir had no influence on lower TKN values, even water flowing out contained more nitrogen than that flowing into the reservoir. It was particularly prominent since September till March. It was probably caused by weekly emptying of the Wasilkow reservoir since September 2008 by Bialystok Water Supply Works. When water was intensively let out, water surface level was much lowered, thus more intensive decomposition of accumulated organic matter occurred on exposed spots of bottom reservoir. Mineral salts and humus substances were the final products of that decomposition. When the reservoir was refilled with water, a secondary water contamination and direct or indirect decrease of the water could take place. Furthermore, exposing large fragments of the bottom often leads to its overgrowing by plants, the

Table 1  
Physicochemical properties of "Wasilkow" waters reservoir

Property	2008												2009			LSD
	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	Mean B				
Apparent color [mg Pt · dm <sup>-3</sup> ]	W <sub>in</sub>	117	57	38	61	38	110	37	75	25	69	69	A = 64.6 B = n.s.			
	W <sub>1</sub>	93	69	34	63	65	94	35	79	25	91	91				
	W <sub>out</sub>	86	166	43	53	29	72	44	74	34	81	81				
	mean	98.7	97.3	38.3	59.0	44.0	92.0	38.7	76.0	28.0	80.3	80.3				
Real color [mg Pt · dm <sup>-3</sup> ]	W <sub>in</sub>	46	36	37	60	24	55	15	44	10	60	60	A = 14.1 B = n.s.			
	W <sub>1</sub>	45	37	32	43	24	52	14	43	22	68	68				
	W <sub>out</sub>	41	34	26	44	25	48	17	52	12	60	60				
	mean	44.0	35.7	31.7	49.0	24.3	51.7	15.3	46.3	14.7	62.7	62.7				
Turbidity NTU	W <sub>in</sub>	13.0	10.0	7.0	2.4	1.4	1.4	3.0	3.5	3.4	3.4	3.4	A = 13.5 B = n.s.			
	W <sub>1</sub>	17.0	10.0	9.0	2.9	1.3	1.3	2.9	3.7	2.6	9.8	9.8				
	W <sub>out</sub>	16.0	34.0	13.0	1.1	1.4	1.3	3.2	3.5	3.3	3.6	3.6				
	mean	15.3	18.0	9.7	2.1	1.4	1.3	3.0	3.6	3.1	5.6	5.6				

Table 1 contd.

Property	2008										2009			Mean B	LSD
	V	VI	VII	VIII	IX	X	XI	XII	I	II	III				
COD <sub>Mn</sub> [mg O <sub>2</sub> · dm <sup>-3</sup> ]	W <sub>in</sub>	3.5	2.5	3.0	3.5	2.5	2.5	1.0	7.0	26.6	7.0	7.5	A = 3.26 B = n.s.	6.1 6.3 6.8	
	W <sub>1</sub>	3.0	2.5	2.0	5.0	4.5	4.0	0.5	6.0	26.2	7.5	8.0			
	W <sub>out</sub>	7.0	3.0	5.5	3.5	2.5	1.5	1.5	7.0	25.6	8.5	9.0			
	mean	4.5	2.7	3.5	4.0	3.2	2.7	1.0	6.7	26.1	7.7	8.2			
Conductivity [μS · cm <sup>-3</sup> ]	W <sub>in</sub>	356	408	410	440	383	372	382	371	259	283	283	A = 28.2 B = n.s.	358.8 366.3 363.6	
	W <sub>1</sub>	409	408	407	434	382	377	380	378	270	292	292			
	W <sub>out</sub>	358	412	408	436	389	378	387	381	271	290	290			
	mean	374.3	409.3	408.3	436.7	384.7	375.7	383.0	376.7	266.7	288.3	288.3			
Water acidity pH	W <sub>in</sub>	7.99	8.18	7.36	7.63	7.67	7.49	7.58	7.50	7.02	7.99	7.99	A = 0.31 B = n.s.	7.67 7.70 7.65	
	W <sub>1</sub>	7.99	8.19	7.40	7.70	7.73	7.53	7.62	7.44	7.04	8.01	8.01			
	W <sub>out</sub>	7.97	8.15	7.25	7.49	7.37	7.44	7.59	7.58	7.41	7.93	7.93			
	mean	7.98	8.17	7.34	7.61	7.59	7.49	7.60	7.51	7.16	7.98	7.98			

LSD (least significant difference)  $p \leq 0.5$ ; Factors: A – times, B – points; n.s. – non-significant; \* –  $p \leq 0.01$ .

Table 2

Physicochemical rates of "Wasilkow" waters reservoir

Property	2008												2009			LSD
	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	Mean B				
TKN [mg TKN · dm <sup>-3</sup> ]	W <sub>in</sub>	13.3	8.8	1.7	13.3	2.0	1.3	0.4	2.5	6.3	0.4	0.8	A = 6.2 B = n.s.			
	W <sub>1</sub>	10.4	5.4	2.1	8.8	2.9	0.8	1.3	4.6	7.5	0.4	0.8				
	W <sub>out</sub>	10.0	4.6	4.2	7.5	8.8	1.7	0.8	5.4	8.8	4.6	5.4				
	mean	<b>11.3</b>	<b>6.3</b>	<b>2.6</b>	<b>9.9</b>	<b>4.6</b>	<b>1.3</b>	<b>0.8</b>	<b>4.2</b>	<b>7.5</b>	<b>1.8</b>	<b>2.4</b>				
Ammonia [mg N-NH <sub>4</sub> · dm <sup>-3</sup> ]	W <sub>in</sub>	0.22	0.11	0.22	0.18	0.18	0.10	0.18	0.46	0.32	0.34	0.37	A = 0.22* B = n.s.			
	W <sub>1</sub>	0.29	0.07	0.22	0.21	0.22	0.09	0.15	0.33	0.26	0.34	0.37				
	W <sub>out</sub>	0.17	0.28	0.21	0.21	0.23	0.29	0.46	0.33	0.34	0.35	0.35				
	mean	<b>0.23</b>	<b>0.15</b>	<b>0.21</b>	<b>0.20</b>	<b>0.21</b>	<b>0.16</b>	<b>0.26</b>	<b>0.37</b>	<b>0.30</b>	<b>0.35</b>	<b>0.36</b>				
Nitrate(III) [mg N-NO <sub>2</sub> · dm <sup>-3</sup> ]	W <sub>in</sub>	0.046	0.083	0.013	0.003	0.013	0.017	0.066	0.050	0.007	0.297	0.30	A = n.s. B = n.s.			
	W <sub>1</sub>	0.003	0.040	0.030	0.020	0.003	0.023	0.030	0.056	0.023	0.026	0.026				
	W <sub>out</sub>	0.050	0.017	0.040	0.020	0.007	0.010	0.066	0.060	0.017	0.010	0.010				
	mean	<b>0.033</b>	<b>0.046</b>	<b>0.028</b>	<b>0.014</b>	<b>0.008</b>	<b>0.017</b>	<b>0.054</b>	<b>0.055</b>	<b>0.015</b>	<b>0.111</b>	<b>0.022</b>				

Table 2 contd.

Property	2008												2009			LSD
	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	Mean B				
Nitrate(V) [mg N-NO <sub>3</sub> · dm <sup>-3</sup> ]	W <sub>in</sub>	1.33	0.44	2.21	1.33	2.21	0.44	2.21	3.10	1.33	3.54	2.21	1.85	A = 2.07 B = 0.76		
	W <sub>1</sub>	2.21	0.44	2.21	0.89	1.33	2.21	2.21	4.43	2.21	4.87	4.43	2.50			
	W <sub>out</sub>	1.33	0.89	3.54	1.33	2.21	3.54	2.66	5.31	2.66	6.64	4.43	3.14			
	mean	1.62	0.59	2.66	1.18	1.92	2.07	2.36	4.28	2.07	5.02	3.69				
Phosphates [mg PO <sub>4</sub> · dm <sup>-3</sup> ]	W <sub>in</sub>	1.30	1.59	1.41	0.59	0.48	0.21	0.55	0.74	0.90	0.58	0.58	0.81	A = 0.82 B = n.s.		
	W <sub>1</sub>	1.09	0.82	2.40	0.73	0.47	0.23	0.64	1.35	0.54	0.64	0.64	0.87			
	W <sub>out</sub>	1.42	0.88	1.33	0.89	0.59	0.25	0.64	0.70	0.89	0.69	0.69	0.82			
	mean	1.27	1.10	1.71	0.74	0.51	0.23	0.61	0.93	0.78	0.64	0.64				
Iron [mg Fe · dm <sup>-3</sup> ]	W <sub>in</sub>	0.43	0.52	0.41	0.38	0.21	0.38	0.70	0.65	0.70	0.89	0.89	0.56	A = n.s. B = 0.32*		
	W <sub>1</sub>	0.43	0.50	0.30	0.34	0.24	0.22	0.68	0.78	0.54	1.03	1.03	0.55			
	W <sub>out</sub>	1.05	0.64	0.31	0.32	1.37	1.17	0.76	1.94	0.52	1.01	1.01	0.92			
	mean	0.64	0.55	0.34	0.35	0.61	0.59	0.71	1.12	0.59	0.98	0.98				
Manganese [mg Mn · dm <sup>-3</sup> ]	W <sub>in</sub>	0.081	0.062	0.048	0.026	0.008	0.029	0.163	0.136	0.246	0.147	0.147	0.099	A = 0.12 B = n.s.		
	W <sub>1</sub>	0.021	0.063	0.058	0.002	0.007	0.002	0.050	0.218	0.107	0.121	0.121	0.070			
	W <sub>out</sub>	0.069	0.040	0.071	0.019	0.135	0.050	0.207	0.124	0.177	0.151	0.151	0.109			
	mean	0.057	0.055	0.059	0.016	0.050	0.027	0.140	0.159	0.177	0.140	0.140				

LSD (least significant difference),  $p \leq 0.05$ , Factors: A – times, B – points, n.s. – non-significant, \* –  $p \leq 0.01$ .

decaying remains of which during reservoir refilling enhance the negative effects on water quality parameters [6].

Concentration of ammonia in waters was subjected to some extent to seasonality. Mean ammonia levels in waters collected at various dates much differed: from 0.15 mg N-NH<sub>4</sub> · dm<sup>-3</sup> in June 2008 to 0.37 mg N-NH<sub>4</sub> · dm<sup>-3</sup> in December 2008 (Table 2).

The lowest values of the parameter were observed in April and October 2008, while since May till September 2008 average ammonia concentrations oscillated within the range of 0.15–0.23 mg N-NH<sub>4</sub> · dm<sup>-3</sup>, and since November 2008 till March 2009, a gradual increase of the item concentration in waters from individual sampling points, was recorded (Table 2). It was probably the effect of emptying the reservoir and thus considerable worsening of water quality. It can be stated that ammonia concentration in waters flowing-out the reservoir was higher than those in flowing-in water. The presence of ammonia in surface waters may be affected mainly by: supplies of that nitrogen form from point and – to a lesser extent – area contamination sources, as well as aerobic conditions and temperature within the reservoir.

Nitrates(III) concentration was high and only slightly differentiated during the survey. A tendency to their elevated amounts in waters collected in May and June as well as November and December, could be observed. The amplitude of nitrates(III) concentrations was narrow (0.003–0.083 mg N-NO<sub>2</sub><sup>-</sup> · dm<sup>-3</sup>); only in February and March 2009, a sudden increase of the parameter up to 0.297 mg N-NO<sub>2</sub><sup>-</sup> · dm<sup>-3</sup> and 0.30 mg N-NO<sub>2</sub><sup>-</sup> · dm<sup>-3</sup>, respectively, was recorded at the measurement point localized near the water inflow to the reservoir. It could be a consequence of uncontrolled municipal and household wastewaters disposal.

Considering the nitrates(V), a gradual increasing tendency in analyzed waters was observed since December 2008 till March 2009. It should be emphasized that waters flowing-out of the reservoir were characterized by higher concentrations, than at other sampling points, which may suggest the negative influence of the reservoir on Suprasl River waters. Mean values of nitrates(v) percentage in total nitrogen in surface waters exceeding 40 % proved the area contamination [7]. Results referring to nitrates(V) concentration in waters that flew into the reservoir since late autumn and in winter indicated the effect of the area sources of nitrogen origin. Univocal reasons of differences in nitrogen compounds concentrations are hardly recognized. Differences both in uncontrolled surface runoffs, contaminants infiltration from agricultural and suburban areas, and varied weather conditions in particular study months seemed to be the most probable.

Phosphorus compounds are a constant component of surface waters, but their concentrations depend on the level of water contamination, thus they vary during a year [8]. Mean phosphates concentration in examined waters varied depending on the sampling dates, while waters collected from three different points contained similar phosphate levels. Phosphates concentrations in waters supplied to the reservoir indicated their area origin. No influence of the quality of water flowing out of the reservoir on Suprasl River water was observed, because average phosphates concentration within waters in reservoir and those flowing out of it, were similar. In opinion of Kiryluk [9], high phosphates level occurring in May, June, and July 2008 in reservoir



water may originate mainly from mineral fertilizers applied for surrounding fields, and river floods during early spring.

Mean iron contents in analyzed waters were not significantly differentiated in reference with the sampling date, yet some increasing tendency was observed in winter. Although amounts of that metal in examined waters much oscillated, tendencies of its higher levels at the water outflow from the reservoir rather than inflow and within the reservoir could be recorded. Elevated amounts of iron may be a cause of its compound precipitation in waters with slightly alkaline reaction, which was present in studied reservoir. According to Gorniak [10], the iron content in surface waters is influenced by a river catchment. Suprasl River is surrounded by organic soils, which favors the release of reduced iron form.

Like in the case of iron, more manganese was found in waters collected in winter. Its elution from a subsoil was a factor determining its concentrations in examined waters. Amount of water-soluble manganese varies very much and usually it is quickly precipitated in a form of colloidal suspension or is bound to bottom sediments and uptaken by plants, which was confirmed by its lower concentrations during the vegetation period.

Natural features of reservoirs and contaminants supplied from their direct catchments affect in concert quite poor water quality, while presence of point sources within a direct catchment determines the water quality regardless of the natural conditions of a reservoir and a catchment [11]. Loading the waters in Wasilkow reservoir with biogens was at relatively low level. The reservoir should be counted to older ecosystems, where matter and principal elements circulation is present, as well as characteristic plant communities developed. These factors should determine the biological balance and appropriate course of water self-purification process. Unfortunately, achieved results not always can confirm it. No doubt, the recreational utilization of the reservoir caused additional increase of majority of measured parameters values in summer. During the study, waters supplying the reservoir were characterized more often by much lower values of analyzed physicochemical indicators than those flowing-out of it. Therefore, quality of the river water below the reservoir was much worsen. Assessment of the water quality of Suprasl River on small retention reservoir in Wasilkow revealed that the reservoir had negative influence on a quality of out-flowing waters, which was probably additionally affected by gradual emptying of examined reservoir. Received results allow to classify water from the first class of water quality to the fifth class waters in accordance with obligatory decree. Parameters lowering the most water quality were: color, turbidity, TKN,  $\text{COD}_{\text{Mn}}$  and nitrate(V).

## Conclusions

Summing up the seasonal changes in physicochemical indicators of water quality in studied reservoir, following conclusions may be drawn:

1. Performed analyses of the reservoir water revealed great instability of its quality.
2. Achieved results were considerable variable and depended on seasons.
3. Wasilkow reservoir had no ability to water self-purification, which could have a negative influence on quality of Suprasl River water below the reservoir.

4. No doubt, a gradual emptying the reservoir also had the effect on out-flowing waters quality.

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## WPLYW ZBIORNIKA MAŁEJ RETENCJI NA JAKOŚĆ WÓD RZEKI SUPRAŚL

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**Abstrakt:** Celem prowadzonych badań była ocena jakości wód małego zbiornika retencyjnego, położonego w zlewni rolniczej w miejscowości Wasilków. Podczas badań wybrano trzy punkty pomiarowo-kontrolne. Wybór i rozmieszczenie punktów badawczych podyktowany był możliwością uchwycenia zmian właściwości fizykochemicznych wody, zachodzących w analizowanym zbiorniku. Pierwszy punkt usytuowany był na dopływie wód, drugi w środkowej części, zaś trzeci na odpływie wody ze zbiornika. Zakres pracy obejmował analizę fizykochemiczną obejmującą następujące oznaczenia: barwa pozorna i rzeczywista, mętność, utlenialność, przewodność (przewodność elektrolityczna), odczyn oraz zawartości TKN (azotu organicznego metodą Kjeldahla), azotu amonowego, azotanów(III), azotanów(V), fosforanów, żelaza ogólnego i manganu. Badania próbek wody, pobieranych z warstwy powierzchniowej strefy brzegowej, przeprowadzono co miesiąc, w okresie od maja 2008 r. do marca 2009 r. Analizy właściwości fizykochemicznych wody wykonano zgodnie z obowiązującą metodyką, zaś obliczeń statystycznych na podstawie wszystkich uzyskanych wyników badań dokonano, stosując dwuczynnikową analizę wariancji dla poszczególnych miesięcy i punktów pobrania. Różnice oceniono testem Tukey'a.

Analizując uzyskane wyniki badań, stwierdzono wyraźną sezonowość zmienności wszystkich badanych wskaźników. Na podstawie dwuczynnikowej analizy wariancji wartości średnich barwy pozornej, barwy rzeczywistej, mętności, utlenialności, przewodności, odczynu oraz zawartości TKN, azotu amonowego, fosforanów i manganu udowodniono istotne różnice tych parametrów pomiędzy terminami poboru próbek, natomiast punkty ich pobrania nie miały istotnego znaczenia. Testem Tukey'a oceniono również, że istotne różnice wartości ocenianych parametrów pomiędzy terminami i punktami pobrania stwierdzono w przypadku azotanów(V), natomiast w przypadku azotanów(III) żaden z tych czynników nie miał znaczenia. Jedynym w przypadku żelaza istotny okazał się wpływ punktu pobrania, zaś terminy okazały się nieistotne.

Wody zasilające zbiornik „Wasilków” miały najczęściej dużo niższe wartości badanych wskaźników fizykochemicznych, niż wartości wód opuszczających akwen, dlatego też jakość rzeki poniżej zbiornika uległa znacznemu pogorszeniu. Obserwacje przestrzennego rozkładu badanych wskaźników wykazały, że zbiornik w Wasilkowie nie ma zdolności do samooczyszczania.

**Słowa kluczowe:** zbiornik małej retencji, zanieczyszczenia, związki biogenne, jakość wód