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Original Research

Sanitary Studies on Water of Selected Lakes in Szczecin

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Abstract

The studies aimed at sanitary evaluation of two small lakes situated in the city of Szczecin, Poland: Rusałka and Syrenie Stawy. The studies were performed in summer months (June to August) in 1995-1996 and 1998-1999. In water samples, total coliforms, faecal coliforms, faecal streptococci and pollution-indicative index bacteria (TVC 20ºC, TVC 37ºC) were estimated. The analyses demonstrated that Rusałka lake exhibited lower levels of pollution than that shown by Syrenie Stawy. Also, the obtained results demonstrated in general higher level of pollution than that noted by other authors in municipal lakes.

Keywords: total coliforms, faecal coliforms, faecal streptococci, municipal lakes.

Introduction

In many towns, municipal lakes are located in recreational areas or parks. Despite this, water in the reservoirs remains, unfortunately, out of any control of the Polish legal system. According to "Guidelines of State Environmental Monitoring in 2003-2005" [1], in 2003 only 10 lakes were tested at the national level while at the regional level only lakes that had over 100 ha area or were important for economy or nature of the country were monitored. The monitoring was performed in 2003 and based on the system of lake quality testing, SOJJ [2]. However, some authors have claimed [3] that the system should be changed due to its shortcomings. One of the latter involves exceedingly frequent changes in lake quality classification (annual) appraised on the basis of the same parameters [3]. In 2004, monitoring should be performed according to guidelines instituted in the Minister for the Environment decree of 11.02.2004 [4] Monitoring according to this decree will be perform only until the end of 2004, decree shall expire on 01.01.2005

Monitoring of water purity in small municipal lakes is considered to be necessary since the water containers are frequently supplied with water streams carrying various contaminants (mainly sewage), which necessarily turns the lakes into water cleaning stations. Thus, the water containers may pose a threat to humans and animals, acting as reservoirs of potentially pathogenic bacteria [5] and viruses [5,6].

Fig.1. Location of studied lakes in Szczecin.

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Table 1. Results of microbiological studies originating from Rusalka Lake at two sampling sites (A,B).

Month of studies	Sampling site	Year of studies	Temp. of water (°C)	Temp. of air (°C)	MPN/100ml total coliforms	coli titre	MPN/100ml faecal coliforms	faecal coliforms titre	MPN/100ml faecal streptococci	TVC 37°C	TVC 20°C
June	A	95	16.0	24.0	6,200	0.02	2,300	0.04	690	3,900	9,200
		96	17.0	16.0	23,000	0.004	23,000	0.004	60	340	900
		98	23.0	34.0	5,000	0.02	5,000	0.02	360	1,330	2,560
		99	16.0	21.0	2,400	0.04	<5	>20	0	66	240
	B	95	22.0	24.0	62	2.0	13	8.0	20	520	1,450
		96	22.0	25.0	230	0.4	230	0.4	970	36	90
		98	21.0	26.0	2,300	0.04	130	0.8	120	1,240	320
		99	16.0	21.0	23	4.0	<5	>20	0	720	130
July	A	95	20.0	22.0	2,300	0.04	620	0.2	240	2,900	260
		96	14.4	14.8	23,000	0.004	2,300	0.04	2,700	340	1,000
		98	20.0	17.0	2,300	0.04	21	5.0	700	300	3,000
		99	18.0	15.0	6	17.0	6	17.0	100	2,300	520,000
	B	95	24.0	22.0	620	0.2	620	0.2	0	740	271
		96	16.2	17.8	62	2.0	62	2.0	300	38	67
		98	21.0	16.0	620	0.2	62	2.0	2,500	530	3,000
		99	18.0	15.0	2,400	0.04	<5	>20	200	1,880	39,000
August	A	95	24.0	24.0	230	0.4	23	4.0	20	1,030	32,000
		96	22.4	17.4	230,000	0.0004	230,000	0.0004	490	275	870
		98	18.0	12.0	2,300	0.04	2,300	0.004	850	2,880	44,000
		99	15.0	18.0	7,000	0.01	<5	>20	200	840	10,500
	B	95	26.0	24.0	230	0.4	23	4.0	50	1,700	14,200
		96	23.2	20.0	230	0.4	230	0.4	160	112	234
		98	19.0	13.0	62	2.0	2,300	0.04	890	115,000	6,500
		99	15.0	18.0	210	0.5	<5	>20	100	1,800	33,000
average	A	95-95, 98-99	18.6	19.6	25,311	1.468	22,132	5.526	534	1,375	52,044
	B		20.3	20.1	587	1.015	307	6.487	443	10,360	8,198

The sanitary studies presented in the literature on national waters which pertain to municipal lakes are related mainly to much larger water reservoirs [7-14]. Other studies in the range dealt with lakes outside municipal regions [12,13-19], and rivers [20-22] or well water [23-25].

The present study aims at evaluation of water in two selected municipal lakes situated in Szczecin city, Rusałka and Syrenie Stawy (Fig.1) in respect to the presence of sanitary bacteria, including total coliforms (TC), faecal coliforms (FC), faecal streptococci (FS) and index bacteria of water pollution (TVC 37ºC and TVC 20ºC).

Material and Methods

Study Area

Rusałka is situated in a valley between hills of Park Kasprowicza in the centre of Szczecin. Area of the container is 3.7 ha. The lake is elongated, its maximum width is 40 m and maximum depth is 2 m. In the lake no stratification of wave formation is observed. In 1997, the bottom of the lake was cleaned and in 1998 its banks were renewed. The lake is supplied by the Osówka Stream. Excess of its water is drained by a subterranean pipe to the Odra River. On the basis of ecological interview and analysis of the terrain shape, two sites of water sampling were selected, including

site A close to the inflow of Osówka and site B on the opposite side of the lake, close to its outflow.

Syrenie Stawy represents a set of three water containers (SI-SIII) joined by artificial inlets and situated in Las Arkoński, the forest park of Szczecin. The largest of the containers covers 1.45 ha, and the two smaller lakes of 0.22 and 0.2 ha, respectively, at a depth of around 1.5-2.0 m. Each of the lakes is supplied with sewage. For testing, four sites of water sampling were selected: site I was present at the eastern bank of SI lake close to the inlet which joins SI and SII lakes, site II – in SII lake, close to the sewage inflow, site III – in SII lake, close to the inlet joining SII and SIII lakes, site IV in SIII, close to the site of sewage inflow.

Sampling

The tests were performed in summer months, i.e. in June to August of 1995-1999 (except 1997, when the bottom of Rusałka lake was cleaned). Water samples were collected at 15-20 cm below water level, directly to sterile glass bottles with a ground cork which were transported in a 4°C insulated container to the testing laboratory. At the site of sampling water and air temperatures were measured.

Microbiological Studies

In water samples the following parameters were tested:

- number (MPN/100ml) and titre of total coliforms (TC)
- number (MPN/100ml) and titre of faecal coliforms (FC)
- number (MPN/100ml) of faecal streptococci (FC) was determined using membrane filters.
- total number (CFU/1ml) of bacteria on agar broth at 37ºC after 24 h incubation (TVC 37ºC),
- total number (CFU/1ml) of bacteria on agar broth at 20ºC after 72h incubation (TVC 20ºC).

The obtained results were appraised on the basis of classification of surface waters, suggested by Cabejszek et al. [26] and according to the principles and guidelines instituted by the Minister for the Environment decree of 11.02.2004 [4].

Results

Results of microbiological tests obtained in the two analyzed water containers in individual months, years and sites of sampling are presented in Tables 1 and 2. Mean values for the entire testing period, minimum values and maximum values of individual parameters are presented in Figs. 2 to 8.

In analysis of the results of water testing obtained for the samples of Rusałka over four years (Table 1) the highest levels of TC (MPN and titre) and FC (MPN and titre) were detected in August, 1996, at site A and they

Table 2. Results of microbiological studies originating from Syrenie Stawy lake at four sampling sites (I, II, III, IV).

Month of studies	Sampling site	Year of studies	Temp. of water (°C)	Temp. of air (°C)	MPN/100ml total coliforms	coli titre	MPN/100ml faecal coliforms	faecal coliforms titre	MPN/100ml faecal streptococci	TVC 37°C	TVC 20°C
June	I	95	24.0	22.0	6	17.0	6	17.0	10	3,600	15,300
		96	22.0	24.0	23	4.0	230	0.4	0	95	525
		98	20.0	19.5	23	4.0	6	17.0	40	300	3,000
		99	16.2	13.2	130	0.8	< 5	> 20	0	185	8,900
	II	95	23.0	22.0	2,300	0.04	620	0.2	420	660	1,760
		96	21.0	25.0	6,200	0.02	620	0.2	0	16,100	46,600
		98	22.5	23.0	2,300	0.04	19	5.0	470	1,120	2,490
		99	16.0	13.1	23	4.0	<5	>20	0	170	24,000
	III	95	24.0	22.0	230	0.4	13	8.0	10	600	4,300
		96	21.0	23.0	23	4.0	230	0.4	0	1,600	1,000
		98	22.0	20.0	2,300	0.04	13	8.0	30	3,000	120
		99	16.0	13.0	62	2.0	6	17.0	100	290	14,800
	IV	95	21.0	22.0	2,300,000	0.00004	620,000	0.0002	32,000	310,000	390,000
		96	20.0	22.0	2,300	0.04	6,200	0.02	7,400	68	4 350
		98	20.0	19.5	230	0.4	6	17.0	180	314	192
		99	16.0	13.0	620	0.2	62	2.0	0	410	40,000

Table 2 continues on next page...

July	I	95	22.0	23.0	130	0.8	230	0.4	150	3,100	26,000
		96	17.0	16.0	62	2.0	62	2.0	120	55	580
		98	20.0	18.0	200	0.5	200	0.5	220	1,142	1 120
		99	19.1	18.0	< 5	> 20	< 5	> 20	100	530	103,000
	II	95	22.0	23.0	1,300	0.08	230	0.4	30	4,200	12,000
		96	15.6	16.2	620	0.2	620	0.2	950	40	160
		98	18.0	18.0	5,000,000	0.00002	620,000	0.0002	68,000	8,100	12,000
		99	19.0	18.3	6	17.0	<5	>20	200	2,500	680,000
	III	95	21.0	23.0	6,200	0.02	6,200	0.02	32,000	9,100	25,000
		96	17.0	16.2	6,200	0.02	32	4.0	6,000	620	200
		98	20.5	18.0	23,000	0.004	23,000	0.004	3,400	1,300	5,200
		99	19.0	18.0	5	>20	<5	>20	300	2,800	900,000
	IV	95	22.0	23.0	620	0.2	620	0.2	20	3,100	6,300
		96	16.5	16.2	2,300	0.04	2,300	0.04	80	51	406
		98	19.0	18.0	230	0.4	23	4.0	120	680	1,310
		99	19.2	18.0	23	4.0	<5	> 20	200	1,100	850,000
August	I	95	22.0	21.0	230	0.4	23	4.0	20	890	6,800
		96	21.2	20.4	500	0.2	9	11.0	20	103	950
		98	16.0	13.0	230	0.4	62	2.0	80	130	320
		99	15.0	18.8	620	0.2	6	17.0	100	1,900	33,000
	II	95	22.0	21.0	2,100	0.05	1,300	0.08	110	21,700	76,000
		96	20.0	19.7	620	0.2	13	8.0	250	286	233
		98	14.5	13.0	23,000	0.004	210	0.5	47,000	209	300
		99	15.0	18.8	2,300	0.04	13	8.0	0	2,400	36,000
	III	95	22.0	21.0	620	0.2	62	2.0	80	1,550	3,800
		96	21.2	19.0	230	0.4	23	4.0	40	380	410
		98	15.5	14.0	23,000	0.004	230	0.4	2,400	370	420
		99	15.2	18.8	1,300	0.08	230	0.4	0	3,200	93,000
	IV	95	23.0	21.0	2,300	0.04	620	0.2	20	4,300	47,000
		96	19.6	19.6	23,000	0.004	2,300	0.04	1,200	174	1,510
		98	15.0	13.0	620	0.2	21	5.0	2,060	220	540
		99	15.7	18.8	62	2.0	62	2.0	900	1,470	45,000
average	I	95-96, 98-99	18.0	18.9	180	4.192	70	9.275	72	1,003	16,625
	II		17.7	19.3	420,064	1.809	51,971	5.215	9,786	4,791	74,301
	III		18.3	18.8	5,264	2.264	2,504	5.352	3,697	2,068	87,354
	IV		18.9	18.7	194,359	0.627	52,685	4.208	3,682	26,824	115,551

amounted to, respectively, MPN – 230,000/100ml for total coliforms and faecal coliforms and the titre of 0.0004 for both groups of the microbes. Also at the same site the highest values of TVC 20°C (520,000/1ml) were detected in July 1999. Whereas the highest number of TVC 37°C (115,000/1ml) was detected in August 1998 at site B. The lowest values of MPN (6.0/100ml) and of the titre (17.0) of TC were noted in July 1999 at site A while in the case of FC analogous values of MPN (<5/100ml) and of titre (>20) were recorded in June and August

1999 at site A and in July, June and August, 1999 at site B. Analogous numbers of TVC 20ºC (67/1ml) and TVC 37ºC (36/1ml) were detected, respectively in July and June 1996 at site B. The highest number of FS (2,700/100ml) was seen in July, 1996 at site A. They could not be detected in June 1999 at site A nor in June 1999 and July 1995 at site B.

In analysis of results obtained in Syrenie Stawy lakes total coliforms showed the highest number (MPN: 5,000,000/100ml and titre of 0.00002) in July 1998 at site II, while faecal E. coli group bacteria (MPN: 620,000/100ml, titre of 0.0002) also in July, 1998 at site II and in June, 1995 at site IV. The highest number of TVC 20ºC, 900,000/1ml, was noted in July, 1999 at site III and the highest number TVC 37ºC, 310,000/1ml, was detected in June, 1995 at site IV. The same level for faecal streptococci (68,000/100ml) was noted in July 1998 at site II. The microbes could not be detected in June, 1996 at sites I, II and III, in June, 1999 at sites II and IV and in August, 1999 at sites II and III. The lowest values for the microbes were recorded as follows: total coliforms: MPN <5/100ml, titre >20 was noted in July, 1999 at sites I and III, faecal coliforms: MPN <5/100ml, titre >20 was noted in June, 1999 at sites I and II and in July, 1999 at sites I, II, III and IV while that for TVC 20ºC (120/1ml) was recorded in June, 1998 at site III, that for TVC 37ºC (40/1ml) in July, 1996 at site II.

Analysis of mean values of tested parameters in the studied period at individual sampling sites (Rusałka lake, two sites, A i B, Syrenie Stawy lake, four sites, I, II, III, IV) demonstrated that in water of the former lake the highest values at site A pertained FC (MPN and titre), MPN of TC, FS, TVC 20ºC and while at site B the highest values were noted for titre of total coliforms, and TVC 37ºC. In Syrenie Stawy lakes the highest values were detected at site IV (MPN and titre of FC, titre of TC, TVC 20ºC, TVC 37ºC) and at site II (MPN of TC and of FS) while the lowest values were recorded at site I (all studied parameters). Comparing the obtained mean values for the two tested lakes, both the highest and the lowest indices were detected in the water of Syrenie Stawy.

In the evaluation of results of our tests according to recommendations of Cabejszek et al. [26] (Table 3) and the principles and guidelines instituted by the Minister for the Environment's decree of 11.02.2004 [4] (Table 4), it should be noted that, according to the first rule [2], only 9% of water samples from Rusałka (site B) and from Syrenie Stawy (site IV) could be classified as strongly contaminated (class 5) when number TVC 37°C but no samples represented the class when number of TVC 20°C or titre of TC were taken into account. Relatively few samples were classified as representing class 4, i.e. water strongly polluted in the field of titre of total coliforms (8% samples of water in each of three sites, II, IV and A) and TVC 37ºC (at site II 25% and at site III 8% samples), although many samples (33 to 59 % samples) represented the class in contamination with bacteria TVC 20ºC. Most of the tested samples fitted the criteria of class 1 to 3, mostly 2 to 3. However, comparing results own studies and according to the principles and guidelines instituted by the Minister's decree of 11.02.2004 [4] it should be noted that in the case of number of total coliforms most of the tested samples was classified as 1 and 2 class water quality i.e. water with good and satisfactory quality and in the case of the number of faecal coliforms tested samples was rated among 1, 2 and 3 class water quality. Considerably lower was percentage of tested samples which was rated among 4 and 5 class of water quality.

Discussion

It remains difficult to compare our own results with results of other authors since literature of the subject contains no studies on analogous microbiological testing of municipal ponds. The data on intra-town lakes pertain to much larger lakes than those we studied [7-14].

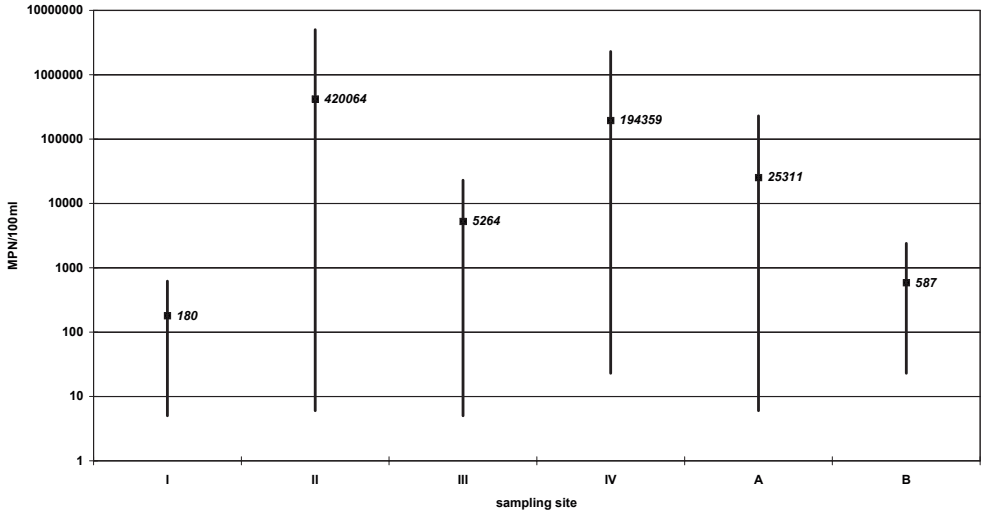

Fig. 2. Most probable number (MPN) of total coliforms (TC) (the square in the min-max bar indicates an arithmetical mean) in water samples originating from Syrenie Stawy (I-IV) and Rusalka (A,B).

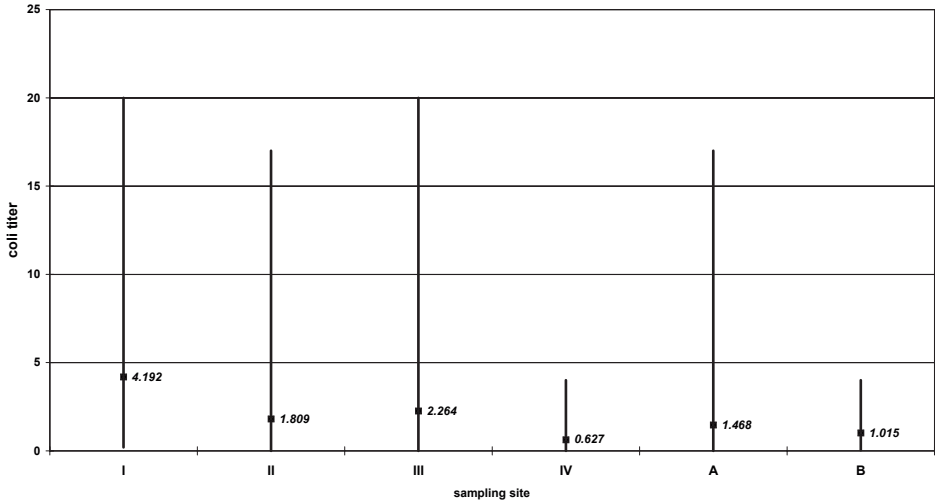

Fig. 3. Titer of total coliforms (TC) (the square in the min-max bar indicates an arithmetical mean) in the water samples originating from Syrenie Stawy lakes (I-IV) and from Rusalka (A,B).

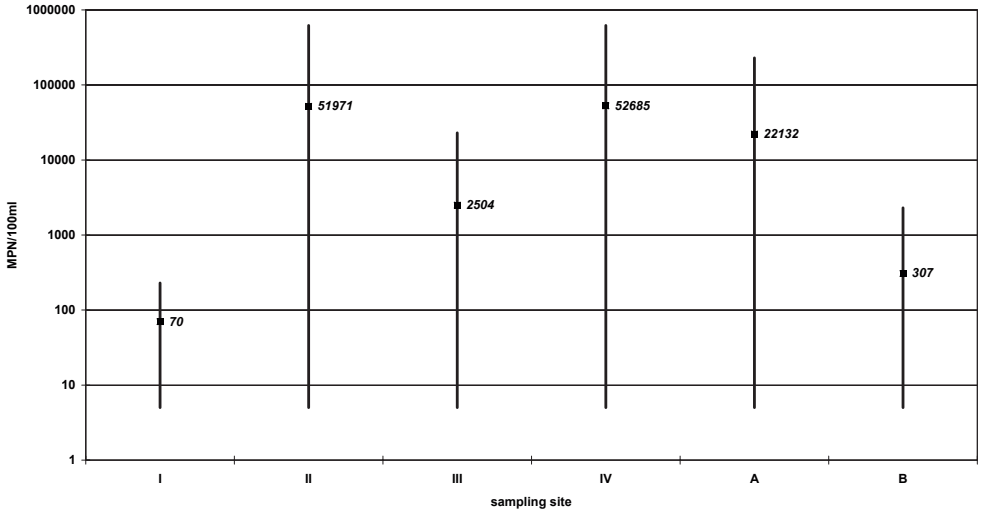

Fig. 4. Most probable number (MPN) of faecal coliforms (FC)(the square in the min-max bar indicates an arithmetical mean) in water samples originating from Syrenie Stawy lakes (I-IV) and from Rusalka (A,B).

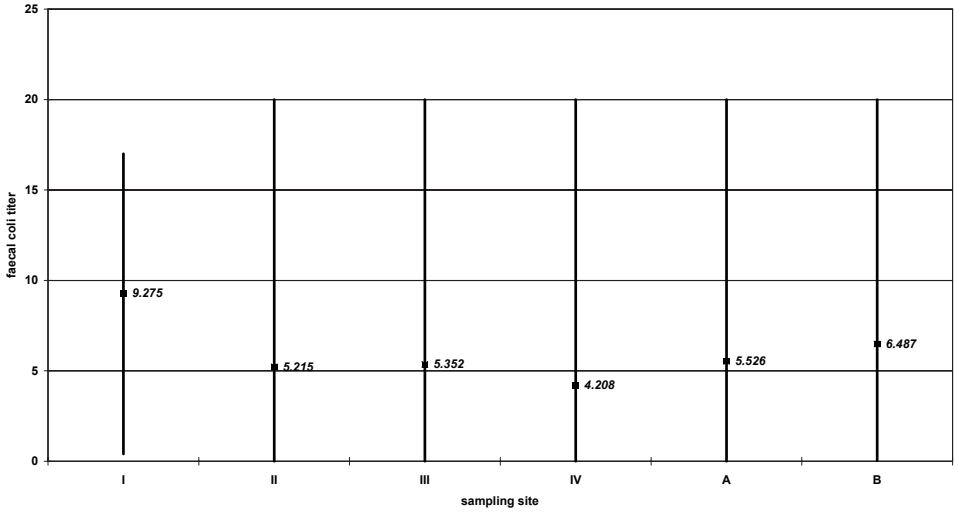

Fig. 5. Titer of faecal coliforms (FC) (the square in the min-max bar indicates an arithmetical mean) in the water samples originating from Syrenie Stawy lakes (I-IV) and from Rusalka (A,B).

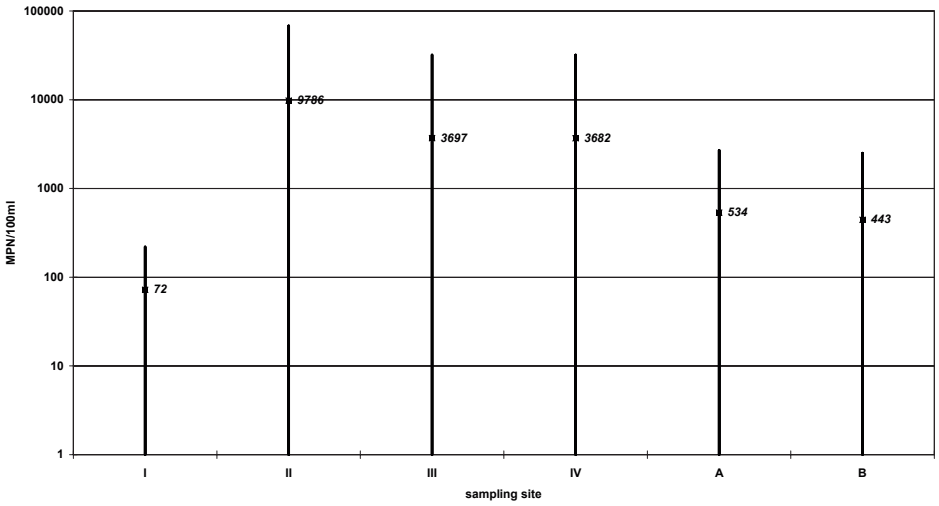

Fig. 6. Most probable number (MPN) of faecal streptococci (FS) (the square in the min-max bar indicates an arthmetical mean) in water samples originating from Syrenie Stawy lakes (I-IV) and from Rusalka (A,B).

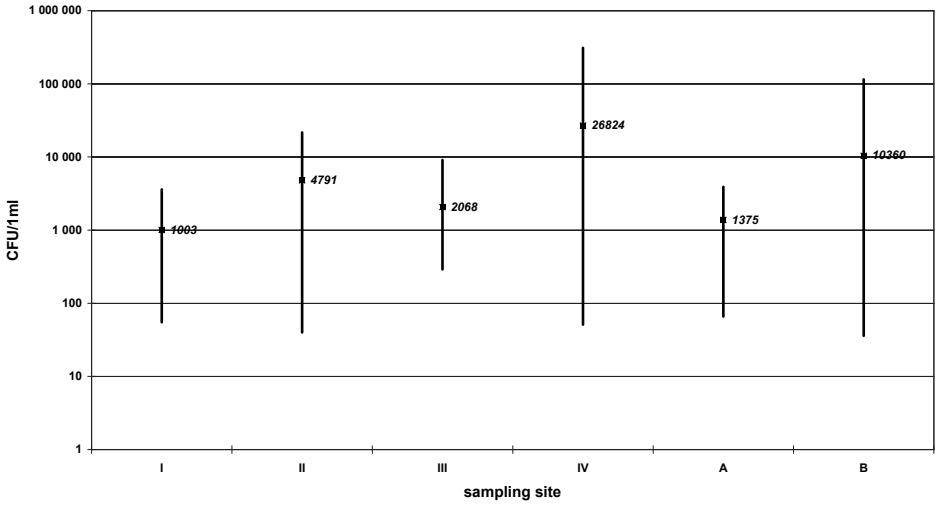

Fig. 7. Total viable count at 37°C (TVC 37°C) (the square in the min-max bar indicates an arithmetical mean) in water samples originating from Syrenie Stawy lakes (I-IV) and Rusałka (A, B).

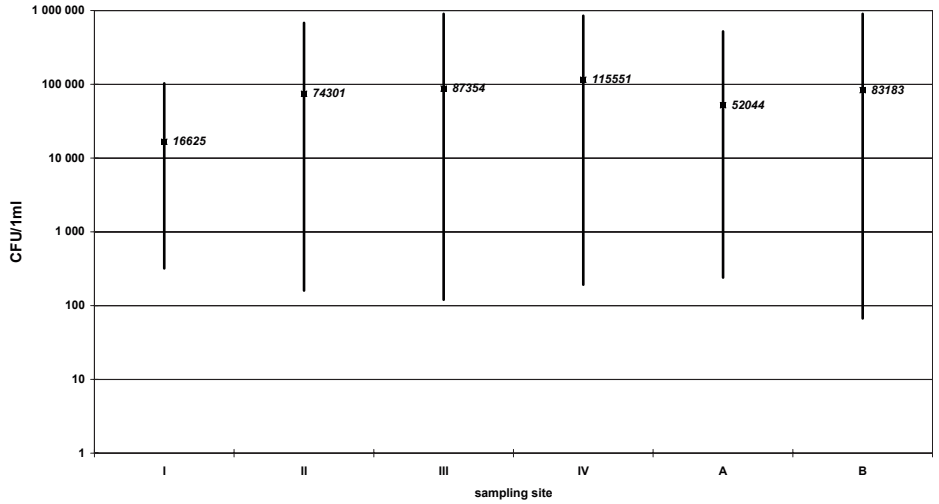

Fig. 8. Total viable count at 20°C (TVC 20°C) (the square in the min-max bar indicates an arithmetical mean) water samples originating from Syrenie Stawy lakes (I-IV) and Rusałka (A, B).

Table 3. Analysis of bacteriological water quality originating from Syrenie Stawy lakes (I-IV) and Rusalka (A,B) using criteria given by Cabejszek et al. [26].

Water quality criteria		Water quality	% of studied samples*					
			Sampling site					
Parameter	Number of bacteria		I	II	III	IV	A	B
[1]TVC 20°C	<300	1	0	16	16	8	16	42
	300 – 5 000	2	50	25	42	42	42	25
	5,000 – 10,000	3	16	0	8	8	8	8
	10,000 – 1,000,000	4	34	59	34	42	33	25
	> 1,000,000	5	0	0	0	0	0	0
[2]TVC 37°C	<200	1	42	16	0	25	8	25
	200 – 1 000	2	25	34	42	33	42	33
	1,000 – 5,000	3	33	25	50	33	50	33
	5,000 – 50,000	4	0	25	8	0	0	0
	> 50,000	5	0	0	0	9	0	9
Coli titre	>1.0	1	42	16	25	16	8	33
	1.0 – 0.1	2	58	16	25	43	8	50
	0.1 – 0.001	3	0	60	50	33	76	17
	0.001- 0.00001	4	0	8	0	8	8	0
	< 0.00001	5	0	0	0	0	0	0

[1] -Total number (CFU/1ml) of bacteria on agar broth at 20°C after 72h incubation (TVC 20°C); [2] - Total number (CFU/1ml) of bacteria on agar broth at 37°C after 24 h incubation (TVC 37°C); Water quality: 1 - unpolluted, 2 - insignificantly polluted, 3 - distincly polluted, 4 - heavilly polluted, 5 - very heavilly polluted, *- 12 samples of water were studied.

Table 4. Analysis of bacteriological water quality originating from Syrenie Stawy lakes (I-IV) and Rusalka (A,B) according to the principles and guidelines instituted by the Minister for the Environment's decree of 11.02.2004 [4].

Water quality criteria		Water quality	% tested samples*					
			Sampling site					
Parametr	Number of bacteria/100ml		I	II	III	IV	A	B
Most Probable Number of fecal coliforms	<20	I	50	42	34	17	33	33
	20-200	II	33	0	25	42	17	33
	200-2,000	III	17	50	25	8	0	26
	2,000-20,000	IV	0	0	8	25	33	8
	>20,000	V	0	8	8	8	17	0
Most Probable Number of total coliforms	<50	I	34	16	16	8	8	8
	50-500	II	58	0	25	26	8	58
	500-5,000	III	8	68	25	50	42	34
	5,000-50,000	IV	0	8	34	8	34	0
	>50,000	V	0	8	0	8	8	0

Water Quality: I - very good water quality, II - good water quality, III - satisfactory water quality, IV - unsatisfactory water quality, V - bad water quality, * - 12 samples were studied.

Comparing MPN of total coliforms (TC) we obtained (Syrenie Stawy: 5 to 5 mln/100ml, Rusałka: 6 to 230,000/100ml) to those noted by other authors [9,11,27], we can conclude that our results have been much higher than those obtained in Ukiel (MPN 0-3,000/100ml [9,11] or in Starodworskie lakes (MPN 0-1,400/100ml) [27]. Titres of TC obtained by us have varied widely both in Syrenie Stawy (>20-0.00002) and in Rusałka (17.0-0.0004). So extensive variations in the parameter have not been noted by other authors [7,8,13,14,28], who observed titre of TC of 0.0001-1.0. Analysis of MPN and of titre faecal coliforms has proven even more difficult since the parameter has been analyzed in a few studies only [10,11,27]. In our studies, MPN has amounted to 5 to 620,000/100ml in Syrenie Stawy and to 5 to 230,000/100ml in Rusałka. Much lower values were detected in Kortowskie (0-54/1ml) [10], Ukiel (0-12/1ml) [11] and Starodworskie lakes (0-1400/100ml) [27]. The number of faecal streptococci have shown lower contrasts: in Syrenie Stawy we have detected 0 to 68,000 bacteria /100ml and between 0 and 2,700 bacteria /100ml in Rusałka. The numbers resemble the data of Niewolak, who estimated them in waters of Kortowskie (0-42,000/100ml) [10], Ukiel (0-272/1ml) [11] and Starodworskie lakes (0-1,400/100ml) [27]. In analysis of TVC 20ºC our estimates have amounted to 120 to 900,000/1ml in Syrenie Stawy and between 67 and 520,000/1ml in Rusałka. Lower values resulting from own studies were obtained by Niewolak [8,27] in Jeziorak Mały (160-20,500/1ml), Jeziorak (100-4,000/1ml), Kortowskie lake (40 to 2,130/1ml), Długie lake (660-1,940/1ml), Miejskie lake (500-3,080/1ml), Ełckie lake (370-9,600/1ml) and Starodworskie lake (0-3,100/1ml) as well as by Zmysłowska and Sobierajska [14] in Długie lake (780-90,000/1ml), by Godlewska-Lipowa et al. [7] also in Długie lake (330-18,100/1ml) and Miejskie lake (1,280- 212,800/1ml), by Szulkowska-Wojaczek [29] in Charzykowo lake (6-1,050/1ml). On the other hand, values higher than ours have been noted in Kortowskie (20-300mln/1ml) [10] and in Ukiel lakes (1,340-110mln/1ml) [11]. Comparing TVC 37ºC, which has reached 40-310,000/1ml in water samples from Syrenie Stawy and 36-115,000/1ml in those from Rusałka, lower values have been observed in Jeziorak (< 1,000/1ml) [28], Starodworskie (1-3,050/1ml) [27] and Iławskie lakes (1-13,600/1ml) [8], Długie (500-45,000/1ml) [14] and Charzykowo lakes (2-500/1ml) [29], while higher levels have been disclosed in Ukiel lake: 12-2.5mln/1ml [9] and 110-85mln/1ml [11] and in Kortowskie lake (35-1mln/1ml) [10].

Conclusions

1. In respect to studied parameters, water in the two reservoirs underwent in the tested period extensive and different variations which indicated a continuous but variable inflow of contaminants to the two reservoirs.
2. In both reservoirs, most of studied indices reached the lowest levels in 1999 but no such regularity was detected in maximum levels.
3. The performed tests documented that, in respect to studied indices, Syrenie Stawy lakes were more polluted than Rusałka lake.
4. In most cases, results of our studies documented higher levels of pollution than those reported in other municipal lakes by other authors.
5. According to criteria provided by Cabejszek et al. [26], most of water samples from the two studied water reservoirs fitted the criteria of class 2 or 3 like principles and guidelines instituted by the Minister for the Environment's decree of 11.02.2004 [4]

References

1. STATE ENVIRONMENTAL MONITORING in 2003-2005. Internet: http://www.gios.gov.pl/pms.rtf (in Polish).
2. KUDELSKA D., CYDZIK D., SOSZKA H. Guidelines for lake basic monitoring. Wyd. II, PIOŚ, Bibl. Mon. Środ., Warszawa **1994**. (in Polish)
3. JAŃCZAK J. Monitoring studies of lakes in Poland – need for changes. Gosp. Wod. **640**, 168, **2002**. (in Polish)
4. Decree of the Environment Minister of 11th of February 2004. Dz. U. z 2004 r., Nr 32, Poz. 284. (in Polish)
5. BARABASZ W. Microbiological and ecotoxicological threat of surface water. Słupskie Prace Przyrodnicze, Seria: Biologia eksperymentalna i ochrona środowiska **1**, 7, **2001**. (in Polish)
6. DEPTUŁA W., BUCZEK J., MARKIEWICZ D. Do viruses occur in the water can be dangerous? Mat. Symp. Nauk. Pt.: "Choroby odzwierzęce człowieka związane z zatruciami pokarmowymi" Szczecin, pp. 52-68, **1995**. (in Polish).
7. GODLEWSKA-LIPOWA W., SOBIERAJSKA M., ZMYSŁOWSKA I. Mikrobiological studies of lakes Długie and Miejskie near the town of Szczytno. Zesz. Nauk. ART. Olsztyn Ochr. Wód i Ryb. Śródl. **3**, 29, **1974.** (in Polish),
8. NIEWOLAK S. Sanitary evaluation of the municipal lakes at Mazurian lakeland in 1967-1971. Gaz, woda i technika sanitarna **46**, 10, **1972**. (in Polish)
9. NIEWOLAK S. Sanitary state and survival of some enteric bacteria in Ukiel lake water. Gaz, woda i technika sanitarna **52**, 90, **1978**. (in Polish)
10. NIEWOLAK S. The hygienic-sanitary evaluation of the housing estate bath at Kortowskie lake in Olsztyn. Zesz. Nauk. ART Olsztyn Ochr. Wód i Ryb. Śródl. **8**, 59, **1978**. (in Polish)
11. NIEWOLAK S. The hygienic-sanitary evaluation of the housing estate bath at Ukiel lake in Olsztyn (in Polish), Zesz. Nauk. ART Olsztyn Ochr. Wód i Ryb. Śródl. **8**, 73, **1978**.
12. NIEWOLAK S. Sanitary and bacterial analysis of water and bottom sediments of a heavily polluted hypertrophic lake. Ekol. pol. **37**, 3, **1989**.
13. ZMYSŁOWSKA I., SOBIERAJSKA M. Microbiological studies of the Kortowskie lake. Pol. Arch. Hydrobiol. **24**, 61, **1977**.
14. ZMYSŁOWSKA I., SOBIERAJSKA M. Microbiological analysis of polluted with communal sewage Długie lake in Olsztyn. Zesz. Nauk. ART Olsztyn Ochr. Wód i Ryb. Śródl. **10**, 39, **1980**. (in Polish)

15. KORZENIEWSKA E., NIEWOLAK S., GOTKOWSKA-PŁACHTA A. Evaluation of sanitary–bacteriological state of pelagial and profundal waters of the Wigry lake in 1997-1999. Słupskie Prace Przyrodnicze, Seria: Biologia eksperymentalna i ochrona środowiska **1**, 61, **2001**. (in Polish)
16. NIEWOLAK S. The sanitary and bacteriological quality of water flowing into Wadąg Lake. Pol. J. Environ. Stud. **2**, 27, **1993**.
17. NIEWOLAK S. Evaluation of pollution and the sanitary-bacteriological state of Lake Wigry, Poland. Part II. Near-shore Waters of Lake Wigry. Pol. J. Environ. Stud. **8**, 169, **1999**.
18. SMYŁŁA A., GŁOWACKA K., KOSTECKI M. Sanitary indicators and potential pathogenic bacteria in water dam reservoir Dzierżno Duże. Archiwum Ochrony Środowiska **28**, 87, **2002**. (in Polish)
19. SZPAKOWSKI J. Changes in the Quality of water from the Solina and Myczkowce dam reservoir from 1971 to 1990. Environment Protection Engineering **18**, 35, **1992**.
20. DONDERSKI W., WILK I. The sanitary state of water in the river Vistula between Wyszogród and Toruń. Pol. J. Environ. Stud. **11**, 509, **2002**.
21. KOTOWICZ J., SZYJKOWSKI A. Evaluation of Odra water quality according to biological conditions in rep section in Wrocław. Wiad. IMGW **37**, 139, **1993**. (in Polish)
22. SZUMILAS T., SOBOL Z., MICHALSKA M., DUTKOWIAK M., BARTOSZEWICZ M., FRYMARK J., KRĘŻEL A., NOWACKI J. Sanitary evaluation of the water of Kacza river along it course based on the studies performed in 1996 and 1997. Biul. Org. Inst. Med. Morsk. i Trop. **30**, 42, **1997**. (in Polish)
23. NIEWOLAK S. Assessment of hygienic and sanitary states of well and spring waters in Wigry National Park, Poland. Pol. J. Environ. Stud. **7**, 99, **1998**.
24. TYMCZYNA L., GOŁUSZKA J. The sanitary state of well water in the piedmont districts in Sucha Beskidzka. Roczn. PZH **52**, 145, **2001**. (in Polish)
25. TYMCZYNA L., ODÓJ J., GOŁUSZKA J. The sanitary state of well water in the Pulawy region. Roczn. PZH **53**, 177, **2002**. (in Polish)
26. CABEJSZEK I., KOŁACZKOWSKI S., KOZIOROWSKI B., ŁUCZAK J. Bill of the standardized guidelines for classification of surface water pollution. Gaz, woda i technika sanitarna **34**, 18, **1960**. (in Polish)
27. NIEWOLAK S., CHRZANOWSKA L., GOŁAŚ I., PIJOREK A., SANDURSKA J. Sanitary and bacteriological survey of an artificially aerated eutrophic Lake Starodworskie, Poland. Pol. J. Environ. Stud. **6**, 33, **1997**.
28. NIEWOLAK S. The sanitary evaluation of surface waters in Iława lakes in 1960-1963. Zesz. Nauk. WSR Olsztyn **21**, 99, **1966**. (in Polish)
29. SZULKOWSKA-WOJACZEK E. Bacteriological assessment of usefulness for communal use of water Charzykowo lake. Gaz, woda i technika sanitarna. **46**, 81, **1972**. (in Polish)