Polish Journal of Environmental Studies Vol. 10, No. 3 (2001), 167-174

The Evaluation of the Degree of Pollution and Sanitary-Bacteriological State of Surface Water in Wigry Lake, North-East Poland. Part III. Waters of Hanczanska Bay and the Areas Adjoing Wigry Lake*

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Received: August 20, 2000
Accepted: January 15, 2001

Abstract

This work comprises the results of examinations of a number of indicator bacteria on the degree of pollution (TVC 20°C, TVC 37°C), sanitary state (TC, FC, FS), and usefulness for recreation of Hanczanska Bay and areas adjoining Wigry Lake. Adequate studies were made in 1997, a year after the start of 3rd degree sewage treatment in the Wastewater Treatment Plant in Suwalki. All of these bacteria in general were more numerous in the water of Hanczanska Bay, especially in spring-summer. In the waters of northern Ploso of Wigry Lake numbers of bacteria were only periodically numerous at some water samples. The highest percentage of pure water samples fulfilling the requirement for bathing waters was found at sites on the border between Hanczanska Bay and the waters of Northern Ploso of Wigry Lake; the lowest percentage was found at sites in Hanczanska Bay. Gradual decrease of TVC 20°C (sometimes 37°C) with the distance from the mouth of the Czarna Hancza River towards south-east sites shows this direction of the movement of main water masses of the Czarna Hancza River. No significant differences in percentage of unpolluted water samples stated in Hanczanska Bay and areas adjoing Wigry Lake with a comparison of data from 1994-1996 years of investigation.

Keywords: Hanczanska Bay, Wigry Lake, national park, pollution, sanitary evaluation, indicator bacteria, recreation, bathing.

Introduction

The waters of Hanczanska Bay of Wigry Lake are among the most eutrophic in Wigry National Park. According to literature data [2, 18] the amount of phosphorus in this part of the lake is one of the highest and is estimated at 0.160-0.220 mg/1 P_{total} in spring and 0.090-0.134 mg/1 P_{total} in summer. Efluent of polluted waters of the Czarna Hancza River influences this amount [8]; the river carries point pollution from the waste treatment plant in Suwalki as well as pollutants from the arable-forestry-pasture-meadow catchment. Since 1996 there has been working a 3rd degree waste treatment plant and the treated wastes from Suwalki have been directed into this river. It is interesting if the bacteria populations carried by the Czarna Hancza River can be a determiner of impact zones and the influence of his effluent on the receiving lake water. Previous bacterio-

* The edition of this paper was sponsored by Wigry National Park.

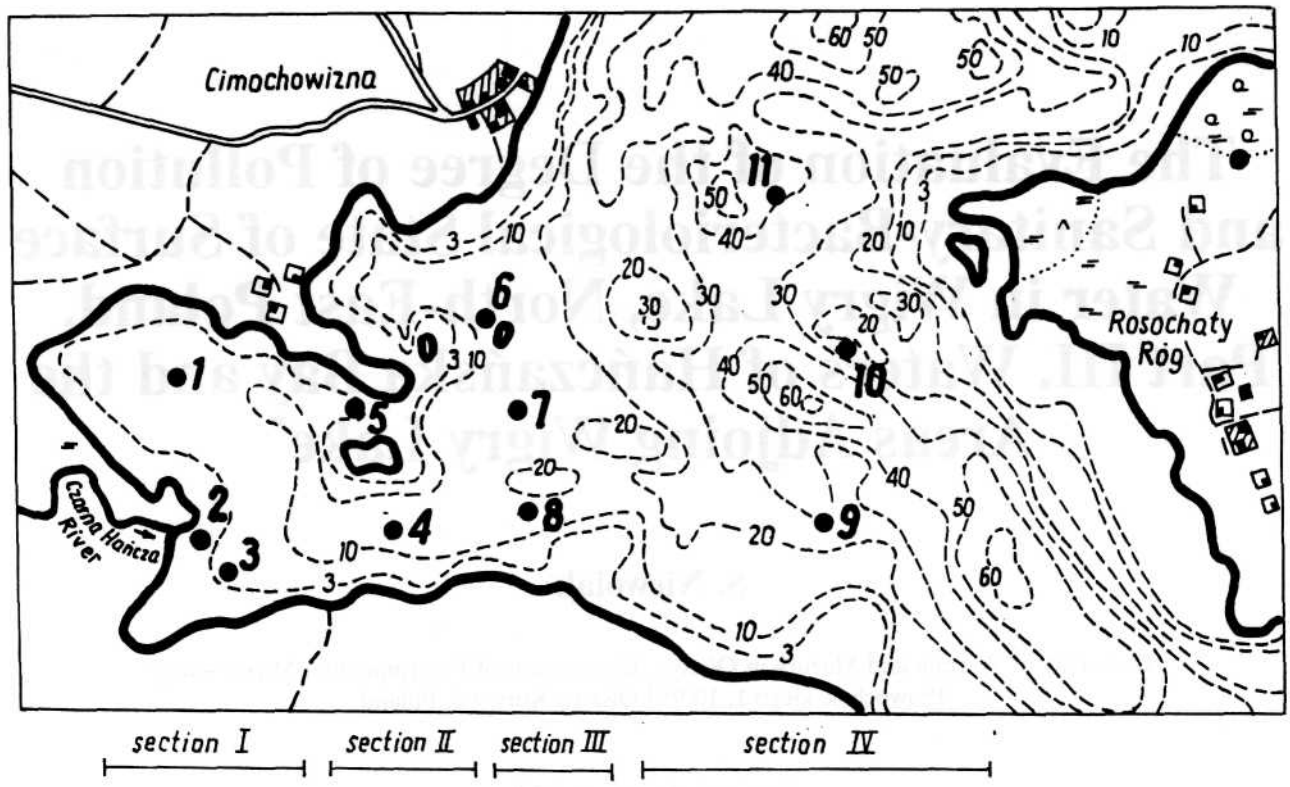

Fig. 1. Situational sketch of Hanczanska Bay and areas adjoing Wigry Lake. 1,2,3...11 - sites for collecting water samples.

logical studies of water in Hanczanska Bay and Wigry Lake in 1994-1996 stated high numbers of TVC 20°C and TVC 37°C [9-11] an indicators of lake trophic status [13]. These numbers sometimes reached several thousand and a few million CFU/1 ml. The average number of these bacteria decreased in consecutive years. As regards the bacteria of the sanitary state, only FS attained higher numbers, whereas numbers of TC and FC did not exceed 2400 MPN/100 ml. These bacteria were usually more numerous at sites close to the inflow of the Czarna Hancza River. Prolongation of Hanczanska Bay towards Ploso Northern of Wigry Lake was characterized by TVC 20°C and TVC 37°C numbers not exeeding 1670 and 825 CFU/1 ml, respectively. TC and FS reached maximally 1400 MPN/100 ml, and FC - 150 MPN/100 ml. The present work was to estimate the degree of bacteriological pollution and sanitary state of the waters of Hanczanska Bay (and the areas close to Wigry Lake in 1997) one year after the initiation of 3rd degree sewage treatment in a municipal Wastewater Treatment Plant in Suwalki. The investigated indicator bacteria were TVC 20°C, TVC 37°C, TC, FC and FS.

Materials and Methods

Hanczanska Bay. Hanczanska Bay of Lake Wigry comprises comparatively small areas of surface waters of this reservoir (about 1 km^2). From the west it is surrounded by morraine hills reaching 143-216 m above the sea level and a valley of the Czarna Hancza River. From the north it borders with a peninsula where a little settlement is situated and further is an agricultural-summer resort village called Cimochowizna. From the east and open waters of Northern Ploso of Lake Wigry opposite Cimochowski peninsula it is surroundend by Cimochowski dry-ground forest islands and numerous shallows. From the south it is surrounded by lowland with pine forest, periodically flooded. The depth of Hanczanska Bay generally does not exceed 10 m. Alder and willow and a little further pine forest with the addition of spruce-trees grow on the shores of Hanczanska Bay. We can distinguish two smaller bays - Piasecznik and Suchar within Hanczanska Bay created by deposits carried by the Czarna Hancza River. They are incised towards the eastern shores of Hanczanska Bay and are separated by a wet ground by grass and bulrush where the Czarna Hancza flows. Until 1992 the river included storm waters and farm and industrial wastes from Suwalki, which were treated only mechanically, surface downflows from arable-forestry-pasture-meadow catchment and from Sobolewo. Since 1992 almost all wastes from Suwalki have been directed to the municipal waste treatment plant, and since 1996 this has been subject to the 3rd degree of treatment [8]. The Czarna Hancza River carries 76.2 mid m^3 water annualy into Hanczanska Bay of Lake Wigry [2]. There is a beaver reserve close to the mouth of the Czarna Hancza River to Hanczanska Bay, one of the largest reserves in Wigry National Park.

Sampling sites. 11 sites were prepared for examination - 5 in Hanczanska Bay and 6 in the area close to Northern Ploso of Lake Wigry. The localization of these sites was presented in Fig. 1.

Table 1. Sites of water sampling.

Lake part	Section	Site No.	Site designation[1]	Distance from mouth of the Czarna Hańcza River (m)	Depth (m)	Number of samples investigated	Depth of sampling (m)
Hańczańska Bay	I	1.	Sosnowik Bay	500	5	5	0.3; 1.0, 2.0; 3.0; 5.0
		2.	at mouth of the Czarna Hańcza River	2-3	1	2	0.3; 0.8
		3.	Suchar Bay	150	2	3	0.3; 1.0; 1.8
	II	4.	Between Cimochowska Island and southern shore of Hańczańska Bay	600	10	6	0.3; 1.0; 2.0; 3.0; 5.0; 9.8
		5.	Between Cimochowska Island and northern shore of Hańczańska Bay	600	6	6	0.3; 1.0; 2.0; 3.0 5.0; 5.8
Northern Ploso (Plos Wigierski)	III	6.	At the edge of Cimochowska Bay and Northern Ploso of Lake Wigry	1100	12	7	0.3; 1.0; 2.0; 3.0; 5.0; 10.0; 11.5
		7.	Towards the east of Cimochowska Island and the edge of Northern Ploso of Lake Wigry	1050	15	7	0.3; 1.0; 2.0; 3.0; 5.0; 10.0; 14.5
		8.	Opposite the mouth of the Czarna Hańcza River to Hańczańska Bay at the edge of Northern Ploso of Lake Wigry	960	12	6	0.3; 1.0; 2.0; 3.0; 5.0; 11.8
	IV	9.	In the central part of Northern Ploso of Lake Wigry	1700	30	3	0.3; 1.0; 2.0
		10.	In the central part of Northern Ploso of Lake Wigry	1850	20	8	0.3; 1.0; 2.0; 3.0; 5.0; 10.0; 15.0; 19.5
		11.	In the central part of Northern Ploso of Lake Wigry	1900	35	8	0.3; 1.0; 2.0; 3.0; 5.0; 10.0; 15.0; 34.5

[1] See Figure 1

Table 2. The regime of determining of the number of indicator bacteria used in the studies.

Indicator bacteria	Nutrient agar	Incubation	
		Temperature (°C)	Time (hours)
1. Total viable count at 20°C (TVC 20°C)	Broth-agar (pH 7.2)	20	72
2. Total viable count at 37°C (TVC 37°C)	Broth-agar (pH 7.2)	37	24
3. Total coliforms (TC)	Endo-agar	37	48
4. Faecal coliform (FC)	Endo-agar	44.5	24
5. Faecal streptococci (FS)	m-Enterococcus Agar	37	72

Sampling procedures. Water samples for examination were taken at 1 month intervals from May to November 1997, from the surface layer (0.3 m) and from depths of 1.0 m; 2.0 m; 5.0 m; 10.0 m and deeper at 10 m intervals down to the bottom. Outline characteristics, numbers of samples and depth of sampling at particular sites was presented in Table 1. Technical methods of taking the water samples and their conservation until bacteriological analysis was the same as in the two previous parts of this paper [9, 10].

Bacteriological examinations. Bacteriological examinations comprised assessment of total viable count at 20 and 37°C, the number of total and faecal coliforms and faecal streptococci (Table 2). All of the examinated water samples (341 samples) were inoculated in 3 parallel repetitions counting all (TVC 20°C, TVC 37°C) or typical (TC, FC, FS) colonies. Physiological solution NaCl was a dilutant in these examinations. The methods of work proving the presence of TC, FC and FS were the same as in the first two parts of research [9, 10]. The obtained

Table 3. The number (mean for study period) of total viable counts at 20°C (TVC 20°C) and 37°C (TVC 37°C) in the water of Hanczanska Bay and the areas adjoing Lake Wigry in 1997.

Section	Site[1]	TVC 20°C (CFU/1 ml)							TVC 37°C (CFU/1 ml)						
		May 16	June 20	July 18	Aug 22	Sept 19	Oct 24	Nov 29	May 16	June 20	July 18	Aug 22	Sept 19	Oct 24	Nov 29
I	1	320	2180	360	1270	490	200	460	245	1020	235	615	130	20	55
	2	350	1980	560	2125	515	–	700	250	395	460	245	135	–	–
	3	2150	2015	500	790	250	40	–	3240	165	190	275	85	145	70
II	4	680	2650	280	825	310	180	–	625	855	90	290	75	35	–
	5	340	740	180	860	250	270	–	330	1290	115	375	75	30	–
III	6	450	140	410	1440	270	140	600	115	485	180	410	40	20	10
	7	1080	715	400	7700	280	115	650	160	175	205	1850	60	35	10
	8	770	440	200	1020	430	80	370	270	130	90	175	65	20	–
IV	9	11270	130	60	730	315	20	615	630	50	40	210	25	10	5
	10	1370	700	280	4990	285	35	310	95	90	200	1800	40	65	5
	11	1260	2200	630	1680	590	35	400	180	1400	275	6200	70	25	5

[1] See Figure 1.

values of bacteriological indicators of the pollution degree (TVC 20°C, TVC 37°C) and sanitary state (TC, FC, FS) of the examinated water samples from Hanczanska Bay and areas close to Wigry Lake were refered to the suggested criteria of the evaluation of the degree of surface water purity [1, 4, 14] and sanitary requirements for waters for recreational and bathing purposes found in literature (5, 16, 17].

Results

TVC 20°C and TVC 37°C numbers (Table 3). Table 3 presents only average numbers of TVC 20°C and TVC 37°C for total column of water at particular sites in Hanczanska Bay (sites 1-5) and the areas adjoing Lake Wigry (sites 6-11). The average number of TVC 20°C for total column of water in Hanczanska Bay ranged from 20 to 11,270 CFU/1 ml. The lowest number was found at sites 3, 8, 9,10, and 11 (20-80 CFU/1 ml in October), the highest number was at sites 7 and 9 (7700 and 11270 CFU/1 ml, respectively). The lowest number was noticed in October and the highest one in May and/or in August, seldom during another period. The average number of TVC 37°C ranged from 5 to 8600 CFU/1 ml. The lowest number observed at sites 8 and 9 (20-270 and 5-210 CFU/1 ml, respectively), the highest number at sites 3 (70-3240 CFU/1 ml), 7 (10-1858 CFU/1 ml), 10 (5-1800 CFU/1 ml) and 11 (5-620 CFU/1 ml). The lowest number was in October and November, the highest in May (site 3), in June (sites 1, 4, 5, 6), July (site 2) and in August (sites 7, 10, 11).

The ratio of TVC 20°C: TVC 37°C (Table 4). The ratio of TVC 20°C: TVC 37°C in 72.2-100% of the examined samples was lower than 10; in 0-27.8% it was higher than 10. The ratio TVC 20°C: TVC 37°C lower than 10 was found more often at sites 1-4; the ratio TVC 20°C: TVC 37°C higher than 10 was found more often in samples taken at 5-11 sites in the open waters of Lake Wigry.

Numbers of TC, FC and FS (Table 5). The average number of TC ranged from 100 CFU/100 ml in the water at different sites and in different seasons up to 11,200 CFU/100 ml at site 10. In the examination season higher pollution by these bacteria was found in August (all sites), exceptionally in October (at sites 3 and 5). The

Table 4. Percentage of water samples collected in Hanczanska Bay having TVC 20°C: TVC 37°C ratio lower and higher than 10.

Temperature ratio test (TVC 20°C : TVC 37°C)	Section[1]										
	I			II		III			IV		
	Site										
	1	2	3	4	5	6	7	8	9	10	11
< 10	90.6	88.8	100	91.4	81.8	80.5	72.2	83.3	76.4	76.8	73.9
> 10	9.4	11.2	0	8.6	18.2	19.5	27.8	16.7	23.6	23.2	26.1
Total number of samples	32	9	18	35	33	41	36	30	17	43	46

[1] - See Figure 1.

Table 5. Mean for study period for the number of total coliforms (TC), faecal coliforms (FC) and faecal streptococci (FS) in the water of Hariczariska Bay and the areas adjoing Lake Wigry in 1997.

Section	Site[1]	Total coliforms (CFU/100 ml)							Faecal coliforms (CFU/100 ml)							Faecal streptococci (CFU/100 ml)						
		May	June	July	Aug	Sept	Oct	Nov	May	June	July	Aug	Sept	Oct	Nov	May	June	July	Aug	Sept	Oct	Nov
I	1	200	100	800	3400	–	1000	400	100	0	100	0	300	100	300	0	0	100	200	100	1200	600
	2	200	100	300	4500	–	–	500	200	0	0	0	22200	–	0	0	0	100	300	300	–	0
	3	1100	200	300	4100	–	7500	500	270	0	100	0	15700	300	100	700	100	100	300	300	2000	1000
II	4	100	400	400	4000	–	600	–	50	0	200	0	12700	100	0	0	100	0	200	300	2400	0
	5	100	100	300	5300	–	2000	–	100	0	100	100	1800	–	–	0	0	0	200	400	400	0
III	6	100	100	500	2500	–	500	100	100	0	0	0	9200	100	0	0	0	100	200	200	400	300
	7	100	100	300	7600	–	400	200	100	0	0	4000	8200	100	0	0	100	0	500	100	200	400
	8	100	100	300	3000	–	400	300	100	0	0	0	0	100	0	0	0	0	200	100	400	0
IV	9	700	100	100	8500	–	200	400	100	0	0	1200	0	0	400	0	100	0	100	300	100	800
	10	100	100	200	11200	–	300	200	100	0	0	100	400	0	300	0	100	100	300	300	300	300
	11	200	300	300	9500	–	500	300	0	0	100	0	7400	400	0	200	0	100	200	300	300	0

[1] - See Figure 1.

Table 6. The analysis of bacteriological water quality of the Hanczanska Bay using criteria given by Cabejszek et al. [4]. A - unpolluted, B - insignificantly polluted, C - distinctly polluted, D - heavily polluted. Percent distribution of samples relevant to the given class.

Bacteriological water quality criteria		Water quality	Section[1]			
			I	II	III	IV
Microorganisms	Number of bacteria (CFU / 1 ml)		Site[1]			
			1, 2, 3	4, 5	6, 7, 8	9, 10, 11
TVC 20°C[2]	< 300	A	21.0	47.0	54.7	45.8
	300 – 500	B	77.2	51.5	40.6	47.7
	5000 – 10000	C	1.8	1.5	2.8	4.7
	> 10000	D	0.0	0.0	1.9	1.8
			(57)[4]	(68)	(106)	(107)
TVC 37°C[3]	< 200	A	56.1	74.6	73.5	71.0
	200 – 1000	B	35.1	19.0	20.5	21.5
	1000 – 5000	C	7.0	4.7	4.9	5.6
	> 5000	D	1.8	1.7	1.1	2.9
			(57)	(63)	(102)	(107)
Faecal Coli titre	> 1	A	61.6	53.4	81.8	74.5
	1 – 0.1	B	22.2	34.5	14.1	18.4
	0.1 – 0.01	C	12.9	10.3	1.0	6.1
	< 0.0	D	3.8	1.8	3.1	0.0
			(54)	(58)	(99)	(98)

[1] - See Figure 1; [2] - Total viable count at 20°C; [3] - Total viable count at 37°C; [4] - In brackets number of investigated samples.

average number of FC ranged from 0 CFU/100 ml in the water at different sites and during various examination periods up to 22,200; 15,700 and 12,700 CFU/100 ml respectively at sites 2, 3 and 4 in September. The lowest number was at sites 1, 5, 8, 9 and 10 (0-1800 CFU/100 ml), the highest one at sites 2,3 and 4 (0-22,200 CFU/100 ml). More of them were found only in August. The average number of FS ranged from 0 CFU/100 ml at different sites in May, June, July and November up to 1200, 2000 and 2400 CFU/100 ml at sites 1, 3 and 4 in October. A few more were found at all sites in October.

The Number of Indicator Bacteria and the Degree of Pollution of Waters in Hanczanska Bay and on the Areas Close to Lake Wigry

The presentation of the results of examination of the number of TVC 20°C and TVC 37°C and FC (coliform index) in the water of Hanczanska Bay and the areas close to Lake Wigry with the data of Cabejszek et al. [4] in Table 6 indicates 20% pure character and little pollution in about 77% of the water samples of Hanczanska Bay taken from sites 1, 2, and 3 in close neighbourhood

Table 7. Analysis of bacteriological water quality of Lake Wigry using criteria given by U.S. Department of the Interior (Federal Water Pollution Control Administration) [17] as the percent distribution of samples relevant to the given criteria.

Section[1]	Sites[1]	Number of samples investigated	Bacteriological water quality standards					
			Total coliforms in 100 ml			Faecal coliforms in 100 ml		
			Recreational		Public water supply	Recreational		Public water supply
			I	*II*		*I*	*II*	
			1000	5000	10000	200	1000	2000
I	1, 2, 3	49/54[2]	71.4	91.8	97.9	74.0	85.8	88.9
II	4, 5	54/58	75.9	91.0	99.0	74.1	89.6	93.1
III	6, 7, 8	86/101	81.4	95.3	96.5	91.0	85.7	96.0
IV	9, 10, 11	9 1/98	73.6	91.2	93.4	71.4	77.5	79.6

[1] - See Figure 1; *I* - Primary contact; *II* - Secondary contact; [2] - TC, FC respectively

of the mouth of the Czarna Hancza River and in Sosnowik Bay. At sites 4 and 5 situated about 600 m from the mouth of the Czarna Hancza River and sites 6, 7 and 8 situated on the edge of Northern Ploso of Lake Wigry 960-110 m from the mouth of the Czarna Hancza River there is little (sites 4 and 5) or more (sites 6, 7 and 8) significant increase of percent of pure water samples, but there is a decrease of percent of water samples little polluted. At sites 9,10 and 11 situated in the open waters of Northern Ploso of Lake Wigry 1700-1900 m from the mouth of the Czarna Hancza River there is a little decrease in the percent of pure water samples but the percentage of little and significantly polluted water samples increases. A similar evaluation of degree of purity can be obtained by a comparison of the number of TVC 20°C and FC in the water of Hanczanska Bay and the areas close to Lake Wigry with Albinger's data [1] not documented in this paper. The values of coliform index (data concerning coliform index for particular water samples are in the possession of the author) according to the Act of the Minister of Environmental Protection, Natural Resources and Forestry dated 5 November 1991 concering the classification of waters [14] permit the inclusion of 61% of water samples taken at sites 1, 2, and 3; 53% of water samples taken at sites 4 and 5; 82% of water samples taken at sites 6, 7 and 8; and 74% of water samples taken at sites 9, 10 and 11 into purity class I. The other percent comprised waters of II and III class purity and waters without any class. The percentage of waters of no class did not exceed 45%, 2%, 3% and 1%, respectively.

The Number of Indicator Bacteria and Water Requirements for Recreation

Table 7 presents the percentage of water samples of Hanczanska Bay and areas close to Northern Ploso of Lake Wigry containing maximum number of TC and FC [16, 17] for waters used for recreation and "public water supply". Most of the examined water samples taken from Hanczanska Bay and the close area of Northern Ploso of Lake Wigry contained a number of TC and FC lower than the maximum permissible for waters used for bathing (direct contact of body with water) and recreation in a very general sense (indirect contact of body with water, e.g. sailing, canoeing, windsurfing) and public water supply. The percentage of water samples fulfilling the bacteriological requirements was the lowest in the region of the mouth of the Czarna Hancza River at sites 1, 2 and 3, slighty increasing at sites 4 and 5, and higher at sites 6, 7 and 8; it decreased less (TC) or more (FC) at sites 9,10 and 11 in open waters of Northern Ploso of Lake Wigry. Table 8 presents the percentage of water samples of Hanczanska Bay and the areas close to Northern Ploso of Lake Wigry fulfilling the requirements of water [5] for bathing purposes as far as the number of TC, FC and FS (Guide values) and TC and FC (Mandatory values) are concerned. Recommended values (Guide Values) were fulfilled by 63-68% of water samples at sites 1, 2 and 3; 67-70% of water samples taken at sites 6, 7 and 8; and 61-85% of water samples taken at sites 9, 10 and 11. Maximum permissible values (Mandatory values) were fulfilled by 89-98% of water samples taken at sites 1-5; 96-98% of waters samples taken at sites 6, 7 and 8, and 93-96% of water samples taken at sites 9, 10 and 11.

Discussion

Detailed analysis of the number of the examined indicator bacteria was carried out on the basis of the classification of microbiological purity of surface waters suggested in literature [1, 4,14] and their use for recreation and bathing [5, 16,17]. In the water of Hanczanska Bay and the areas close to Northern Ploso of Lake Wigry there were 3 zones determined with different degrees of pollution. The first zone comprises the waters of Hanczanska Bay from the mouth of the Czarna Hancza River together with Sosnowik and Suchar Bays from the west to the Islands of Cimochowski dry-ground forests and numerous shallows from the east. The second zone com-

Table 8. The analysis of water quality of the Hanczanska Bay using criteria given by EEC (5). Percent distribution of samples fulfilling guide and mandatory values for bathing waters.

Section[1]	Sites[1]	Number of investigated samples	Guide values			Mandatory values		
			TC	FC	FS	TC	FC	S/E[2]
			500	100	100	10000	2000	0
I	1, 2, 3	49/54/56[3]	63.2	68.5	64.3	98.0	88.9	–
II	4, 5	54/58/64	70.3	67.2	67.2	98.1	88.0	–
III	6, 7, 8	86/97/99	74.5	77.3	70.7	96.5	98.0	–
IV	9, 10, 11	91/98/96	69.2	84.7	61.4	93.4	95.9	–

[1] - See Figure 1; [2] - S - Salmonella/1 l, E - Enteroviruses Plaque Forming Units/10 l.; S/E measurement is only required when an inspection in the bathing area shows that the parametr may be present, or when water quality has deteriored;[3] - TC, FC, FS respectively

prises the area of mixing the waters of Hanczanska Bay with the open Northern Ploso of Lake Wigry. The third zone comprises the waters of Northern Ploso of Lake Wigry. In the first zone (Hanczanska Bay) the waters taken directly at the mouth of the Czarna Hancza River and/or in Suchar Bay (sites 2 and 3), sometimes 600 m away at site 4 situated in the southern part of Hanczanska Bay between the Cimochowska Island and southern shores of Lake Wigry show the highest degree of bacteriological pollution. This is probably the main direction of the movement of the waters of the Czarna Hancza River towards the open waters of Lake Wigry. It is caused by the dominant southwestern winds, gradually increasing in depth (from 10 m at site 4) with a wide gorge between the Cimochowska Island and the shore of Lake Wigry. As a result, the number of the examined indicator bacteria (especially TVC 20°C taken at site 4) often remains at the level found at the mouth of the Czarna Hancza River. Hanczanska Bay in a way plays the role of a sedimentation pond [12] for the pollutants flowing with the waters of the Czarna Hancza River. In this buffer zone between the Czarna Hancza River and the open waters of Lake Wigry the factors limiting the number of indicatory bacteria (TVC 20°C, TVC 37°C) and sanitary state (TC, FC, FS) getting into the open waters of Lake Wigry are of suspension sedimentation, bactericocidal activity of UV rays of solar light, temperature fluctuation (strong warming in summer), antibiotic secretion of blue geen algae, preining by protozoa, zooplankton and bacteriophages. In the second zone the decrease of the number of examined indicatory bacteria (especially TVC 20°C) and accompanied percentage increase of the sample of pure water and fit for recreation and bathing is a result of nutrient dilution limiting the increase of the population of bacterial heterotrophes, differences in salinity of Hanczanska Bay and Lake Wigry, and deeper penetration of bactericidal UV rays of solar light in water with lower number of suspension. The last one can be observed in a vertical stratification of the examined indicatory bacteria during the summer stratification, characterized by their lower number in the water at 0.3 m depth and their higher at 1-3 m depth and in the bottom water (data concerning vertical stratification of indicator bacteria for particular sites in a yearly cycle are in the author's possession). In the third zone less or more significant increase of the number of examined indicatory bacteria in August (except streptococci) may be a result of the inflow of pollution from Rosochaty R6g and surrounding areas during storm rainfalls. The same increase of TVC 20°C observed in May may be earlier snow melt, which in this region starts in the end of April [2]. During rainfall or snow melt pollution from fields, cow-sheds are accompanied heterotrophic bacteria may get into the lake. Heterotrophic bacteria estimated on broth-agar at 20°C and 37°C were the most numerous among the examined indicatory bacteria in the water samples taken from Hanczanska Bay and the area close to Lake Wigry. The number of these bacteria was at least 100-times more than TC, FC and FS. At particular sites of Hanczanska Bay and areas close to Lake Wigry the differences in the number of these bacteria were significantly higher than the differences in the number of TC, FC and FS. The last three groups of indicatory bacteria often were not found in proper water volumes. Therefore the number of TVC 20°C and TVC 37°C may be a better indicator of the degree of water purity. Exceptional sensitivity of these aerobic heterotrophic bacteria allows them to be used in routine bacteriological examination of water reservoirs taking in sewage pollution as a useful "tool" in the evaluation of coastal water quality and the degree of their trophy. The total number of bacteria counted on broth-agar or similar ones at 20°C is a generally used indicator of the pollution degree of waters by organic substance easily decomposed [1, 3]; at 37°C - by domestic sewage [15] and the possibility of pathogenic bacteria occurrence [6]. A sudden increase of the number of these bacteria in water signals the worsening of its quality and the necessity of taking up steps leading to its improvement. The above results prove the ratio of TVC 20°C:TVC 37°C (differential temperature ratio test) in differentiation of pure waters (the ratio higher than 10:1) from polluted ones (the ratio lower than 10:1) [7].

A comparison of indicatory bacteria number of the pollution degree and sanitary state in Hanczanska Bay water in 1997 to the data from 1994-1996 [9, 10] shows a significant (100-1000 times) decrease especially TVC 20°C in least period. The decrease may be connected with the initiation of 3rd degree of sewage treatment in Wastewater Treatment Plant in Suwalki and a lower number of biogenes flowing in the Czarna Hancza River to Hanczanska Bay of Wigry Lake. The lack of significant differences of the number of TVC 37°C, TC and FC in

1994-1996 and 1997 may be connected with pollutant leakage (e.g. cesspool) in Sobolewo below the Wastewater Treatment Plant in Suwalki [8].

Conclusion

1. Several times lower numbers of TVC 20°C and TVC 37°C found in Hanczanska Bay water in 1997 than in 1994-1996 can be attributed to the initiation of 3rd degree sewage treatment in Wastewater Treatment Plant in Suwalki. A lower amount of biogenic compounds let out by the Czarna Hancza River to Wigry Lake being a substratum of heterotrophic bacteria is attributed to this initiation as well.

2. The lack of significant differences in the numbers of TVC 37°C, TC and FC in Hanczanska Bay water as well as in Nothern Ploso of Wigry Lake in 1997 and in 1994-1996 may be attributed to the leakage of sewage from Sobolewo into the Czarna Hancza River and then into Wigry Lake (below a Wastewater Treatment Plant in Suwalki).

3. The lowest percentage of pure water samples fulfilling the requirement for bathing water was found at sites in Hanczanska Bay, the highest percentage was found at sites on the border between Hanczanska Bay and the waters of Northern Ploso of Wigry Lake. The highest percentage of pure water on the border between Hanczanska Bay and the waters of Northern Ploso of Wigry Lake is influenced by the dilution of nutrients carried by the Czarna Hancza River, differences in salinity, and the dilution of bacteria.

Acknowledgment

I am grateful to M. Kaminski DSc and L. Krzysztofiak DSc (Wigry National Park at Krzywe) for help in carrying out the present research in the area of Wigry National Park and its surroundings. I am also grateful to A. Dobrzeniecka MSc and M. Gawronska MSc for technical help in realization of this research.

This study was financially supported under Project KBN 05.030.207 and in part by Wigry National Park.

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