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The Evaluation of the Contamination Degree and the Sanitary and Bacteriological State of the Waters in the Czarna Hańcza River in the Region of Suwałki and Wigry National Park

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Abstract

This paper evaluates contamination and sanitary and bacteriological states of the waters in the Czarna Haricza River in the region of Suwalki and Wigry National Park, and treated wastes corning from an urban sewage treatment plant.

Microbiological examinations were carried out every month, in three annual cycles, in 1994-1996. Water samples were taken at 11 stations situated in the most characteristic places above Suwalki, below Suwatki, before inflow of treated wastes coming from the sewage treatment plant, in Sobolewo and at the mouth of the Czarna Haricza River to Wigry Lake, besides the tract from Czerwony Folwark to Wysoki Most towards the east of Wigry Lake. The following microbiological indices were examined: TVC 20°C, TVC 37°C, TC, FC, FS, *Clostridium perfringens* as well as numerical ratio FC:FS. The results of the examination of the number of respective indicator bacteria were compared with the purity criteria, organic substance loading and excrement material and water usefulness for recreation. Unsignificant contamination of the Czarna Haficza River was observed in Stary Br6d not far from Suwatki and in Czerwony Folwark, Mackowa Ruda and Buda Ruska in the eastern part of Lake Wigry, significant and/or strong water contamination of this river was noticed on the track from Suwalki to its mouth to Wigry Lake. The sources of the contamination were shown: point (sewages) and spacious (catchment) and leakage from cesspools in Sobolewo. A significant decrease of the number of the examined indicator bacteria of the contamination degree (TVC 20°C, TVC 37°C) of this part of the river in 1995 and 1996 was observed. The usefulness for bathing the examined fragment of the River Czarna Haricza above Suwalki and the fragment from Czerwony Folwark to Wysoki Most towards the east from Wigry Lake was presented.

Keywords: River, water pollution, sanitary evaluation, indicator microorganism, bacteria.

Introduction

The evaluation of the polution degree and sanitary-bacteriological state of river waters is of great significance in planning recultivational activities and from the point of view of public health of town and rural settlement inhabitants. River waters are not only communication routes, but a source of water supply for water mains and recreation. Therefore, these should be constantly controlled by sanitary-bacteriological services as they play a role in the process of transporting pathogenic microorganisms of human and animal alimentary tracts [11, 12, 16]. Domestic and industrial sewage (from a slaughter-house, a dairy plant, a tannery) carried to the river often without preliminary treatment or after mechanical treatment (seldom after biological) are regarded as a source of viral, bacterial, of parasitic contamination of river waters. Storm waters in towns and villages washing down contaminants deposited by people and domestic animals (dogs, cats), farms (cattle, horses, domestic birds) and wild animals (rates, fowls and others)

are of great significance. "Cross-connection" between sanitary and storm drainage systems, faulty waste deposition, storage of sediments in a discharge sewer and "regrowth" of sanitary bacteria in stagnant waters, leakage from cesspools, septic tanks, storm waters washing away pollution from agricultural catchments may be of significant importance as well [8, 19, 38]. The worsening of the bacteriological quality of river waters in the periods of high water and floods is connected with the leakage of contaminants from the bank areas and from the bottom of the river. Seasonal fluctuations of sanitary bacteria quantities may be connected with temperature fluctuations, insolation, precipitation, and differences in these microorganisms' survival in particular seasons of the year. Physiography of the drained landscape may be a modifying factor of the degree of bacteriological pollution of river waters. The Czarna Hafi-cza is the largest river on Suwalki-August6w Lake District. Until 1992 the river collected storm waters and domestic sewage without proper treatment from Suwatki. This influenced eutrophication of nearby Lake Wigry in the region of so called Haficzanska Bay, where the mouth of the Czarna Hancza River is found. Since 1992 almost all sewage from the town has been sent to an urban sewage treatment plant; since 1996 with degree III treatment. In the available literature there is a lack of data concerning the size of microbiological pollution and bacteriological sanitary state of the middle part of this river in the region of Suwalki and Wigry National Park. Knowledge about these problems is very important due to the importance of tourism. This paper presents the results of the sanitary-bacteriological investigations of the Czarna Hancza water in the region of Suwalki and Wigry National Park in 1994-1996. It is a part of microbiological study of surface and underground waters in Wigry National Park and it comprises sanitary-bacteriological examinations of Wigry waters and 40 other smaller lakes, rivers and underground waters (wells and natural springs) as well.

Materials and Methods

The Czarna Hancza River

After Bajkiewicz-Grabowska [3] the Czarna Hancza River starts from springs at 230 m a.s.l. in lake Jegliszki in North-Suwalki Lake District. It is the main river of the Niemen Basin and the largest river in Wigry National Park. In the upper course it flows across Hancza Lake (the deepest lake in the eastern-European lowland, reaching over 100 m). In the middle course it meanders strongly, in the lower course it is sewered and included in the Augustow Canal system. On its whole length it shows a high river gradient (on average 1.9‰), typical for mountain rivers. Below Hancza Lake it flows in a post-glacial channel with a large depression. On its way it takes waters from springs dewatering glacial plateau and valley sandr. Above the border of Wigry National Park its average annual flow is 37 m/s ± 0.8 m. The main high waters take place in April and in September and/or in October. During spring high water is sometimes 2-3 times higher than the average annual flow. The lowest stages on the river are observed in winter (in January and February) and in summer (in August and September). The flow in the river at that time is about 55% of the average annual flow. The part of the Czarna Hancza River from Wigry Lake to the border of the country is a lowland character. In the period of thaw high water in April the flow in this part of the river increases an average 1-2 twice in comparison to the average annual flow 4.03 m/s. The lowest flows also take place in January and February and in August and September. At that time they reach about 60% of average annual flow. An average unit flow from a catchment in this part of the Czarna Hancza is 8.9 $m^3/s/km^2$. The northern part of Wigry Lake takes part in the river flow. The Czarna Hancza introduces on average 76.2 X 10^9 m^3 water per year into Wigry Lake [3]. At the mouth of the Czarna Hancza River to Wigry Lake there is a nature reserve and one of the largest habitats of beavers on the area of Wigry National Park. This area is 41.5 ha and in majority surrounds the banks of Wigry Lake in the region of the Hancza Bay. The small river called Marycha is the main tributary of the Czarna Hancza.

Sewage Treatment Plant

On the part of the Czarna Hancza River below Suwalki there is an outlet of the canal supplying treated sewage from a nearby Sewage Treatment Plant in Suwalki with degree III of treatment. All the sewage from the town reaches this sewage treatment plant; some part is supplied by water carts a catchment connected to a municipal sewer. The total number of sewage is 16,000 to 18,000 m^3/d. According to the data obtained from the Sewage Treatment Plant in Suwalki the treated sewage supplied to the Czarna Hancza River has the following physico-chemical parameters: BOD_5 7.7 mg O_2/dm^3; ChOD 50.0 mg O_2/dm^3; total suspension 24.0 mg/dm^3; N-NU, 0.72 mg N_{NH4}/dm^3; N-NO_3 6.8 mg N_{NO3}/dm^3; $N_{Kjeld.}$ 3.8 mg N/dm^3; P_{total} 1.1 mg P/dm^3. In Suwalki only "Sudovia" dairy cooperative has a biological sewage treatment plant. Biologically-treated sewage from this dairy plant are supplied to a municipal sewer.

Sample Collection

Water samples from the Czarna Hancza River were taken every month from May 1994 to November 1996 (except in the winter). The water samples were taken directly into sterilized, glass vessels with a ground cork of 300 cm^3 capacity. Sites included the current of the river at 7 sites situated from Stary Brod before Suwalki up to its mouth to Wigry Lake in Hancza Bay, and at 4 sites situated from the outflow of the river from Wigry Lake up to Wysoki Most outside Wigry National Park (Fig. 1).

These sites of sample collection on the Czarna Hancza River were:

Site 1 - in Stary Brod before Suwalki;

Site 2a - below Suwalki, 10 m before the flow of the treated sewage from the municipal sewer in Suwalki;

Site 2b - below Suwalki, 10 m below the flow of the treated sewage from the municipal sewer in Suwalki;

Site 3 - in Sobolewo at the first bridge on Krzy-we-Sobolewo direction (near a water mill);

Site 4 - in Sobolewo at the second bridge on Krzy-we-Sobolewo direction;

Site 5 - in the region of the old river-bed of the Czarna Hancza River on a forested and wet area;

Site 6 - at the bridge about 100 m before the mouth of the Czarna Hancza River to Wigry Lake in the region of Hancza Bay;

Site 7 - in Czerwony Folwark at the bridge near Postaw Lake;

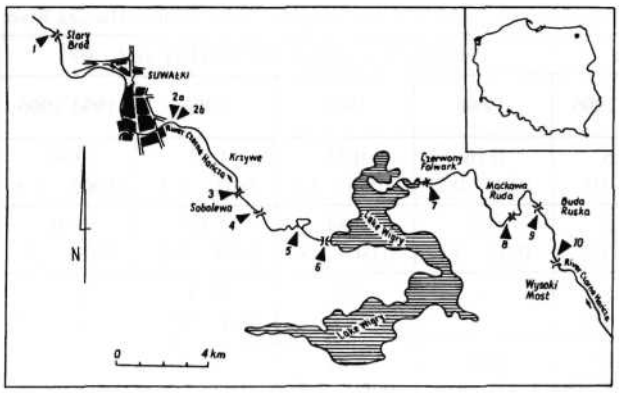

Fig. 1. Situational sketch of Czarna Haricza in the region of Suwalki and the area of the Wigry National Park.
1, 2a, 2b, ... 10 - sites for collecting water samples.

Site 8 - in Mackowa Ruda at the bridge;
Site 9 - in Buda Ruska at the bridge and
Site 10 - in Wysoki Most at the bridge.

The samples of treated sewage from the municipal sewer in Suwalki were taken at the outlet of a covered canal, situated 2-3 m above the water surface in the Czarna Hancza River between sites 2a and 2b, at the same time the samples of the river water at the same sites were taken to the same glass vessels as the river water. The time from taking the water samples on the Czama Hancza River and sewage for carrying out microbiological analysis did not exceed 12 hours. In the meantime the collected samples were kept at 4°C.

Microbiological Study

Microbiological studies of the taken samples of the river water and treated sewage flowing into the river from the sewage treatment plant in Suwalki comprised the following estimations:

1. the total number (CFU/1 cm^3) of bacteria on broth-agar after 72 h incubation at 20°C (TVC 20°C);
2. the total number (CFU/1 cm^3) of bacteria on broth-agar after 24 h incubation at 37°C (TVC 37°C);
3. the total number (MPN/100 cm^3) of bacteria from *Es cherichia coli* group (TC) on the Eijkman medium after 48 h incubation at 37°C;
4. the number (MPN/100 cm^3) of fecal bacteria from ***Es cherichia*** *coli* group (FC) on the Eijkman medium after 24 h incubation at 44.5°C;
5. the number (MPN/100 cm^3) of fecal streptococci (FS) on the Slanetz and Bartley medium with sodium azide and crystal violet after 72 h incubation at 37°C;
6. the number (MPN/100 cm^3) of anaerobic spore-forming bacteria reducing sulphites *(Clostridium perfringens)* on the Wilson-Blair medium in pasteurized (80°C/10 min) water/sewage samples after 18 h incubation at 37°C.

The total number of TVC 20°C and TVC 37°C was determined according to the accepted bacteriological technique for the investigation of drinking water. The most probable number of TC, FC, FS was determined according to the Standard Methods [2]. The most probable number of anaerobic spore-forming bacteria *(Clostridium perfringens)* was determined by the method of dilution inoculating in sequence the increased dilutions of the examined water or sewage in high columns of the agar medium in test tubes. All determinations were carried out in 3 parallel repetitions. The results of the investigations of TC, FC, FS and *Clostridium perfringens* numbers were read from McCrady's tables. A physiological solution of NaCl was used for sample dilutions. Positive results for the presence of coliforms in the fermentation test on the Eijkman medium were checked on the Endo medium, on the lauryl-tryptone broth bouillon, and in biologicals coloured with Gram method. Positive results for the presence of streptococci in the Slanetz and Bartley medium were checked on the m-Enterococcus Agar medium. Typical colonies which grew on this medium were dark red and they were grafted into the broth determining growth ability at 44.5°C, at pH 9.6, with the presence of 6.5% NaCl and in milk with 0.01% methylene blue. Positive results for the presence of anaerobic spore-forming bacteria reducing sulphites *(Clostridium perfringens)* were checked in a fermentation test on degreased milk. In this research culture media produced by Difco and Merck were used. Obtained value of microbiological coefficients for contamination (TVC 20°C, TVC 37°C) and sanitary states (TC, FC, FC, *Clostidium perfringens)* of the examined river water and sewages were compared to those in literature [1, 7], criteria of the degree of surface water purity (river), requirements of sewages supplied to surface water [34] and suggested requirements for water for recreation [10].

Results

The Number of Indicatory Bacteria of Sanitary State and the Degree of Pollution in the Czarna Hancza River

The Part of the Czarna Hancza River from Stary Brod above Suwalki to its Outflow to Wigry Lake

In the water of the Czarna Hancza River from Stary Br6d above Suwalki to its outflow to Wigry Lake (1-6 sites) the total number TVC 20°C (psychrophilic bacteria) ranged from 320 to 55 mln CFU/1 cm^3 (Table 1). On average during the investigation period the lowest number was

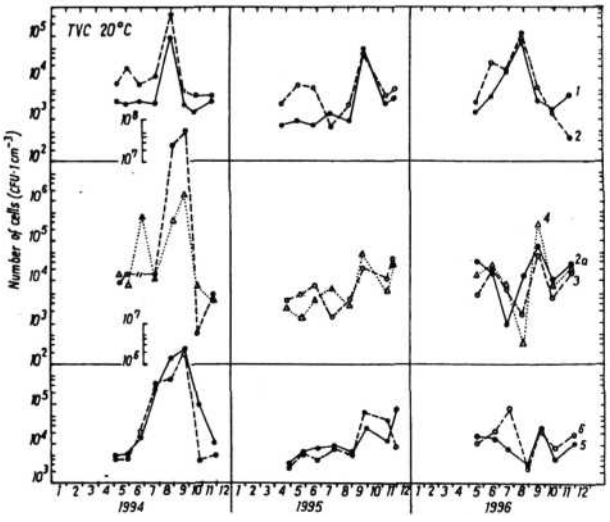

Fig. 2. Seasonal changes of the number TVC 20°C in the water of the Czarna Hancza from Stary Brod above Suwalki to its inflow to Wigry Lake 1, 2a, 2b, 3...6 - sites for collecting water samples

Table 1. Mean (for study period) and range for the numbers of total viable counts at 20°C and 37°C in the water of the Czarna Haricza River

Site[1]	Number of samples	Total viable count at 20°C (CFU/1 $cm^3 \cdot 10^3$)				Total viable count at 37°C (CFU/1 $cm^3 \cdot 10^3$)			
		1994	1995	1996	1994-1996	1994	1995	1996	1994-1996
1	23 A B	14.0 1.7 – 95	8.5 0.7 – 57.5	15.5 1.5 – 81.5	12.5 0.7 – 95	0.16 0.01 – 0.2	0.35 0.005 – 1.8	0.41 0.02 – 1.5	0.31 0.005 – 1.8
2a	23 A B	49.1 3.7 – 335	8.5 0.6 – 42	7.0 0.3 – 24.7	22.2 0.3 – 335	3.2 0.03 – 13	0.84 0.04 – 1.8	1.82 0.03 – 9.2	1.95 0.03 – 13
2b	8 A B	– –	22.4 22.4	22.9 0.8 – 67.8	22.9 0.8 – 67.8	– –	3.5 3.5	12.4 0.04 – 50.2	11.2 0.04 – 50.2
3	22 A B	11956.3 0.6 – 55050	12.1 3.2 – 35.6	13.4 1.7 – 41	3813.0 0.6 – 55050	86.7 0.45 – 625	1.01 0.04 – 2.5	4.12 0.53 – 18	33.2 0.04 – 625
4	23 A B	254.1 7.0 – 1635	10.9 1.3 – 45	46.8 0.3 – 255	109.6 0.3 – 1635	68.8 0.20 – 530	0.93 0.06 – 2.1	23.8 0.33 – 155.5	32.15 0.06 – 530
5	23 A B	556.2 5.8 – 2520	18.8 3.2 – 76	11.2 2.8 – 21.8	263.2 2.8 – 2520	4.8 0.10 – 14.5	1.7 0.05 – 2.4	3.0 0.5 – 6.7	3.1 0.05 – 14.5
6	23 A B	116.3 4.0 – 428	17.5 2.6 – 63.5	23.0 2.4 – 77.5	50.7 2.4 – 428	9.5 0.10 – 66.2	1.4 0.10 – 4.3	5.3 0.68 – 18.0	5.4 0.10 – 66.2
7	23 A B	61.6 0.2 – 450	3.6 0.3 – 16.5	0.75 0.1 – 1.7	31.0 0.1 – 450	15.6 0.01 – 112	0.48 0.01 – 1.9	0.17 0.02 – 0.4	5.6 0.01 – 112
8	22 A	129.7 0.4 – 744	7.4 0.1 – 18	1.10 0.05 – 2.3	44.3 0.05 – 744	4.1 0.07 – 30.5	0.35 0.06 – 0.65	0.28 0.0 – 0.85	0.48 0.00 – 30.5
9	23 A B	260.9 1.4 – 2000	2.3 0.4 – 1.6	2.3 0.17 – 5.2	151.5 0.17 – 2000	0.75 0.005 – 4.6	0.30 0.01 – 1.35	0.50 0.07 – 1.05	0.52 0.005 – 4.58
10	23 A B	2.35 0.9 – 4.3	3.25 0.2 – 13.2	2.9 0.83 – 8.9	2.9 0.25 – 13.2	1.52 0.015 – 9.6	0.58 0.10 – 2.3	0.58 0.17 – 1.05	0.90 0.015 – 9.6

1 – See Figure 1; A – Average; B – Range

in Stary Brod (site 1) above Suwatki, the largest number in Sobolewo (site 3) below Suwatki. In Stary Brod (site 1) above Suwaiki their average number was almost the same in particular years. At sites 2a-6 below Suwaiki their average number was lower in 1995 and 1996, higher in 1994. In Stary Brod (site 1) above Suwaiki and nearby municipal sewage treatment plant 10 m before the flow of treated sewage from this sewer (site 2a) below Suwaiki the highest number was found in August or September, at sites in the nearby municipal sewage treatment plant 10 m below the outflow of the treated sewage from this plant (site 2b), in Sobolewo (sites 3 and 4) and in the region of the old riverbed and about 100 m from the flow to Wigry Lake (sites 5 and 6) in August and September (in 1994) or in September (in 1995 and 1996), more seldom in other months (Fig. 2).

The total number TVC 37°C (mesophilic bacteria) ranged from 5 to 625,000 CFU/1 cm^3 (Table 1). On the average for the research period the lowest number was found in Stary Brod (site 1) above Suwaiki. Their average number was almost the same in partilcular years; at the municipal sewage treatment plant (sites 2a and 2b), in Sobolewo (sites 3 and 4), in the region of the old riverbed of the Czarna Haricza River and nearby its flow to Wigry Lake (sites 5 and 6). Below Suwaiki their average number was lower in 1995 and 1996 and higher in 1994. In particular years their maximum numbers were found in different months depending on the site (Fig. 3).

The total number of bacteria from *Escherichia coli* group (TC) ranged from <3 to 1,400,000 MPN/100 cm^3 (Table 2). On the average their lowest number was observed in Stary Brod (site 1) above Suwaiki, the largest number was nearby the municipal sewage treatment plant 10 m below the flow of the treated sewage from this plant (site 2b) below Suwaiki and in Sobolewo (site 4). Their average number in the following years increased, reaching the highest values in 1996. In 1994 the highest number appeared in August and September and/or in October, in 1995 and

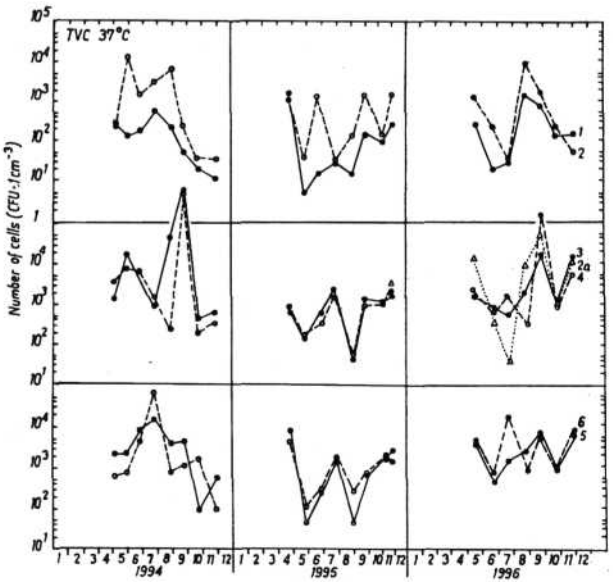

Fig. 3. Seasonal changes of the number TVC 37°C in the water of the Czarna Haricza from Stary Brod above Suwaiki to its inflow to Wigry Lake. Explanations as in Figure 2.

Table 2. Mean (for study period) and range for the number of total coliforms, fecal coliforms and fecal streptococci in the water of the Czarna Hancza River, in 1994-1996

Site[1]	Number of samples	Number of total coliforms (MPN/100 cm^3)				Number of fecal coliforms (MPN/100 cm^3)				Number of fecal streptococci (MPN/100 cm^3)			
		1994	1995	1996	1994-1996	1994	1995	1996	1994-1996	1994	1995	1996	1994-1996
1	23 A	725	2000	4375	2280	675	155	460	420	530	1840	830	1085
	B	43–2400	93–11000	240–11000	43–11000	11–4500	9–460	23–1400	9–4500	43–2500	23–11000	240–1400	23–11000
2a	23 A	5820	4850	6630	7700	1435	2760	5030	2930	3950	40620	3210	31580
	B	240–24000	460–14000	1100–14000	240–24000	95–4500	39–11000	43–14000	39–14000	23–14000	240–140000	240–14000	23–140000
2b	8 A	–	1400	6570	42360	–	1400	12000	10675	–	2000	34350	31560
	B	–	1400	4500–140000	4500–140000	–	1400	1500–25000	1400–25000	–	2000	1500–140000	1500–140000
3	22 A	5560	26800	35640	23110	6040	5880	12700	8890	21360	13650	30065	21550
	B	460–14000	460–140000	4500–110000	460–140000	3–14000	93–15000	460–45000	3–45000	9–110000	1100–46000	460–140000	9–140000
4	23 A	25260	8135	266800	94620	2090	5890	95930	32015	8440	4825	65710	36950
	B	3–150000	1100–14000	4600–1400000	3–1400000	3–4500	1400–15000	140–460000	3–460000	43–46000	1100–11500	1100–460000	43–460000
5	23 A	7250	8800	10640	7840	4140	8695	4390	6910	9975	12335	6515	9860
	B	240–14000	240–20000	1400–14000	140–20000	43–14000	460–14000	350–11000	43–14000	23–46000	1100–30000	240–14000	23–46000
6	23 A	10730	22295	66850	32050	5545	5690	26130	11430	5380	16040	9365	10300
	B	460–46000	460–140000	4500–150000	460–150000	75–24000	1100–11000	1400–110000	75–110000	4–24000	240–110000	460–14000	4–110000
7	23 A	750	1510	130	825	605	245	10	115	790	305	2030	1000
	B	9–2400	45–7500	23–460	9–7500	<3–2400	<3–75	4–23	<3–2400	7–2400	3–1100	<3–14000	3–14000
8	22 A	735	1150	250	765	450	740	18	420	775	400	2630	1230
	B	9–2400	23–4600	39–750	9–4600	23–2400	23–4500	<3–43	<3–2400	43–2400	4–2000	9–14000	4–14000
9	23 A	1430	290	1845	1165	370	235	70	135	675	3245	2410	2100
	B	3–4500	9–1100	150–11000	3–11000	9–2400	9–1100	4–93	4–2400	9–2400	15–14000	43–14000	9–14000
10	23 A	1280	810	1935	1335	85	470	50	205	145	2030	3760	1770
	B	9–4500	9–1400	140–11000	9–11000	<3–460	4–2000	15–93	<3–2000	9–460	4–11000	4–14000	4–14000

1 – See Figure 1; A – Average; B – Range

1996 - in different months, particularly in summer and autumn (Fig. 4).

The number of fecal bacteria from *Escherichia coli* group (FC) ranged from <3 to 460,000 MPN/100 cm^3 (Table 2). On the average for the investigated period the lowest number was found in Stary Brod (site 1) above Suwalki, and the highest number in Sobolewo (site 4) below Suwalki. Their average number in the folloving

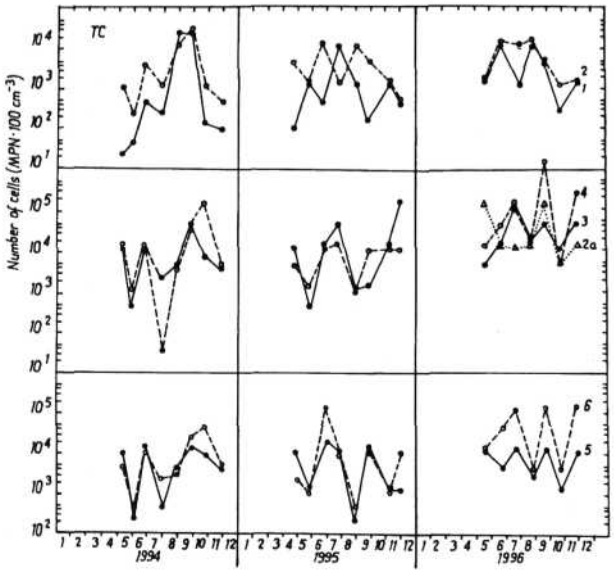

Fig. 4. Seasonal changes of the number TC in the water of the Czarna Hancza from Stary Brod above Suwalki to its inflow to Wigry Lake. Explanations as in Figure 2.

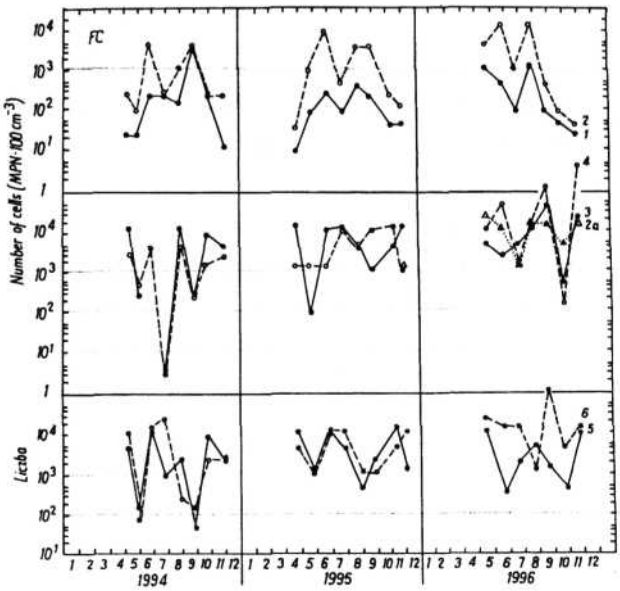

Fig. 5. Seasonal changes of the number FC in the water of the Czarna Hancza from Stary Brod above Suwalki to its inflow to Wigry Lake. Explanations as in Figure 2.

Table 3. Percentage distribution of the values of ratio FC:FS in the water of particular sites in Czarna Haricza River

FC:FS ratio	Site[1]											
	1	2a	2b	3	4	5	6	7	8	9	10	1-10
< 0.7	77	59	43	41	41	48	22	92	47	67	65	52.0
0.7 – 4.0	18	27	57	45	36	39	43	8	53	28	18	34.0
> 4.0	5	14	0	14	23	13	35	0	0	5	17	14.0
	(21)[2]	(22)	(7)	(22)	(22)	(23)	(23)	(13)	(15)	(18)	(17)	(215)

[1] – See Figure 1; [2] – In brackets number of investigated samples

years decreased (in Stary Brod site 1), increased (sites 2a, 3, 4, 6) below Suwatki or increased in 1995 and decreased in 1996 (site 5 in the region of the old riverbed of the Czarna Hancza). In the following years their maximum numbers appeared in different months, in spring, summer and autumn (Fig. 5).

The number of fecal streptococci (FS) ranged from 9 to 460,000 MPN/100 cm^3 (Table 2). On the average for the research period their lowest number was in Stary Brod (site 1) above Suwalki, the largest number was in Sobolewo (site 4). Their mean number increased in 1995 and decreased in 1996 (site 1 in Stary Brod above Suwalki, 2a in the nearby of the sewage treatment plant 10 m before the flow of the treated sewages, 5 and 6 in the region of the old riverbed of the Czarna Hancza and about 100 m from its mouth to Wigry Lake) or decreased in 1995 and increased in 1996 (sites 3 and 4 in Sobolewo). In the following years their maximum number was found in different months in spring, summer and autumn (Fig. 6). The number ratio FC:FS in the water of the above-described part of the Czarna Hancza ranged from 0.0004 in Sobolewo (site 4) in July 1994 to 68.6 at a distance of 100 m from the mouth of Wigry Lake (site 6) in July of the same year.

In 22-77% of the examined water samples this ratio was lower than 0.7, in 18-57% it ranged from 0.7 to 4.0 and in 0-35% it was higher than 4.0 (Table 3). In the examined period the fewest water samples with the ratio FC:FS lower than 0.7 was about 100 m before the mouth of the Czarna Hancza to Wigry Lake (site 6), the most in Stary Bród (site 1) above Suwalki. On the part of the Czarna Hancza below Suwalki (sites 2a-6) the number of water samples with the ratio FC:FS lower than 0.7 decreased; however, the number of water samples with the ratio FC:FS in the range from 0.7 to 4.0 and higher increased.

The number of anaerobic spore-forming bacteria reducing sulfites *(Clostridium perfringens)* was examined only in 1966 ranged from <3 to 2500 MPN/100 cm^3. In Stary Brod (site 1) above Suwalki these bacteria were not found. They were found only in June and August near the sewage treatment plant 10 m above the flow of the treated sewage (site 2a); 10 m below the flow of the treated sewage from this sewer (site 2b) - almost during the whole period of research. In Sobolewo (sites 3 and 4) and in the region of the old riverbed of the Czarna Hancza and in the distance of 100 m from its mouth to Lake Wigry (sites 5 and 6) - in different months (Table 4).

The Part of the Czarna Hancza River from Czerwony Folwark to Wysoki Most Situated in the East from Wigry Lake

The total number TVC 20°C in the period of research ranged from 50 to 2,000,000 CFU/1 cm^3 (Table 1) in the waters of the Czarna Hancza from Czerwony Folwark to Wysoki Most (sites 7-10). The fewest number of them was found in Wysoki Most (site 10), the largest one in Buda Ruska (site 9). In Czerwony Folwark, Mackowa Ruda and Buda Ruska (sites 7-9) their average number was lower in 1995 and 1996, higher in 1994; in Wysoki Most (site 10) - more or less the same in all three years. In 1994 and 1995 their abundance was observed in the end of September, in 1996 - in June and October (Fig. 7).

Table 4. Number of anaerobic, spore-forming, sulphite reducing bacteria *(Clostridium perfringens)* in the water of Czarna Hancza River in 1996

Date	Site[1]										
	1	2a	2b	3	4	5	6	7	8	9	10
	(MPN/100 cm^3)										
26.06.1996	< 3	40	250	40	< 3	40	< 3	< 3	< 3	< 3	< 3
24.07.1996	< 3	< 3	< 3	< 3	< 3	< 3	2500	< 3	< 3	< 3	< 3
27.08.1996	< 3	90	450	70	250	90	< 3	< 3	< 3	< 3	< 3
26.09.1996	< 3	< 3	450	90	90	250	< 3	< 3	< 3	< 3	< 3
25.10.1996	< 3	< 3	90	< 3	40	40	90	< 3	< 3	< 3	< 3
29.11.1996	< 3	< 3	950	250	250	90	250	< 3	< 3	< 3	< 3

[1] – See Figure 1

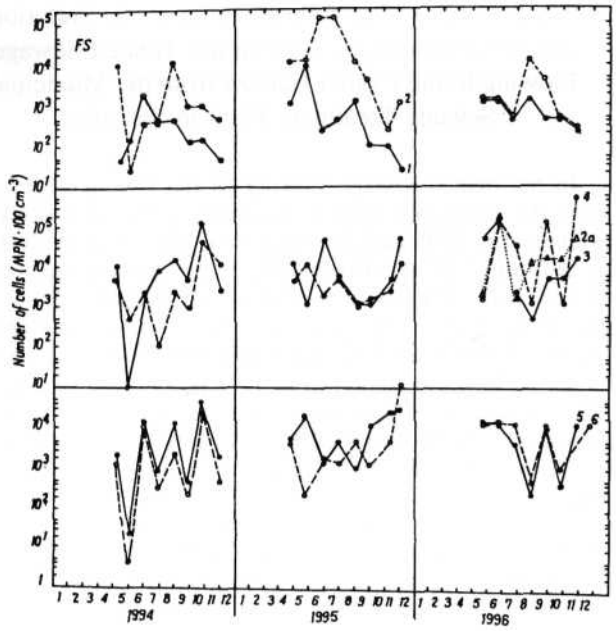

Fig. 6. Seasonal changes of the number FS in the water of the Czarna Haricza from Stary Bród above Suwatki to its inflow to Wigry Lake. Explanations as in Figure 2.

The total number TVC 37° C ranged from 5 to 112,000 CFU/1 cm^3 (Table 1). On average, their lowest number was observed in Mackowa Ruda, Buda Ruska and Wysoki Most(sites 8-10), the largest number was in Czerwony Folwark (site 7). In Czerwony Folwark (site 7) there were fewer of them in 1995 and 1996, more in 1994; in Mackowa Ruda, Buda Ruska and Wysoki Most (sites 8-10) their average number in the following years was similar. The largest number was found in 1994 in May and July in Wysoki Most (site 10) and in October; in 1995 and 1996 - in different periods in spring, summer and autumn (Fig. 8).

The total number of bacteria of *Escherichia coli* group (TC) ranged from 3 to 11,000 MPN/100 cm^3 (Table 2). The lowest number was found in Czerwony Folwark and Mackowa Ruda (sites 7 and 8), the largest number was in Buda Ruska and Wysoki Most (sites 9 and 10). In Czerwony Folwark and Mackowa Ruda the lowest number was in

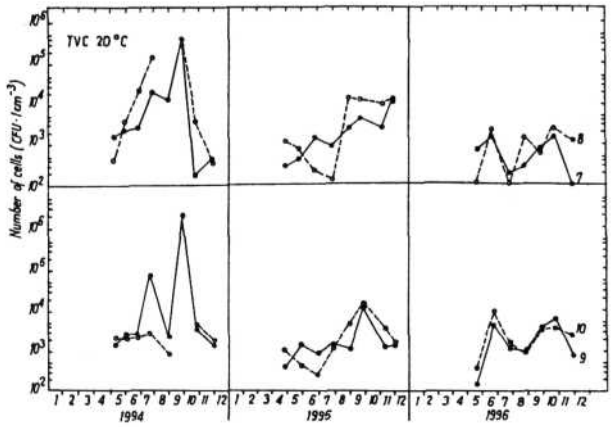

Fig. 7. Seasonal changes of the number TVC 20°C in the water of the Czarna Hancza from Czerwony Folwark to Wysoki Most towards the east from Wigry Lake 7, 8, 9, 10 - sites for collecting water samples

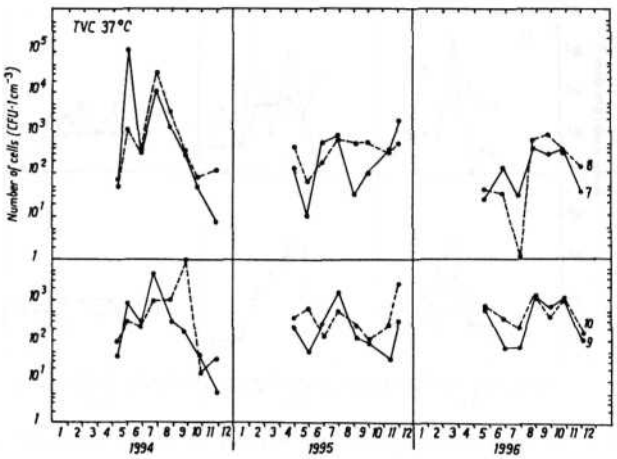

Fig. 8. Seasonal changes of the number TVC 37°C in the water of the Czarna Hancza from Czerwony Folwark to Wysoki Most towards the east from Wigry Lake. Explanations as in Figure 7.

1996, the highest number in 1995; in Buda Ruska and Wysoki Most - the lowest in 1995, the highest in 1996 (Table 2). In Czerwony Folwark and Mackowa Ruda (sites 7 and 8) in 1994 the highest number was observed in July and September, in 1995 - in April and June, in 1996 - in July and September; in Buda Ruska and Wysoki Most (sites 9 and 10) in 1994 - the highest number in August and September, in 1995 - in May, in 1996 - in June or July (Fig. 9).

The number of fecal bacteria of *Escherichia coli* group (FC) ranged from <3 to 2400 MPN/100 cm^3 (Table 2). On average the lowest number was found in Czerwony Folwark and Buda Ruska (sites 7 and 9), the highest number in Mackowa Ruda and Wysoki Most (sites 8 and 10). In all four places the lowest number was in 1996, the highest number in 1994 (Czerwony Folwark and Buda Ruska) or in 1995 (Madkowa Ruda and Wysoki Most). In 1994 in all places the highest number was found in July, in 1995 - in May and/or in June (in Mackowa Ruda also in the end of September), in 1996 their number was almost equal (Fig. 10).

The number of fecal streptococci (FS) ranged from <3

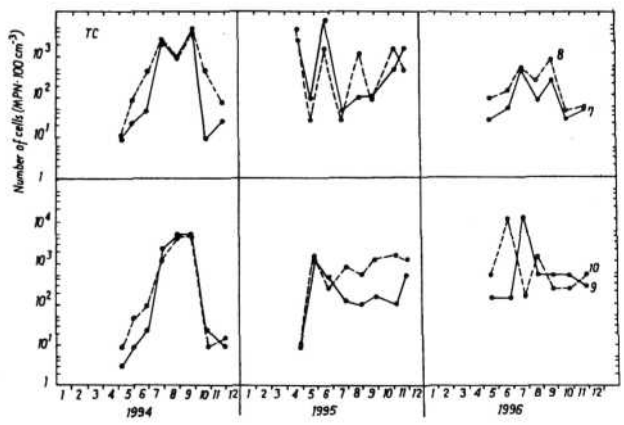

Fig. 9. Seasonal changes of the number TC in the water of the Czarna Hancza from Czerwony Folwark to Wysoki Most towards the east from Wigry Lake. Explanations as in Figure 7.

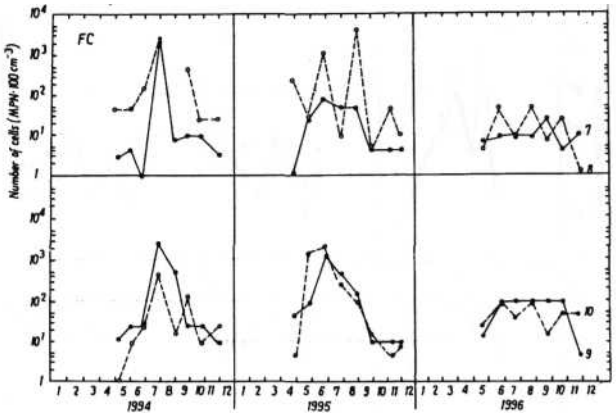

Fig. 10. Seasonal changes of the number FC in the water of the Czarna Haricza from Czerwony Folwark to Wysoki Most towards the east from Wigry Lake. Explanations as in Figure 7

to 14,000 MPN/100 cm^3 (Table 2). On average their lowest number was in Czerwony Folwark (site 7), more in Mackowa Ruda and Wysoki Most (sites 8 and 10), the highest number was in Buda Ruska. In Czerwony Folwark and Mackowa Ruda the lowest number was in 1995, the highest in 1996; in Buda Ruska and Wysoki Most - the lowest number was in 1994, the highest in 1995 and 1996. In the following years generally they were more numerous in May and/or in June, exceptionally in November (in 1995 and 1996), seldom in July and August (in 1994) (Fig. 11). The ratio FC:FS ranged from 0.0008 in Buda Ruska (site 9) in November in 1995 to 60.0 in Wysoki Most (site 10) in July 1995. In 47-67% of the examined water samples it was lower than 0.7; in 18-33% it ranged from 0.7 to 4.0 and in 0-14% it was higher than 4.0 (Table 3). The largest number of water samples with an FC:FS ratio lower than 0.7 was found in Czerwony Folwark, with the ratio FC:FS 0.7-4.0 - in Mackowa Ruda, with the ratio higher than 4.0 in Wysoki Most. None of the examined water samples collected from this part of the Czarna Hancza showed the presence of anaerobic spore-forming bacteria reducing sulfites *{Clostridium perfringens)* (Table 4).

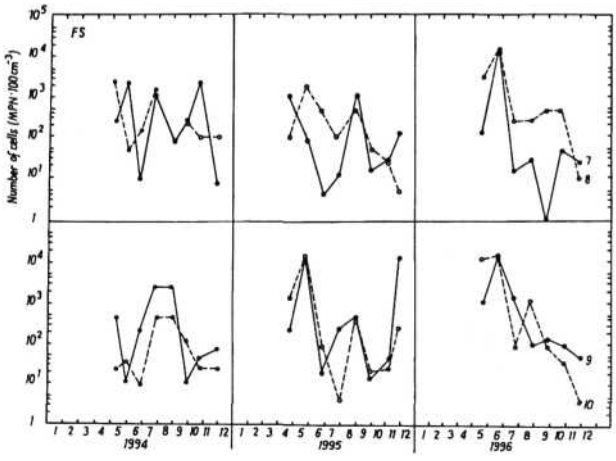

Fig. 11. Seasonal changes of the number FS in the water of the Czarna Haricza from Czerwony Folwark to Wysoki Most towards the east from Wigry Lake. Explanations as in Figure 7

The Number of Indicator Bacteria of the Pollution Degree and Sanitary State in the Treated Sewage Flowing to the Czarna Hancza from the Municipal Sewage Treatment Plant in Suwalki

In the treated sewage flowing to the Czarna Hancza from the municipal sewage treatment plant in Suwalki (examined in 1995 and 1996) the total number TVC 20°C ranged from 1930 to 540,000 CFU/1 cm^3; the total number of TVC 37°C ranged from 930 to 325,000 CFU/1 cm^3; the number TC, FC and FS was 1,400-1,400,000; 14,000-110,000 and 2,000-1,400,000 MPN/100 cm^3. The ratio FC:FS ranged from 0.07 to 700. The number of anaerobic spore-forming bacteria reducing sulfites *(Clostridium perfringens)* ranged from 40 to 950 MPN/100 cm^3 (Table 4). The number TVC 20°C was generally lower in summer months, higher in autumn months. TC, FC, FS and *Clostridium perfringens* were in smaller amounts in June and in the end of November 1995 and in June 1996, in the largest amounts in July and November 1996, more seldom in other months.

The Number of Indicator Bacteria and the Pollution Degree of the Examined Parts of the Czarna Hancza

Taking into consideration the total number of TVC 20°C and FC in the water of the Czarna Hancza as well as bacteriological criteria of water purity in rivers suggested by Kavka [20] and Kohl [21] modified by Albinger [1] presented in Table 5 one can estimate the degree of pollution in this river by organic substance easily decomposed by heterotrophic bacteria or by human and animal excrements as follows:

1. Water in the Czarna Hancza in Stary Bród (site 1) above Suwalki is characterized by little and/or moderate organic load easily decomposed and little, moderate and/or moderately high human and animal excreta load.
2. Water in the Czarna Hancza below Suwalki nearby the municipal sewage treatment plant 10 m below the flow of the treated sewage from this plant (site 2a) is charac terized by a moderate and/or moderately high organic load easily decomposed or little, moderate, moderately high and/or very high human and animal excreta load.
3. Water of the Czarna Hancza below Suwalki nearby the municipal sewage treatment plant in the distance of 10 m below the flow of the treated sewages from this plant (site 2b) is characterized by most often moderately high organic load easily decomposed and moderately high and very high human and animal excreta load.
4. Water of the Czarna Hancza in Sobolewo is charac terized by most often moderate and/or moderately high (si te 3) and moderately high and/or high (site 4) organic load easily decomposed or moderately high and very high (sites 3 and 4) human and animal excreta load.
5. Water of the Czarna Hancza in the region of a nature reserve (sites 5 and 6) in Wigry National Park is charac terized by moderately high and/or high organic load easily decomposed and moderate, moderately high and/or very high human and animal excreta load.
6. Water of the Czarna Hancza from Czerwony Folwark (site 7) to Wysoki Most (site 10) towards the east from Lake Wigry is characterized most often by a moderate (in

Table 5. Number of total viable count at 20°C and 37°C and total coliforms, fecal coliforms, fecal streptococci and *Clostridium perfringens* in treated sewages flow to the Czarna Haricza River from Sewage Treatment Plant in Suwalki, in 1995 and 1996

Date	TVC 20°C[1]	TVC 37°C[2]	TC[3]	FC[4]	FS[5]	FC:FS ratio	CP[6]
	(CFU × 10^3/1 cm^3)		(MPN × 10^3/100 cm^3)				MPN/100 cm^3
26.06.1995	7.35	2.78	14.0	14.0	4.5	3.1	–
1.09.1995	19.35	0.93	450.0	140.0	2.0	70.0	–
28.09.1995	400.0	18.5	1100.0	150.0	75.0	2.0	–
9.11.1995	130.0	106.5	1100.0	1100.0	30.0	–	–
31.11.1995	540.0	5.5	14.0	14.0	20.0	0.7	–
17.05.1996	15.0	3.5	210.0	110.0	115.0	0.9	–
25.06.1996	52.0	19.8	1400.0	110.0	1400.0	0.07	250
24.07.1996	10.0	1.65	110.0	11.0	25.0	0.44	40
27.08.1996	1.93	11.64	140.0	110.0	250.0	0.44	450
26.09.1996	106.8	167.5	1100.0	450.0	75.0	6.0	950
25.10.1996	28.6	13.7	110.0	110.0	25.0	4.4	450
30.11.1996	384.0	325.0	1100.0	450.0	140.0	3.0	950

[1] – Total viable count at 20°C; [2] – Total viable count at 37°C; [3] – Total coliforms; [4] – Faecal coliforms; [5] – Faecal streptococci

Czerwony Folwark, Mackowa Ruda, Buda Ruska) or moderately high (in Wysoki Most) organic load easily decomposed or very little, little and/or moderately high human and animal excreta load.

A similar estimation of water pollution of the examined parts of the Czarna Hancza is obtained by comparing the results of the investigation concerning the numbers of TVC 20°C, TVC 37°C and fecal coliform index (FC) with the estimation criteria for the domestic conditions presented by Cabejszek et al. [7] shown in Table 6. According to these criteria most samples taken in Stary Brod (site 1) above Suwalki show a little degree of pollution. Nearby the municipal sewage treatment plant at site 2a 10 m above the flow of the treated sewage coming from that plant the participation of pure water and/or slightly polluted samples decreases, whereas the participation of slightly, distinctly or even strongly polluted water samples increases. At site 2b 10 m below the flow of the treated sewage coming from the nearby municipal sewage treatment plant most of the examined samples show distinct and/or strong pollution. In Sobolewo (sites 3 and 4) and in the region of the old riverbed and the mouth of the Czarna Haricza to Lake Wigry (sites 5 and 6) almost half or more of the examined water samples show distinct or strong pollution. At the sites situated in Czerwony Folwark, Mackowa Ruda, Buda Ruska and Wysoki Most (sites 7-10), most of the examined water samples of the Czarna Hancza meet the values given by Cabejszek et al. [7] for pure and/or slightly polluted surface waters. Only in Wysoki Most (site 10) did about one third of the examined water samples show strong pollution.

The Number of Indicator Bacteria and Sanitary--Bacteriological Requirements for Water Used for Recreation

According to the data of the European Committee for Water Quality for Recreation [10] the number TC and FC should not exceed 500 and 100 MPN/100 cm^3, respectively (at least in 85% of the examined samples), whereas FS is 100 MPN/100 cm^3 in at least 90% in the examined samples (guide values). However, TC and FC not exceeding 10,000 and 2000 MPN/100 cm^3, respectively, in at least 95% of the examined samples (mandatory values) at the total lack of pathogenic bacteria as *Salmonella* in 1 dm^3 water and enteropathogenic viruses in 10 dm^3 water in at least 95% of the examined samples can be accepted. Examinations detecting the presence of *Salmonella* and enteropathogenic viruses are required only when there is a suspicion that these viruses are present in recreational areas [12]. To what extent does the water of the Czarna Hancza fulfill the abovementioned requirements? Guide values requirements for TC, FC and FS in Stary Brod (site 1) above Suwalki fulfilled 48, 52 and 22% of the examined water samples, respectively. Nearby the municipal sewage treatment plant 10 m above the flow of the treated sewage from the plant (site 2a) the requirements fulfilled only 13, 17 and 4% of the examined water samples, respectively. In the same region 10 m below the flow of the treated sewage from this plant none of the examined water samples fulfilled the requirements. In Sobolewo (sites 3 and 4) and in the region of the old riverbed and the mouth of Czarna Hancza to Wigry Lake the requirements were fulfilled by 4-13%, 4% and 4% of the examined samples, respectively. From Czerwony Folwark to Wysoki Most towards the east from Wigry Lake the requirements of guide values TC, FC and FS were fulfilled 64-78%, 68-95% and 27-56% of the examined samples, respectively (Table 7). Mandatory values (for TC and FC) fulfilled Stary Brod (site 1) above Suwalki were 87 and 96% of the examined samples, respectively, nearby the municipal sewage treatment plant 10 m above the treated sewage from this plant 78 and 65% of the examined water samples and 10 m below the flow of the treated sewage only 25 and 25% of the examined samples. In Sobolewo (sites 3 and 4) and in the region of the old riverbed of the Czarna Hancza and its mouth to Wigry Lake (sites 5 and 6) it was 48-55% and 22-43% of the examined samp-

Table 6. The analysis of water quality of the Czarna Haricza River using criteria given by Kavka [20] and Kohl [21] after Albinger [1] Percent distribution of samples relevant to the given class

Water quality criteria		Water quality level[4]	Site[1]											
Micro-organisms	Number of bacteria (CFU · 1 cm^{-3})		1	2a	2b	3	4	5	6	7	8	9	10	1-10
TVC 20°C[2]	> 500	1	0	5	0	0	5	0	0	30	27	9	14	8.5
	500 – 1000	2	22	4	13	5	0	0	0	13	9	9	9	7.3
	1000 – 10000	3	69	65	13	45	47	48	55	39	32	69	73	52.6
	10000 – 50000	4	0	22	62	41	35	30	27	9	23	5	4	20.9
	50000 – 100000	5	9	0	12	0	0	13	9	0	0	4	0	4.3
	100000 – 750000	6	0	4	0	0	9	0	9	9	9	0	0	3.8
	>750000	7	0	0	0	9	4	9	0	0	0	4	0	2.6
			(23)[5]	(23)	(8)	(22)	(23)	(23)	(22)	(23)	(22)	(23)	(22)	(234)
FC[3]	0.01 – 0.1	1	4	0	0	4	4	0	0	74	35	18	26	15.0
	0.1 – 1	2	48	17	13	4	0	4	5	22	30	61	52	23.2
	1 – 10	3	35	35	0	13	13	22	9	4	22	13	13	16.2
	10 – 50	4	13	35	25	35	48	44	41	0	13	8	9	24.8
	50 – 100	5	0	0	0	9	0	4	0	0	0	0	0	1.2
	100 – 1000	6	0	13	62	35	31	26	41	0	0	0	0	18.9
	> 1000	7	0	0	0	0	4	0	4	0	0	0	0	0.7
			(23)	(23)	(8)	(23)	(23)	(23)	(22)	(23)	(23)	(23)	(23)	(237)

[1] - See Figure 1
[2] - Total viable count at 20°C (saprophytic bacteria as CFU/1 cm^3)
[3] - Number of fecal coliforms (MPN/1 cm^3)
[4] - Degree of loading with organic substances, which can be well decomposed by bacteria (TVC 20ºC) and degree of loading with faecal substances (FC): 1 - very little; 2 - little; 3 - moderate; 4 - moderate high; 5 - high; 6 - very high; 7 - extreme high
[5] - In brackets number of investigated samples

Table 7. The analysis of bacteriological water quality of the Czarna Hancza River using criteria given by Cabejszek et al. [7] 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	Site[1]											
Micro-organisms	Number of bacteria (CFU · 1 cm^{-3})		1	2a	2b	3	4	5	6	7	8	9	10	1-10
TVC 20°C[2]	< 300	A	0	0	0	0	4	0	0	22	18	5	5	5.1
	300 – 5000	B	82	52	12	36	22	13	36	61	36	69	86	48.2
	5000 – 10000	C	0	22	13	14	26	35	23	0	0	4	5	12.8
	>10000	D	18	26	75	50	48	52	41	17	46	22	4	33.8
			(23)[4]	(23)	(8)	(22)	(23)	(23)	(22)	(23)	(22)	(23)	(22)	(234)
TVC 37°C[3]	– < 200	A	61	35	12	9	13	12	9	47	41	52	26	30.2
	200 – 1000	B	31	17	13	32	30	22	41	36	50	35	56	34.0
	1000 – 5000	C	8	39	25	41	22	44	41	9	5	13	13	23.4
	> 5000	D	0	9	50	18	35	22	9	8	4	0	5	12.4
			(23)	(23)	(8)	(22)	(23)	(23)	(23)	(23)	(22)	(23)	(23)	(235)
Faecal Coli titre	>1	A	39	9	0	4	5	4	0	96	70	52	65	33.4
	1 – 0.1	B	48	43	0	18	13	22	13	0	15	39	26	22.9
	0.1 – 0.01	C	13	35	38	36	52	48	43	4	15	9	9	26.8
	< 0.01	D	0	13	62	42	30	26	44	0	0	0	0	16.9
			(23)	(23)	(8)	(22)	(23)	(23)	(23)	(23)	(22)	(23)	(23)	(236)

[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

les, respectively. From Czerwony Folwark to Wysoki Most (sites 7-10) the values were fulfilled in 96-100% and 95-100%, respectively (Table 7).

Discussion

The Number of Indicator Bacteria in the Water of the Czarna Haricza River from Stary Brod above Suwalki to its Mouth to Wigry Lake

The total number of bacteria determined on the broth-agar at 20°C (TVC 20°C) is a widely used indicator of the degree of water pollution by organic load easily decomposed by bacteria [5] at 37°C (TVC 37°C), by domestic sewage [35] and the possibility of pathogenic bacteria occurrence [22], A sudden increase of the number of the above mentioned bacteria in drinking water (for domestic purposes or recreation) shows the worsening of its quality and the necessity of taking improvement actions. The number of TC, FC, FS and *Clostridium perfringens* are indexes of the water sanitary state and their estimation allows us to determine the present epidemiological state and long age fecal pollution of the water. Besides, it allows us to determine the character of these pollutions and their origin from people and/or animals [4, 14, 15, 30]. The number of these bacteria in the water of the Czarna Hancza in Stary Brod (site 1) above Suwalki does not differ from their number found from Czerwony Folwark to Wysoki Most towards the east from Wigry Lake. At the sites situated below Suwalki the number of bacteria does not differ from the values given for river waters taking in pollution from municipal areas [9, 11, 23] and draining agricultural catchments [18, 25, 33, 36, 38]. Pollution deposited by domestic, farm, and

Table 8. The analysis of water quality of the Czarna Hancza River using criteria given by EEC [10]. Percent distribution of samples fulfilling guide and mandatory values for bathing waters

Site[1]	Number of investigated samples	Guide values			Mandatory values		
		TC	FC	FS	TC	FC	S/E[2]
		500	100	100	10000	2000	0
1	23	48	52	23	87	96	–
2a	23	13	17	4	78	65	–
2b	8	0	0	0	50	25	–
3	22	9	4	4	50	23	–
4	23	4	4	4	39	43	–
5	23	13	4	4	48	35	–
6	23	9	4	4	56	22	–
7	23	70	96	57	100	100	–
8	22	64	68	27	100	95	–
9	23	78	74	39	96	100	–
10	23	61	69	52	96	100	–

[1] - See Figure 1

[2] - S - Salmonella/1 dm^3, E - Enteroviruses PFU/10 dm^3.
S/E measurement is only required when an inspection in the bathing area shows that the parameter may be present, or when water quality has deteriorated.

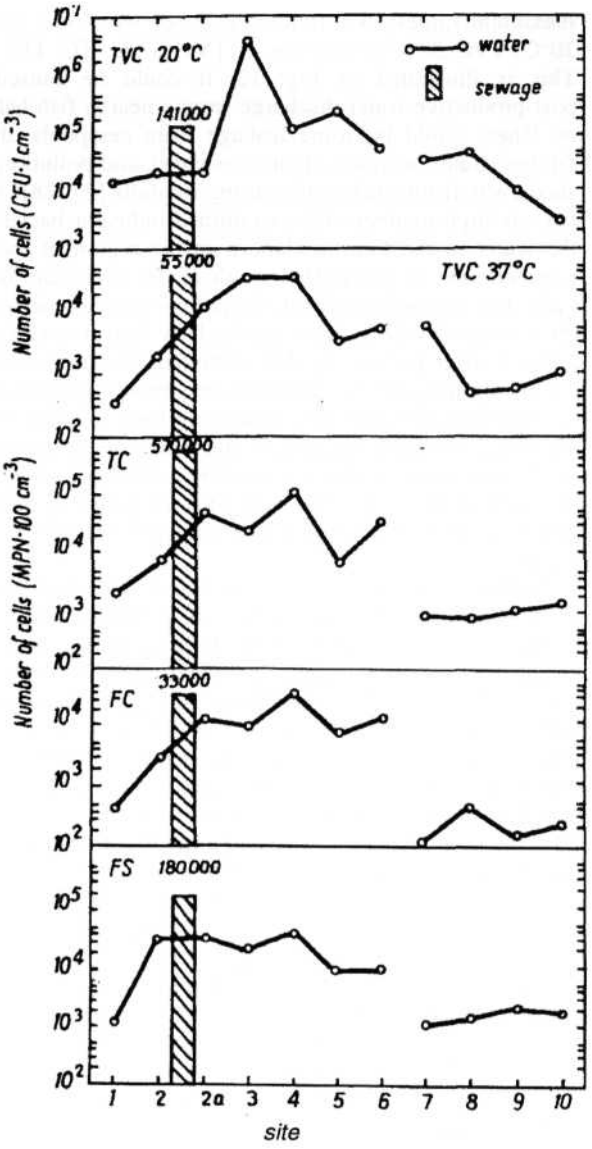

Fig. 12. Average number TVC 20°C, TVC 37°C, TC, FC, FS in the water of investigated parts of the Czarna Hancza in 1994-1996 years and in treated sewages flow into river in 1995 and 1996.

wild animals; dustbins; etc. are the sources of these bacteria in Suwalki and its surroundings, washed down during atmospheric falls to storm drainage systems and small watercourses [14, 17, 23, 31, 32], "overflows sanitary sewage", "cross connection with sanitary sewers" [9, 11, 31] and the treated sewage flowing to the Czarna Hancza through a covered canal from the municipal sewage treatment plant in Suwalki. This plant has worked in a three degree system (mechanical, biological and nitrogen and phosphorus removal treatment) since 1995 and the treated sewage removed from it do not always fulfil satisfactory sanitary bacteriological requirements [10]. As a result, the water of the Czarna Hancza in the region of the sewage treatment plant may contain maximum number of the examined indicator bacteria of the pollution degree (TVC 20°C and TVC 37°C) and sanitary state (TC, FC, FS and *Clostridium perfringens).* With the river course the number of these bacteria, according to literature [5], should decrease. In reality, however, it often increased reaching the

maximum values 5 km farther, in Sobolewo at site 3 (TVC 20°C, TVC 37°C) or at site 4 (TVC 37°C, TC, FC, FS). This is illustrated in Fig. 12. It could be caused by post-productive water discharge from a nearby fish hatchery. There could be some leakage from cesspools, decay ditches (liquid manure, organic manure), and pollution washed away from catchments during rainfalls [27, 28]. A relatively high number of the examined indicator bacteria in the water in the Czarna Hancza in the region of the old riverbed (site 5) and in the mouth of the river near Wigry Lake may be connected with the pollution in Sobolewo and the activity of wild animals, particularly beavers (which are under a strict protection). Uncontrolled foul disposal with cesspool emptying [14, 15] from neighbouring places may be a modifying factor of a relatively high number of the examined indicator bacteria in the water of the mouth of the Czarna Hancza. This is shown by a number ratio FC:FS 0.7-4.0 and above 4.0 (characteristic for pollution originating from people) in most examined water samples in this region.

Maximum number of the examined indicator bacteria often observed in the end of August, in September and/or in October in the water of the Czarna Hancza may be connected with more intensive rainfalls [24, 32, 39]. During rainfalls riverflow sometimes increases 2-3-times in comparison to the mean annual flow [3]. As a result, some areas close to the river may be flooded so that pollution deposited by farm and wild animals together with alimentary tract bacteria may get into river water. Some bacteria from the riverbed can inleak when there is a higher flow. The curve of the number of the examined indicator bacteria in river water and in bottom sediments is similar (S. Niewolak - Total viable count and concentration of enteric bacteria in bottom sediments from River Czarna Hancza, Northeast Poland, in prep.). Larger numbers of the examined indicator bacteria in autumn were observed by the author in well waters in Sobolewo in the region of the Czarna Hancza [29]. Smaller numbers of TVC 20°C and TVC 37°C was found in 1995 and 1996 than in 1994 may be attributed to the opening of the degree III sewage treatment plant in Suwalki. The improvement of bacteriological quality of river waters as new sewage biological treatment plants are opened or already existing plants are modernized is well documented [6, 13, 25, 26, 34].

The Number of Indicator Bacteria in the Water of the Czarna Hancza from Czerwony Folwark to Wysoki Most

The number of indicator bacteria of pollution and sanitary state in the water of the Czarna Hancza from Czerwony Folwark to Wysoki Most are significantly different than the one observed from Suwalki to its mouth to Wigry Lake. Many times fewer numbers of TVC 20°C, TVC 37°C, TC, FC, FS and the total lack of anaerobic spore-forming bacteria *(Clostridium perfringens)* is a result of "deprivation" of pollution and bacteria being of sanitary importance in Wigry Lake. As a result, water flowing from this reservoir starts a completely new river of the same name. On the river course of the Czarna Hancza starting from Wigry Lake there is a small, shallow lake called Postaw which plays the role of a settling pond for possible pollutants and indicator bacteria which can inleak from Wigry Lake. Besides, on the entire Czarna Hancza there is a lack of point sources of pollution. Extensive agricultural economy in this area, a weak river current, covered with rush plants facilitate sedimentation of possible pollutants carried from catchments during rainfalls. Activity of waterfowl (from spring to autumn) and canoe tourism (in summer) may be a modyfying factor of a low degree of pollution of this part of the Czarna Hancza.

Final Remarks

In order to improve the purity of the Czarna Hancza River from Suwalki to its mouth to Wigry Lake it is necessary to take up activities to limit the inflow of point or space pollutions. These activities may comprise using the natural biological shield of the bank belt, building a system of drains enabling filtration of surface flows through soil imitating filtration fields (or soil filters utilized in the process of sewage treatment by the soil method), and the removal of leakage to a collective sewer and sewage treatment plant. From the ecological point of view an alternative could be the removal of cattle and farm animals from areas close to the river. But actions should be proceeded by a careful recognition of all possible states of purity in the natural environment of a given area.

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