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SPATIAL AND SEASONAL CHANGES IN BACTERIOPLANKTON OF HEATED KONIŃSKIE LAKES[1]

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A B S T R A C T. Thermal pollution considerably affected spatial and seasonal structure of bacterioplankton of two lakes used as cooling reservoirs for water discharged by coal power plants. Bacterioplankton was several times more numerous, and the average cell volumes were lesser comparing to bacteria of non-heated waters. Heating intensified microbiological processes of the mineral and organic forms of basic nutrients.

Key words: LAKE, HEATED WATER, POLLUTION, BACTERIOPLANKTON.

INTRODUCTION

Konińskie lakes are a unique lake system in Poland used for cooling the discharge water from two coal power plants „Konin" and „Pątnow". Studies carried out for over 30 years revealed that the lakes differed in terms of production, consumption, and destruction from typical non-heated lakes (Spodniewska 1984, Kraska 1988, Wilkońska 1983, Tunowski 1988). The lakes are characterised by non-stable environmental conditions due to strong anthropogenic impacts (Hillbricht-Ilkowska, Zdanowski 1988, Zdanowski et al. 1991, Zdanowski 1994).

Studies on micro-organisms of strongly heated reservoirs showed that temperature increase affects the number and proliferation rate of bacterioplankton, and determines intensity of destruction and mineralisation of organic matter (Gurienovich 1995, Światecki 1994a, Szubiernicki, Niergu 1988).

The present study shows changes in bacterioplankton of lakes Licheńskie and Ślesińskie, as well as of the supplying and discharge channels of „Konin" and „Pątnów" power plants at the time of operation of various systems of cooling the discharge water.

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MATERIAL AND METHODS

Studies on Licheńskie and Ślesińskie lakes, and the supplying and discharge channels of „Konin" and „Pątnów" power plants, as well as on the channel supplying water from Pątnowskie Lake to „Konin" power plant, were carried out in 1991-1994. The lakes and the cooling system were described in details by Zdanowski (1994). Basic limnological parameters of the lakes are shown in Table 1.

The system of cooling the discharge water from „Konin" and „Pątnów" power plants consists of a series of reservoirs periodically included into the circulation, depending on air temperature and temperature of the discharge water (Fig. 1). From September to May „Konin" power plant works in the so-called „closed cooling system". Water discharged from the plant is supplied through the channels to the central part of Licheńskie Lake, and flows to Pątnowskie Lake through the southern basin of this reservoir . It is then carried through the channel to „Konin" power plant again. At the same time, „Pątnów" power plant uses only Gosławskie Lake. Length of that system is about 20 km.

During warm season (usually from mid-May to mid-September), also Ślesińskie Lake is included into the system, the so-called „extended cooling system". Heated water flows from the central basin of Licheńskie Lake south-west to Pątnowskie Lake, and to the north, through a narrow part of the reservoir, to the channel carrying water to Ślesińskie Lake. From Ślesińskie Lake, through its southern basin , this water reaches Mikorzyńskie, and then Pątnowskie Lake. It is carried from Pątnowskie Lake through a channel to „Konin" power plant. Total length of the „extended cooling system" is about 40 km.

Water for microbiological analyses was collected during the following seasons: winter-early spring (January-March), after the „extended cooling system" has been put into operation (May-June), in summer (July-August), and in autumn (October).

TABLE 1

Limnological characteristics of Ślesińskie and Licheńskie Lakes (according to Zdanowski 1994)

Lake	Area (ha)	Depth max. (m)	Retention (days)	Limnological type
Ślesińskie	148.1	25.7	7	dimictic eutrophic
Licheńskie	153.6	13.3	5	monomictic eutrophic

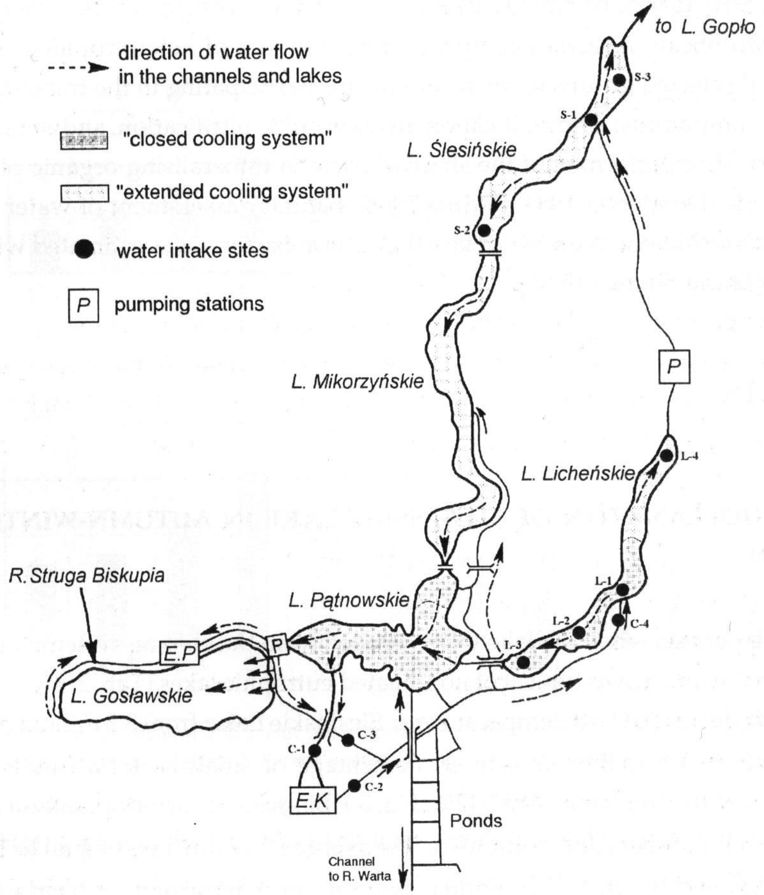

Fig. 1. Cooling system of Konińskie lakes

Sampling sites were situated at maximum depth points, at the inflow of heated water, and at permanent and periodical outflows (Fig. 1.). Water was sampled from the surface layer and from the layer just above the bottom. In the supplying channel of „Pątnów" power plant it was collected from a site situated 1 km from the water intake in Pątnowskie Lake. Samples from the discharge channel of „Konin" power plant were taken at the sites situated 200 m and 9 km (Licheński Channel) from the discharge of heated water. Water from the discharge channel of „Pątnów" power plant was collected 5 km from the discharge.

Total number of bacteria, their morphological structure, and the biomass were determined using membrane filter technique and acridine orange staining (Hobbie et al. 1977). Structure of bacterioplankton was analysed using computer image analysis system MultiScan. Analyses comprised total number of heterotrophic bacteria and number of selected groups of micro-organisms participating in the transformation of nitrogen compounds: ammonification, heterotrophic nitrification, and denitrification. Estimates were performed of the share of bacteria mineralising organic phosphorus compounds (Donderski 1983, Rodina 1968). Sanitary assessment of water was done using routine indices. Number of faecal Coliform bacteria was estimated with the use of a membrane filter method.

RESULTS

BACTERIOPLANKTON OF ŚLESIŃSKIE LAKE IN AUTUMN-WINTER SEASON

In the periods when the lake was excluded from the cooling system, the bacterioplankton dynamics was typical of non-heated eutrophic lakes (Tab. 2, Fig. 2). Number of bacteria decreased with temperature of Ślesińskie Lake: from 3.3 million cells per ml in autumn to 1.9 million in winter. Percentage of small bacteria (under 0.1 μm^3) fluctuated within the range of 37-42% (Fig. 3.). Biomass of bacterioplankton calculated from the cell numbers and volume (on the average 0.19 μm^3) was equal to 145 µg C/l in autumn, and 94 µg C/l in winter. Number of heterotrophic bacteria fluctuated within the range 0.3-2.2 thousand cells per ml. Concentration of ammonia nitrogen was 0.24 mg/l on the average (Tab. 3.). In winter, numbers of ammonifying bacteria were 3 fold lower, and average concentration of ammonia-nitrogen was equal to 0.067 mg/l. Nitrifying bacteria comprised 5% of the total number of heterotrophic bacteria (Fig. 5.). Their activity during autumn-winter season caused an increase of concentration of nitrate nitrogen from 0.02 mg/l in October to 0.52 mg/l in January-March. Number of bacteria mineralising organic phosphorus decreased at that time from 130 (in autumn) to 30 cells per ml in winter. In autumn, bottom water layer in Slesińskie Lake (site I) contained 3 times as many denitrifying bacteria as the subsurface water, 0.2 thousand cells in ml on the average. At that time very low nitrate-nitrogen concentration was observed - less than 0.01 mg/l, as well as a considerable increase of ammonia-nitrogen - 1.91 mg/l.

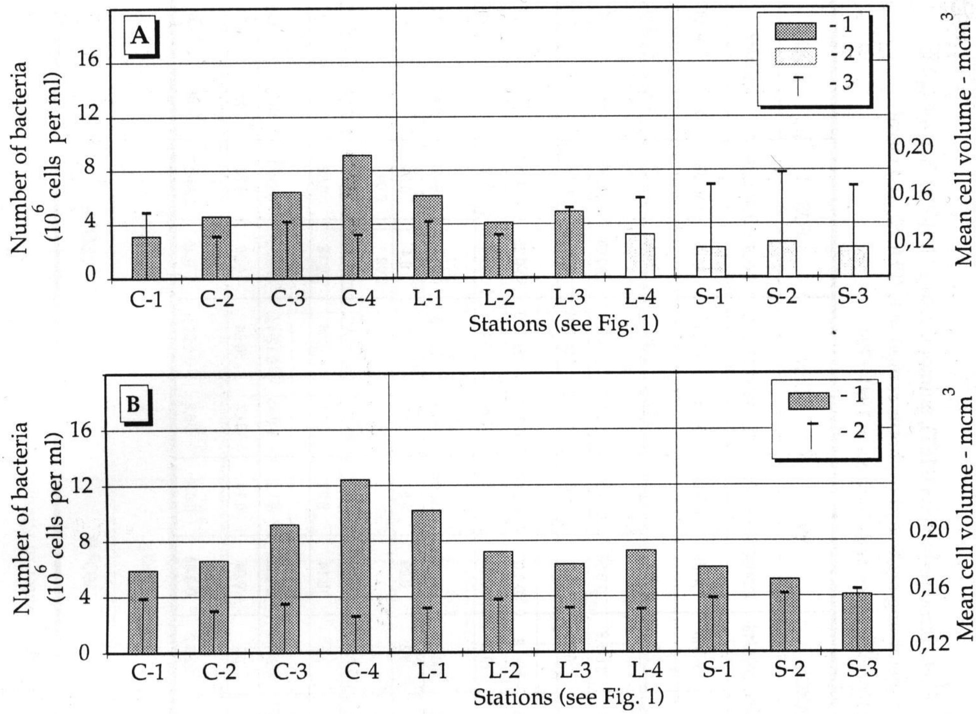

Fig. 2. Total number of bacteria and mean cell volume at the time of operation of the „closed" (A), and „extended" (B) cooling systems (1 - heated waters, 2 - non-heated waters, 3 - mean cell volume)

BACTERIOPLANKTON OF ŚLESIŃSKIE LAKE IN SUMMER.

Lake including into the „extended cooling system" caused considerable changes of physical and chemical properties of water (Tab. 3). A rapid increase of water temperature was observed from March to May - 13°C on the average. In the following months temperature increased gradually up to a maximum of 29°C in August 1994. Strong water outflow from the discharge zone resulted in homogenous distribution of nutrients within the whole lake. Spatial variation of bacterioplankton numbers was observed (Fig. 2.). At the inflow of heated water to the lake (site S-1), average numbers amounted to 6.2 million cells per ml. At the water outflow (sites S-2 and S-3), bacterioplankton was less abundant: 5.1 and 4.2 million cells per ml respectively. Bacteria under 0.1 μm^3 comprised 46% of total the bacteria numbers, and the mean cell volume was equal to 0.17 μm^3. The biomass was within the range of 135,0-328.7

TABLE 2

Total number of bacteria (TNB), bacteria biomass (BB), number of heterotrophic bacteria (HET), ammonificators (AMON), heterotrophic nitrifying bacteria (NIT), denitrificators (DEN), bacteria mineralising organic phosphorus compounds (PHOS), and faecal Coliforms (COLI) in water of the Koniskie lakes and channels in 1991-1994

Basin	OLB		BB		HET		AMON		NIT		DEN		FOS		COLI	
	thousand cells/ml		μg C/l		thousand cells./ml		thousand cells/ml		thousand cells/ml		thousand cells/ml		thousand cells/ml		cells/ml	
	X-III	V-VIII	X-III	V-VIII	X-III	V-VIII	X-III	V-VIII	X-III	V-VIII	X-III	V-VIII	X-III	V-VIII	X-III	V-VIII
Supplying channel El. Konin	3.1*	5.9	5.9	140.2	1.4	240.7	1.4	2.8	0.3	0.8	0.03	0.1	0.02	0.12	0.03	0.14
	1.6-6.2	3.8-7.4	75.0-248.6	160.2-353.3	0.4-2.6	1.2-4.1	0-0.9	0.6-1.8	0-0.08	0.04-0.1	0-0.08	0-0.2	0-0.08	0-0.52	0-13	0-6
Discharge channel El. Konin	4.6	6.1	6.1	190.2	275.3	1.2	3.1	0.3	0.7	0.03	0.07	0.06 0.42	0.07	0.13	3	2
	2.8-6.4	3.6-8.1	122.1-282.6	142.6-310.4	0.7-2.8	2.1-3.7	0.2-0.5	0-1.2	0-0.07	0.03-0.1	0-0.12	0.04-0.8	0-0.35	0.02-0.5	0-8	0-15
Supplying channel El. Pątnów	6.4	9.2	272.4	376.7	3.8	5.3	1.3	1.9	0.09	0.18	0.8	1.3	0.19	0.3	8	3
	5.3-9.5	6.2-12.4	235.6-392.6	266.1-519.3	0.4-5.5	2.3-6.8	0.2-2.3	0.6-3.1	0-0.18	0.02-0.4	0-1.6	0.5-1.8	0.06-0.5	16-0.6	0-40	0-20
Channel Licheński	8.5	12.4	366.4	498.5	5.3	7.1	1.8	3.2	0.29	0.53	0.92	1.5	0.4	0.28	10	6
	7.2-13.1	6.3-16.2	290.7-548.4	285.4-619.4	0.6-8.7	3.8-12.3	0.4-4.6	1.6-5.3	0.02-0.6	0.0-1.1	0.01-1.8	0.8-1.8	0.1-1.3	0.3-0.9	0-130	0-75
Lake Licheńskie	5.5	7.5	230.3	340.6	3.6	4.6	1.9	3.9	0.14	0.32	0.21	0.45	0.12	0.62	6	10
	2.1-8.2	4.3-18.6	95.1-360.1	160.2-711.2	0.6-8.2	1.6-11.3	0.1-2.6	0.9-6.9	0-0.25	0-1.2	0-0.45	0.12-1.2	0-0.58	0.2-1.1	0-50	0-140
Lake Ślesińskie	2.1	5.4	100.5	210.6	0.8	3.6	0.4	2.3	0.04	0.18	0.07	0.24	0.06	0.36	0.5	8
	1.2-4.5	3.1-8.2	68.4-190.3	135.0-328.7	0.3-2.2	1.6-6.2	0-1.3	0.9-3.2	0-0.08	0-0.4	0-0.2	0.08-0.6	0-0.42	0.08-0.7	0-8	0-60

* - *mean of 1991-1994 seasons, seasonal averages, and range*

TABLE 3

Physical and chemical properties of water in Konińskie lakes

Basin	Temperature		Oxygen		NH_4-N		NO_3-N		Tot-N		PO_4-P		Tot-P	
	°C		mg O_2/l		mg/l		mg/l		mg/l		mg/l		mg/l	
	X-III	V-VIII	X-III	V-VIII	X-III	V-VIII	X-III	V-VIII	X-III	V-VIII	X-III	V-VIII	X-III	V-VIII
Supplying channel El. Konin	8.4*	21.8	11.7	8.8	0.09	0.16	0.18	0.03	2.76	1.41	0.05	0.02	0.09	0.08
	0.8-14.2	18.0-23.7	9.0-16.1	8.4-9.2	0..01-0.18	0.02-0.43	0-0.64	0-0.16	0.6-7.06	0.97-2.47	0.01-0.12	0.01-0.06	0.05-0.15	0.03-0.15
Discharge channel El. Konin	17.9	29.7	10.0	7.9	0.15	0.17	0.19	0.03	1.86	1.48	0.06	0.02	0.1	0.07
	12.5-22.2	26.8-32.7	7.5-13.0	6.8-9.1	0.03-0.32	0.03-0.4	0.018-0.61	0-0.15	0.58-6.06	0.86-2.46	0.02-0.13	0.02-0.04	0.06-0.13	0.05-0.08
Discharge channel El. Pątnów	18.3	30.8	9.3	7.53	0.12	0.16	0.4	0.04	2.64	2.20	0.08	0.04	0.11	0.07
	10.9-21.8	26.2-33.2	6.6-14.8	7.0-7.9	0.02-0.23	0.025-0.36	0.06-1.05	0.01-0.16	0.74-5.14	0.83-4.37	0.05-0.14	0.02-0.07	0.06-0.16	0.07-0.1
Channel Licheński	16.0	30.0	10.0	7.6	0.12	0.2	0.18	0.01	3.38	1.5	0.05	0.01	0.1	0.1
	9.5-20.0	25.9-32.6	8.7-12.0	6.7-9.5	0.02-0.2	0.03-0.38	0.07-0.5	0-0.1	0.72-15.9	1.13-2.13	0.01-0.1	0.02-0.04	0.07-0.14	0.03-0.19
Lake Licheńskie	11.3	26.8	11.0	9.2	0.11	0.13	0.22	0.06	3.06	1.88	0.05	0.03	0.09	0.09
	2.1-18.4	18.3-30.5	8.7-18.9	6.6-14.1	0-0.39	0.01-0.4	0.03-0.72	0-0.19	0.63-14.8	0.72-6.31	0.01-0.13	0-0.06	0.05-0.16	0.06-0.2
Lake.Ślesińskie	7.8	20.3	11.8	10.9	0.15	0.15	0.28	0.08	2.45	1.31	0.07	0.03	0.1	0.08
	0.9-13.3	14.0-26.2	8.5-17.1	8.2-14.1	0.02-0.58	0.03-0.44	0-1.1	0-0.3	0.66-8.2	0.55-2.36	0.02-0.14	0.01-0.06	0.06-0.15	0.04-0.19

* - *mean and range*

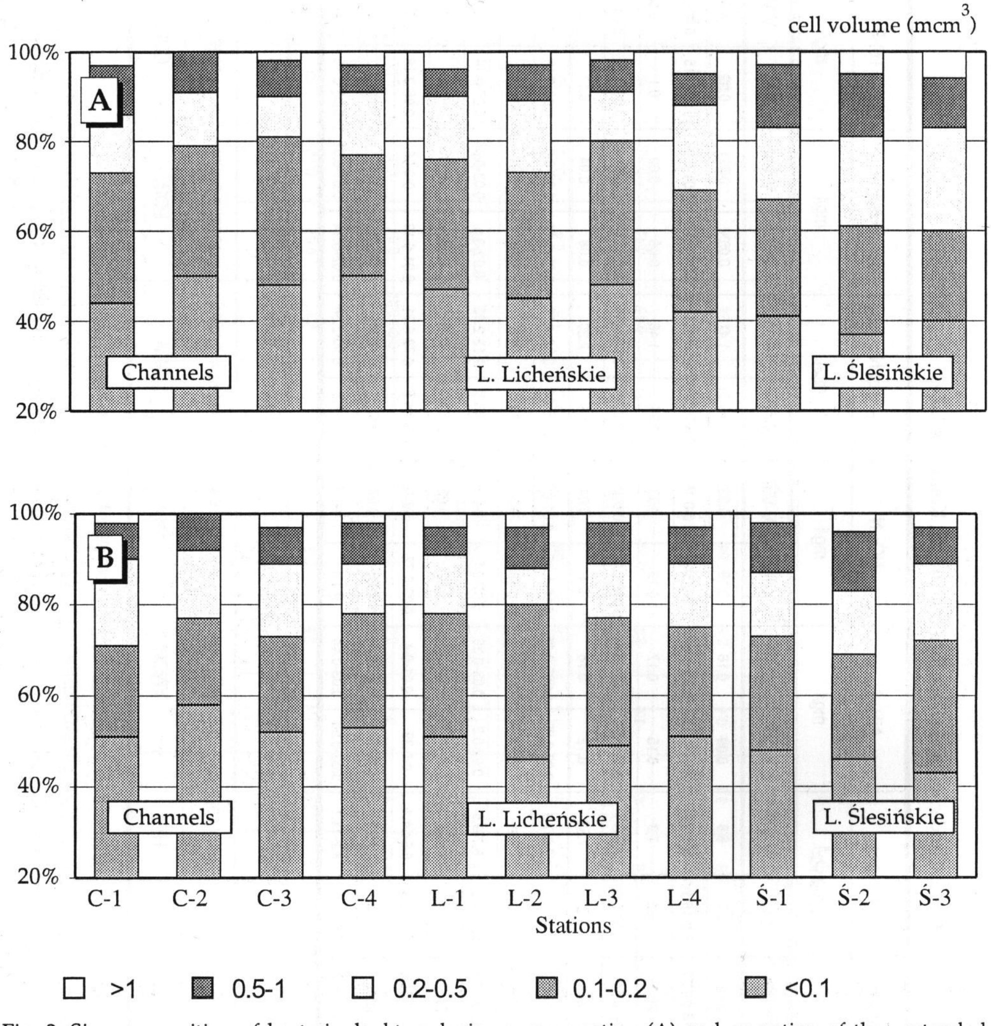

Fig. 3. Size composition of bacterioplankton during non-operating (A) and operating of the „extended cooling system".

mg/l. Among heterotrophic bacteria (average 3.6 thousand cells per ml), ammonificators predominated - 2.3 thousand cells per ml (83% of the total number). Comparing to the spring season, concentration of ammonia-nitrogen increased: 1.5 times in May-June, up to 0.11 mg/l, and two-fold in July-August, up to 0.16 mg/l. Average number of nitrifying bacteria was equal to 180 cells per ml (about 5% of the total number of heterotrophic bacteria) (Fig. 5.). High concentration of nitrate-nitrogen was

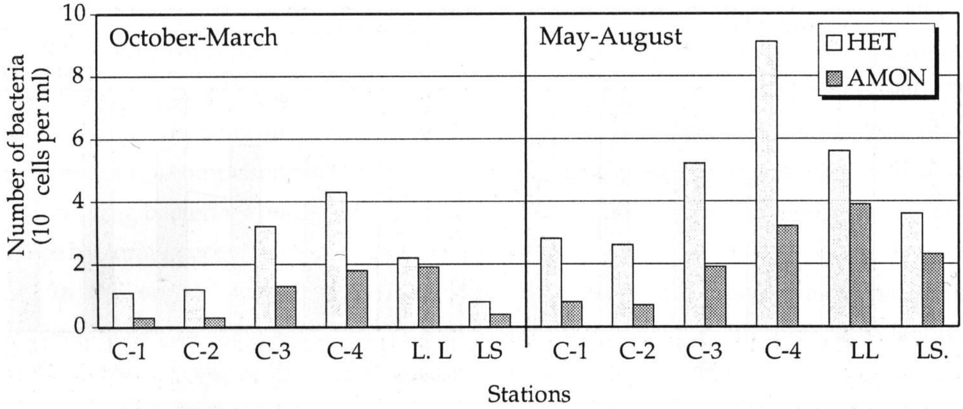

Fig. 4. Total number of heterotrophic bacteria (HET) and ammonifying bacteria (AMON) in water of Koninskie lakes and channels.

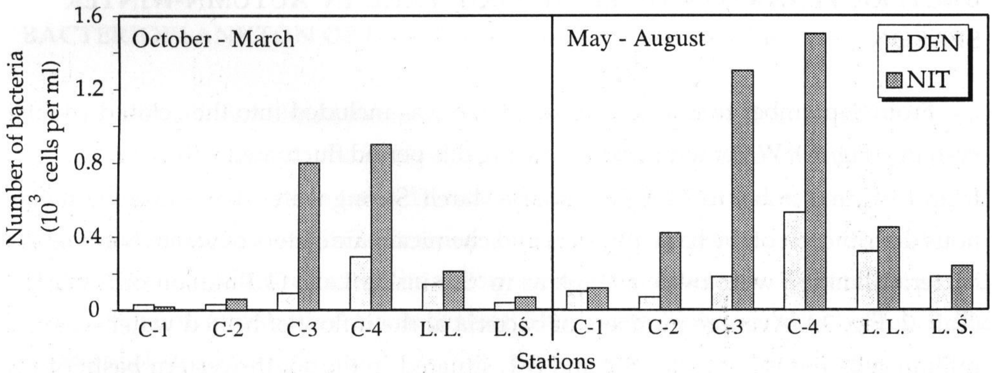

Fig. 5. Number of heterotrophic nitrificating bacteria (NIT) and denitrifying bacteria (DEN) in water of Konińskie lakes and channels.

observed only in May 1994 (0.3 mg/l), and July 1992 (0.16 mg/l). During the remaining periods concentration was much lower - 0.06 mg/l. Number of bacteria mineralising organic phosphorus compounds was low (360 cells/l). These bacteria were more numerous - up to 0.7 thousand cells per cm^3 only at the outlet of the channel. Denitrifying bacteria were most abundant in anoxic water near the bottom (site S-1) - 410 cells $\cdot$ cm^{-3}. Water of the bottom layer was rich in ammonia-nitrogen: the seasonal average concentration was 0.2 mg/l. Sanitary status of water in Ślesińskie lake qualified it to class I, and periodically to class II of purity. Faecal Coliform bacteria were abundant from March to June (800 cells per 100 ml) (Fig. 6.).

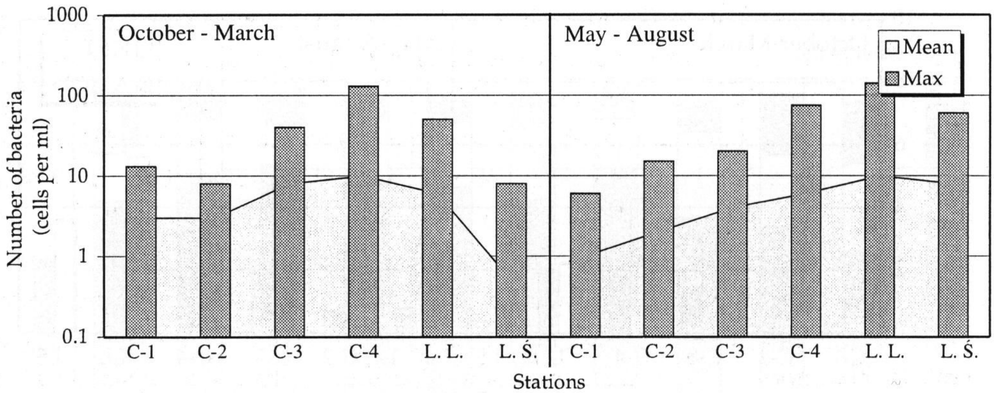

Fig. 6. Number of faecal Coliforms in water of Konińskie lakes and channels.

BACTERIOPLANKTON OF LICHEŃSKIE LAKE IN AUTUMN-WINTER SEASON

From September to May Licheńskie Lake was included into the „closed cooling system" (Fig. 1.). Water temperature during this period fluctuated within the range of from 13°C in October to 7.4°C in January-March. Strong water flow caused homogenous distribution of the basic physical and chemical parameters of water. Numbers of bacterioplankton were twice as high as in Ślesińskie Lake (4.3 million cells per ml) (Tab. 2, Fig. 2.). Average numbers of bacteria at the inflow of heated water were 6.2 million cells per ml. At sites S-2 and S-1, situated in the south-western basin of the lake, numbers of bacteria gradually decreased to 4.2 and 3.6 million cells per ml respectively (Fig. 2.). The lowest average number of bacteria was observed in the northern basin of the lake, which was excluded from the inflow of heated water: 2.7 million cells per ml. In the central and south-western basins of the reservoir, share of small bacteria under 0.1 μm^3 was equal to 47% of the total bacteria numbers, and the mean cell volume was 0.17 μm^3. In the north basin of the lake small bacteria comprised 42% of the total bacteria numbers. Total density of heterotrophic bacteria fluctuated within the range of from 1.3 thousand cells · ml in the north basin to 4.2 thousand in heated areas. Most of the heterotrophic bacteria (86% of the total number) showed an ability of ammonification (Fig. 4.). High numbers of ammonificators (2.2 thousand cells per ml) found in autumn were accompanied by high concentration of ammonia-nitrogen: 0.18 mg/l. A decrease of the numbers of this group of bacteria to 1.1

thousand cells per ml took place twice in winter and was each time accompanied by an increase of the concentration of total nitrogen to 3.4 mg/l, and by a decrease of ammonia-nitrogen to 0.08 mg/l. The average number of nitrifying bacteria was 140 cells per ml (Fig. 5). In winter, maximum concentration of nitrate-nitrogen was observed: 0.48 mg/l. Denitrificators comprised, on the average, 9% of heterotrophic bacteria. High numbers of denitrifying bacteria were noted in autumn (0.5 thousand per ml). In winter, numbers of these bacteria dropped down to 150 cells per ml.

In the north basin (site S-4) densities of heterotrophic bacteria in particular physiological groups were 1.5-2.5 times lower. In winter, the numbers were comparable to those noted at the same time in Ślesińskie Lake. Statistical analysis revealed that in winter bacteria community of the north basin of the lake was different from that of the remaining parts.

BACTERIOPLANKTON OF LICHEŃSKIE LAKE IN SUMMER

The „extended cooling system" which operated since May (Fig. 1.) resulted in an inflow of heated water to the north of the lake system: to Ślesińskie Lake, and to the south-west - to Pątnowskie Lake. The mean water temperature in summer was 27°C, reaching a maximum of 32°C. Bacterioplankton densities increased considerably. In the central basin of the reservoir the average bacteria number was 10.6 million per ml, and in the north and south-western basins 8.3 and 6.8 million respectively (Tab. 2, Fig. 2.). Share of small bacteria was high: 52% (Fig. 3.), and the average cell volume in the whole lake was equal to 0.16 mm^3. Number of heterotrophic bacteria varied considerably within the range 1.6-11.3 thousand cells per ml. The highest numbers were observed in the central basin of the reservoir - 6.4 thousand cells per ml. At the outlets from the lake, numbers of bacteria were twice lower. Ammonifying bacteria comprised 85% of the total number of heterotrophic bacteria (fig. 4.). Intensive protein and amino acid decomposition in July-August resulted in an increase of ammonia-nitrogen concentration (up to 0.19 mg/l). Share of denitrifying bacteria was about 8% of the total number of heterotrophic bacteria. In the bottom layer (site S-2), elevated number of those bacteria (18% percent of the total number) was accompanied by high concentration of ammonia-nitrogen (1.15 mg/l).

Bacteriological studies of Licheńskie Lake revealed the presence of numerous faecal Coliform bacteria in the north basin in summer. Indicatory bacteria were isolated from 35% of all water samples. Maximum density of this group of organisms was 14 thousand cells per 100 ml. During this period Licheńskie Lake was qualified to class II of purity, and periodically to class III or to off-class waters.

BACTERIOPLANKTON IN „WARM" CHANNELS

Water temperature in course of the studies fluctuated in the discharge channels within the range of from 14.5°C in winter to 36°C in summer. Despite wide thermal gradient, no seasonal changes of bacterioplankton density were observed (Fig. 2.). The average total number of bacteria was 8.4 million cells per ml.

The highest density of bacterioplankton was noted in Licheński Channel from March to June - 13.2 million cells per ml. Maximum density of bacterioplankton in the discharge channel of „Pątnów" power plant was observed in summer (12.4 million cells per ml). In „warm" channels small bacteria under 0.1 μm^3 comprised 54% of the total bacteria numbers, and the mean cell volume was 0.15 μm^3 (the lowest from all lakes of the system). Among heterotrophic bacteria (4.3 thousand cells per ml), ammonifying bacteria predominated - 38% of the total numbers. High intensity of ammonification in summer was accompanied by high concentration of ammonia-nitrogen (0.16 mg/l). Densities of micro-organisms nitrifying, denitrifying, and mineralising organic phosphorus were highly variable. Their numbers did not correlate with the concentrations of mineral and organic nutrients. Lower bacterioplankton density and lower density of heterotrophic bacteria were found in the discharge channel of „Konin" power plant (Fig. 1.). Heterotrophic bacteria in that channel were 2.5 fold less numerous than in the other heated channels. During autumn-winter season, a correlation was found between density of bacterioplankton at the inlet and outlet of „Konin" power plant . Coliform bacteria were isolated from the water of all channels. They were most abundant in the heated Pątnowski and Licheński Channels - 650 cells per 100 ml on the average.

BACTERIOPLANKTON IN A NON-HEATED CHANNEL

In the channel supplying „Konin" power plant with water from Pątnowskie Lake water temperature fluctuated from 5°C in winter to 26°C in summer. Seasonal dynamics of bacterioplankton was similar to that in Licheńskie Lake. In summer average density of bacteria was equal to 5.9 million cells per ml. In autumn and winter the density decreased to 3.2 and 2.3 million per ml respectively. Mean cell volume (0.17

μm^3) was higher comparing to that observed in Lichenskie Lake and the heated channels. Ammonifying bacteria comprised only 30% of the total number of heterotrophic microorganisms, and were most abundant in summer (Fig. 4.). Densities of other groups of bacteria varied according to the seasonal dynamics of bacterioplankton. Denitrifying bacteria and heterotrophic nitrificators were less numerous than in Licheńskie Lake (50 and 80 cells per ml respectively).

DISCUSSION

The study of heated Licheńskie and Ślesińskie lakes confirmed the hypothesis that quantitative and qualitative composition of bacterioplankton were determined mainly by the changes in thermal regimes and water retention time, as well as by trophic status (Świątecki 1994). Density of bacterioplankton observed in Konińskie lakes, twice as high as in non-heated reservoirs, was typical of thermally polluted waters. Studies carried out in Ukraine and in Russia revealed that temperature increase by 10°C caused a 1.2-1.6 fold increase of bacteria densities (Gurienovich 1995, Protasov et al. 1991, Zielenin 1983). Low seasonal variations of bacterioplankton density are also characteristic of such type of waters. Intensive mixing and flow of heated water in Licheńskie Lake resulted in a considerable homogeneity of bacterioplankton. In Ślesińskie Lake and north basin of Lichenskie Lake, which are heated only periodically and freeze in winter, the seasonal dynamics of bacterioplankton was typical of non-heated waters.

Composition of bacterioplankton of the heated lakes is also affected by an inflow of micro-organisms with discharge water (Protasov et al. 1991). Abrupt increase of bacteria densities at the inlet of heated water to Ślesińskie Lake (site S-2), and to Licheńskie Lake (site S-3) showed that allochthonous bacteria played an important role in the total numbers of bacteria. Decrease of bacterioplankton density observed at the sites situated far from the inflow of heated water was due to the dilution of heated effluent and dispersion of allochthonous bacteria.

Density and morphological composition of bacterioplankton are important indices of environmental conditions (Godlewska-Lipowa 1976, Gurienovich 1995). Domination of small bacilli of less than 0.1 μm^3 in the total bacterioplankton numbers suggests intensive bacteria development. Proliferation rate depends on thermal and trophic conditions of the environment (Godlewska-Lipowa 1976, Protasov et al. 1991). The results of the present study revealed that thermal and trophic conditions in Konińskie lakes, in periods when they were included into the cooling system, were optimum for bacterial development. Development of heterotrophic bacteria was also affected by nutrients: their concentration and composition determined density and composition of bacterial populations (Donderski 1983, Godlewska-Lipowa 1974). High dynamics of the density of heterotrophic bacteria in Konińskie lakes was caused by varying trophic conditions. The increase of number of bacteria during high inflow of heated water and low retention indicate that allochthonous supply of easily assimilated nutrients played an important role. High level of pollution and high trophy of Konińskie lakes resulted in considerable intensity of microbiological processes in the basic organic and mineral nutrients. Ammonificators that predominate among heterotrophic bacteria in Konińskie lakes are considered a sensitive indicator of organic matter inflow. By decomposing amino-acids they produce ammonia causing an increase of ammonia-nitrogen concentration in water (Donderski 1983, Danielak 1994, Niewolak 1965, Świątecki 1994a). Correlation between the number of ammonifying bacteria and concentration of ammonia was observed only in autumn, which may be explained by the complexity of microbiological processes, among others more intensive autotrophic and heterotrophic nitrification and assimilation of ammonia-nitrogen by the phytoplankton in other seasons. Lower share of ammonificators observed in the heated channels might have resulted from low concentration of easily available organic matter (non-complete proteolytic processes), and from temperatures over the optimal range. Studies of Konińskie lakes carried out in 1989-90 revealed considerable decrease of proteolytic ability of bacteria in water over 30°C (Świątecki 1994a). Also high density of denitrifying bacteria suggests high level of pollution of the lakes. Potential ability of denitrification is common among heterotrophic bacteria but appears only under conditions of abundance of organic matter and temporal DO depletion (Donderski 1983, Ossowska-Capryk 1981). High number of denitrifying bacteria in the bottom water layer was usually accompanied by high concentration of ammonia-nitrogen.

Main sources of pollution of Konińskie lakes are: fishery management in heated water, including cage rearing, and point sewage discharge (Zdanowski 1994, Świątecki 1994b). Faecal Coliforms found in Konińskie lakes indicate that water was contaminated with domestic sewage. Periodical sewage inflow, particularly high in summer, caused high level of bacteriological pollution of Licheńskie Lake.

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STRESZCZENIE

PRZESTRZENNE I SEZONOWE ZMIANY W BAKTERIOPLANKTONIE W PODGRZANYCH JEZIORACH KONIŃSKICH

W latach 1991-1994 przeprowadzono badania mikrobiologiczne wody dwóch „podgrzanych" jezior: Ślesińskiego i Licheńskiego oraz kanałów rozprowadzających wody zrzutowe z Elektrowni Konin i Pątnów (rys. 1) Analizowano ogólną liczbę bakterii, ich strukturę morfologiczną i biomasę oraz liczbę bakterii heterotroficznych prowadzących procesy amonifikacji, nitryfikacji heterotroficznej, denitryfikacji oraz rozkładu organicznych związków fosforu. W jeziorach stale (J. Licheńskie) i okresowo(J.Ślesińskie) włączonych w obiegi schładzania wód zrzutowych stwierdzono charakterystyczne zmiany bakterioplanktonu (rys. 2). W porównaniu z „naturalnymi" niepodgrzanymi jeziorami o podobnej trofii, liczebność bakterii w tych zbiornikach była średnio 2 krotnie wyższa. Wysoki udział drobnych pałeczek o objętości poniżej 0,1 μm^3 stanowiących ponad połowę ogólnej liczby bakterii oraz niska średnia objętość komórek bakteryjnych (0,16 μm^3) wskazuje na intensywne namnażanie się drobnoustrojów (rys. 2). Wysoka liczebność bakterioplanktonu w rejonach dopływów wód podgrzanych, sugeruje allochtoniczne pochodzenie części drobnoustrojów izolowanych z jezior. Stwierdzona w podgrzanych wodach wysoka liczebność bakterii heterotroficznych wskazuje na intensywne procesy rozkładu i mineralizacji substancji organicznych. Wykazano, trudno zauważalną w zbiornikach „niepodgrzanych" zależność pomiędzy liczebnością bakterii heterotroficznych a okresowymi zmianami ilości mineralnych i organicznych form podstawowych biogenów. Szczególnie wyraźną zależność wykazano pomiędzy liczebnością amonifikatorów w wodzie powierzchniowej i denitryfikatorów w wodzie nadosadowej a koncentracją jonów amonowych (rys. 3). Mikrobiologiczną odrębność J. Ślesińskiego i północnej części J. Licheńskiego wykazano w okresach wyłączenia tych wód z obiegu schładzania. Obok temperatury istotnym czynnikiem wpływającym na bakterioplankton jest zanieczyszczenie jezior ładunkiem materii organicznej i mineralnej wprowadzanym kanałami. W kanałach rozprowadzających wodę z elektrowni wykazano średnio najwyższą liczebność bakterioplanktonu, co wskazuje na dużą koncentrację łatwo przyswajalnych substratów pokarmowych. Źródłem zanieczyszczenia tych wód jest m. in. wykorzystanie kanałów do celów rybackich (stawy i sadzowy podchów ryb). Na okresowy dopływ ścieków do wody kanałów wskazują liczne izolacje bakterii z kałowej grupy coli.

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