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Sanitary and Bacteriological Examinations of Lake Oświn Water

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Abstract

The investigation was carried out in the "Seven Islands" nature reserve. It has been discovered that in the spring, summer and autumn the number of determined pollution degree indicator bacteria (TVC 22°C and TVC 37°C) of the water of Lake Oświn ranged from tens to thousands of CFU per 1 ml, depending on the research station. The sanitary state indicator bacteria (TC, FC, FS) occurred from single cells to several hundred thousand cells per 100 ml of water. In 36.5% of the lake water samples, the FC:FS ratio was determined as higher than 4.0, but it also ranged from 0.7 to 4.0. In 18% of Lake Oświn water samples it ranged from 0.043 to 0.7, and in 9% it was lower than 0.043. This proves excretal contamination with prevailing excrements of human origin.

Keywords: nature reserve, lake, water, bacteria, sanitary and bacteriological indicators

Introduction

Lakes are a large water store which are important for the formation of the water balance of our country. They are also a significant source of water supply for agriculture, industry, public utilities, as well as an area of fish culture and recreation. Furthermore, lakes are resources of nature with specific plant and animal complexes, the preservation of which for future generations is our obligation. The main cause of the deterioration of water quality and of the acceleration of eutrphication processes in lakes is an excessive inflow of biogenic elements, which stimulate the development of plants, and in consequence, cause the disappearance of valuable fish species in the ichtiofauna [9, 13]. The eutrophication process occurs particularly fast in shallow reservoirs, which include Lake Oświn. The state of lake purity in Poland is generally alarming and undergoing continuous deterioration. The causes are hardly controllable surface flows, insufficiently treated sewage discharged directly to them or to their tributaries, as well as a lack of sewage treatment plants in some towns, recreational resorts, small industrial plants, animal farms, etc. [12, 15]. Together with sewage, pathogenic microorganisms, mainly those of the alimentary tract, which may cause epidemics of dangerous consequences, are introduced to surface waters. A possibility of human waterborne infection enforces a continuous sanitary and bacteriological control of drinking waters [6], in swimming pools as well as in surface water reservoirs [9].

The protection of the natural environment, particularly water protection, constitutes an important problem, because it relates to human health protection. Therefore, a tendency to maintain the present purity state as well as to prevent a further degradation of the water environment, and, first of all, measures aimed at an overall improvement of the quality of water resources are a significant issue in water protection.

The aim of this paper is to determine the degree of contamination and the sanitary and bacteriological state

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of the waters of Lake Oświn, situated in the "Seven Islands" nature reserve.

Material and Methods

Lake Oświn

Lake Oświn, called the lake of Seven Islands, is situated in the northern part of the Mazurian Lake District, near the town of Węgorzewo, close to the Russian border. This reservoir together with surrounding marshes, wasteland and forests (1000 ha in total) is under special protection (convention RAMSAR-PAO 02.03.3.09) and constitutes a valuable "Seven Islands" nature reserve of international importance. A lot of rare waterfowl and mud fowl species reside there.

Lake Oświn has an area of 360 ha, of which open waters cover 226 ha. It is a shallow eutrophic reservoir with a mean depth of 1.0 m, while its maximum depth comes to 3.5 m. The eastern part of this reservoir is characterized by high water transparency and abundant vascular vegetation covering the bottom. In its western part, water has a significantly higher turbidity and is poorer in submersed vegetation. The shores of Lake Oświn are heavily overgrown, and the reservoir is surrounded by a wide belt of wetland and reedy areas which, after being detached, form "floating islands". The catchment basin of this lake is mostly made up of meadows, pastures and fertile ploughland. On its southern side, Lake Oświn is supplied by the River Radwa, carrying the excess of waters from Lake Rydzówka and Lake Węgielsztyńskie. The Ruda River, which drains meadow and wasteland areas, flows in from the south. Lake Oświn has its runoff in the northwest part. This is the River Oświnka, which flows into the River Borudinka, which is a tributary of the River Łyna.

Monitoring Sites and Sampling

The distribution of Oświn Lake water sampling sites is presented in Fig. 1. Water samples for sanitary and bacteriological tests were taken from 6 research stations. Stations 1- 4 were situated in different sites of the reservoir, while station no. 5 was in a bay, and station no. 6 was in the River Radwa tributary, supplying Lake Oświn. Due to the small depth of the reservoir under study, water samples were collected from a depth of 0.3 m directly to sterile glass bottles with a ground-in stopper. Water samples were brought to the laboratory at a temperature of 4°C and determinations were made within 4 hours after sampling.

Microbiological Studies

Microbiological studies comprised the following analyses:

- total number (CFU/1 ml) of bacteria on agar broth at 22^0C after 72 h incubation (TVC 22^0C);
- total number (CFU/1 ml) of bacteria on agar broth at 37^0C after 24 h incubation (TVC 37^0C);
- number (MPN/100 ml) of total coliforms (TC) on Eijkman medium (MERCK) at 37^0C after 48 h incubation;
- number (MPN/100 ml) of faecal coliforms (FC) on Eijkman medium (MERCK) at $44,5^0$C after 24 h incubation;
- number (MPN/100 ml) of faecal streptococci (FS) on Slanetz and Bartley medium with sodium azide and crystaline violet at 37^0C after 72 h incubation.

Total numbers of bacteria on agar broth at 22^0C and 37^0C were determined according to the methods generally used for the examination of drinking water. Total coliforms and faecal coliforms were determined using the most probable number method (MPN) based on sample solutions described in Standard Methods [1]. Positive results for the presence of coliforms were checked on Endo medium, in a fermentation-test tube sample on lauryl-tryptose broth and in preparations stained with Gram's method. Positive results for the presence of faecal sterptococci were checked on m-Enterococcus Agar. Typical colonies which developed on this medium were transferred to a broth medium and determinations were made of their growth potential at 44.5^0C at pH 9.6, in the presence of 6.5% NaCl and in milk with the addition of 0.01% methylene blue. Physiological NaCl solution was used as solvent. The most probable numbers of total coliforms, faecal coliforms and faecal sterptococci were obtained from MacCrady's tables published by Meynell, Meynell [10]. The results were recalculated to 1 (TVC 22^0C and TVC 37^0C) or 100 ml (TC, FC, FS) of water.

The results of the examination of the number of bacteriological indexes of the degree of contamination (TVC 22^0C, TVC 37^0C) and the sanitary state (TC, FC, FS) of

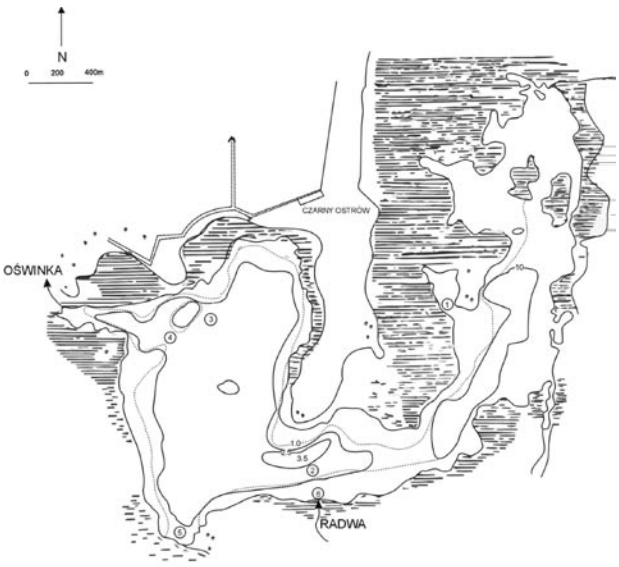

Fig. 1. Location sketch of lake Oświn.
1,2,3,4,5,6 - sampling sites.

the examined water samples of Lake Oświn referred to the criteria of the estimation of the degree of surface water purity presented in literature [3, 4, 7,8].

Results

The results of the investigations concerning the mean values and ranges of the presence of the number of TVC 22°C and the number of TVC 37°C per 1 ml of Lake Oświn water are presented in Fig. 2. The numbers of these bacteria ranged from several tens of CFU/1 ml to several thousands of CFU/1 ml of water depending on a research station. The lowest means of the numbers of both groups of microorganisms under study have been found out at station 5. The highest means of the number of TVC 22° were recorded at station 1, and the highest means of the number of TVC 37°C – at station 2.

The mean numbers and ranges of the occurrence of the sanitary state indicator bacteria (TC, FC, FS) per 100 ml of the investigated waters of Lake Oświn are presented in Fig. 3.

The number of TC ranged from 1 MPN/100 ml to 75,000MPN/100 ml depending on a research station. The lowest means of their number were recorded at station 5 (15 MPN/100 ml), and the highest at station 6 (33,000 MPN/100 ml).

The ranges of the occurrence of FC in the studied water samples were similar to those of the number of TC. However, they were not identified at stations 3 and 5. The highest means of the number of FC occurred at station 6.

In the water of Lake Oświn, the number of FS ranged from 1 MPN/100 ml at stations 2, 3 and 5 to 95,000 MPN/100 ml at station 1. The lowest means of their number were recorded at station (27 MPN/100 ml), and the highest at station 4 (6,040 MPN/100 ml).

Fig. 4 presents the faecal coliforms (FC): faecal streptococci (FS) numerical ratio expressed as a percentage. In 36.5% of examined lake water samples, this ratio was determined as higher than 4.0, as well as ranging from 0.7 to 4.0. In 27% of the samples it was lower than 0.7, not exceeding the value of 0.043 in 9% of the examined Oświn Lake water samples.

As regards the classification given by Cabejszek et al. [4], most of the examined water samples correspond to non-polluted or insignificantly polluted waters in terms of the number of pollution degree indicator bacteria (TVC

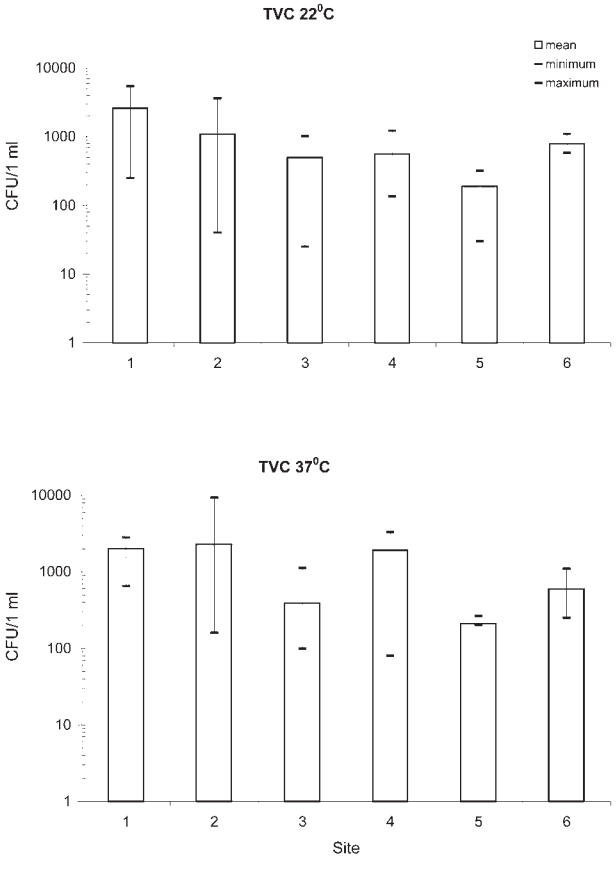

Fig. 2. Mean and range for the numbers of total viable counts at 22^0C (TVC 22^0C) and total viable count at 37^0C (TVC 37^0C) in the water of Lake Oświn.

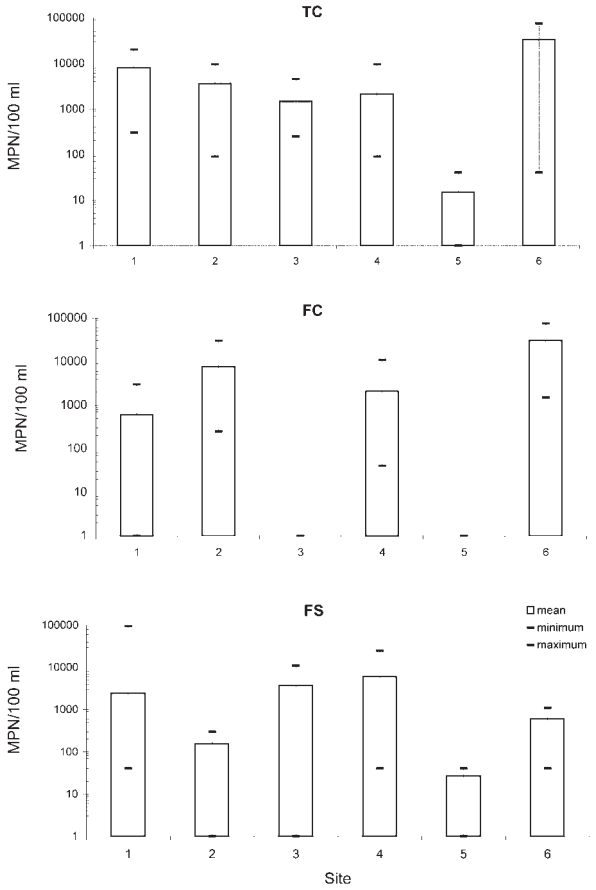

Fig. 3. Mean and range for the numbers of total coliforms (TC), faecal coliforms (FC) and faecal streptococci (FS) in the water of Lake Oświn.

22°C and TVC 37°C). On the other hand, the FC titre indicates waters with distinct or even high pollution (Table 1).

The classification proposed by Kavka [7], Kohl [8] modified by Albinger [3] indicates a very low, low or insignificant pollution of the examined waters of Lake Oświn with easily decomposable organic substances (Table 2).

Discussion

In the water of Lake Oświn, the occurence of particular pollution degrees (TVC 22°C and TVC37°C) and sanitary state (TC, FC, FS) bacteria was dependent on a research station. As a rule, the smallest numbers of investigated microorganisms, found at station 5 (in the bay), resulted from the morphometric features of this reservoir including its small depth. Various microorganism groups often move from water to water deposits and from water deposits to water [2, 9, 11, 14, 15]. Higher numbers of TC and FC found out in the subsidiary water may indicate a possibility of polluting this reservoir by the Radwa River. Such point source pollution surface water reservoirs by tributary watercourses are known from literature [9, 13, 15].

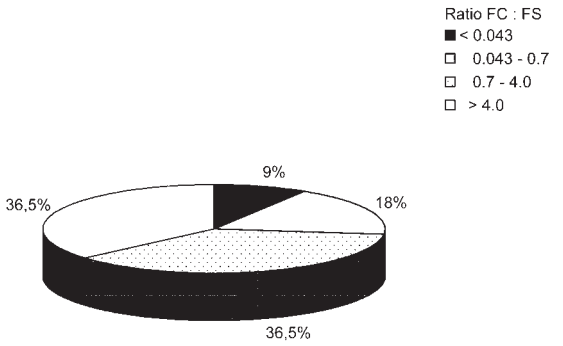

Fig. 4. Percentage distribution of values of ratio FC : FS in the water of Lake Oświn.

As regards the standards proposed by Cabejszek et al. [4] and on the basis of the numbers of the pollution degree indicator bacteria (TVC 22°C and TVC37°C), the examined waters can be regarded as non-polluted, insignificantly polluted or distinctly polluted. On the other hand, as regards the results concerning the FC titre, a distinct or even heavy pollution of this reservoir can be concluded. Such a sanitary and bacteriological state of the waters under study is confirmed by the classification proposed by Kavka [7] and Kohl [8] modified by Albinger [3]. According to this, the examined waters of Lake Oświn can, in principle, be regarded as polluted by easily decomposable organic substances to a very low, low or insignificant degree (TVC 22°C). On the other hand, the degree of pollution by faecal substance (FC) varied from very low to high, depending on a research station.

The presence of over 100 MPN of FC and FS per 100 ml of the lake water in 40% of the examined water samples allows determination of the character of Lake Oświn pollution. According to Geldreich [5], the FC:FS numerical ratio indicates the type and origin of pollution. In about 27% of the examined water samples it was less than 0.7, which indicates pollution of animal origin. In 36.5% of the examined water samples, this ratio ranged from 0.7 to 4.0 and suggested mixed pollution. It was also in 36.5% of water samples that the FC:FS numerical ratio was higher than 4.0, which indicates pollution of human origin.

Table 1. Analysis of bacteriological water quality of Lake Oświn using criteria given by Cabejszek et al. [4]. Sample percentage per class. A – unpolluted. B – insignificantly polluted. C – distincly polluted. D – heavilly polluted.

Water quality criteria		Water quality	Site[1]					
Microorganisms	Number of bacteria		1	2	3	4	5	6
TVC 22^0C [2] (CFU/1 ml)	≤ 300	A	33.3	33.3	50.0	16.7	66.7	0.0
	300-5,000	B	50.0	66.7	50.0	83.3	33.3	100.0
	5,000-10,000	C	16.7	0.0	0.0	0.0	0.0	0.0
	> 10,000	D	0.0	0.0	0.0	0.0	0.0	0.0
			(6) [5]	(6)	(6)	(6)	(3)	(3)
TVC 37^0C [3] (CFU/1 ml)	≤ 200	A	0.0	33.3	66.7	16.7	33.3	0.0
	200-1,000	B	16.7	33.3	33.3	0.0	66.7	66.7
	1,000-5,000	C	83.3	0.0	0.0	83.7	0.0	33.3
	> 5,000	D	0.0	33.4	0.0	0.0	0.0	0.0
			(6)	(6)	(6)	(6)	(3)	(3)
Coli titre [4]	> 1	A	33.3	0.0	0.0	33.3	0.0	0.0
	1-0.1	B	16.7	33.3	0.0	50.0	0.0	0.0
	0.1-0.01	C	16.7	50.0	0.0	0.0	0.0	33.3
	< 0.001	D	33.3	16.7	100.0	16.7	100.0	66.7
			(6)	(6)	(6)	(6)	(3)	(3)

[1] – See Figure 1; [2] – Total viable count at 22^0C after 72 h incubation (saprophytic bacteria); [3] – Total viable count at 37^0C after 24 h incubation; [4] – Faecal coli titre ; [5] – In brackets number of samples investigated

Table 2. Water quality evaluation of Oświn Lake according criteria given by Kavka [7] and Kohl [8] in Albinger's modification [3]. Sample percentage per class.

Criteria of water quality evaluation		Water quality [4]	Site[1]					
Microorganisms	Number of bacteria		1	2	3	4	5	6
TVC 22^{0}C [2] (CFU/1 ml)	≤ 500	1	33.3	50.0	50.0	50.0	100.0	0.0
	500-1,000	2	0.0	16.7	33.3	33.3	0.0	100.0
	1000-10,000	3	66.7	33.3	16.7	16.7	0.0	0.0
	10,000-50,000	4	0.0	0.0	0.0	0.0	0.0	0.0
	50,000-100,000	5	0.0	0.0	0.0	0.0	0.0	0.0
	100,000-750,000	6	0.0	0.0	0.0	0.0	0.0	0.0
	> 750,000	7	0.0	0.0	0.0	0.0	0.0	0.0
			(6) [5]	(6)	(6)	(6)	(3)	(3)
FC [3] (MPN/100 ml)	1-10	1	33.3	0.0	100.0	0.0	100.0	0.0
	10-100	2	33.3	0.0	0.0	33.3	0.0	0.0
	100-1,000	3	16.7	33.3	0.0	50.0	0.0	0.0
	1,000-5,000	4	16.7	33.3	0.0	0.0	0.0	33.3
	5,000-10,000	5	0.0	16.7	0.0	0.0	0.0	66.7
	10,000-100,000	6	0.0	16.7	0.0	16.7	0.0	0.0
	> 100,000	7	0.0	0.0	0.0	0.0	0.0	0.0
			(6)	(6)	(6)	(6)	(3)	(3)

[1] – See Figure 1; [2] – Total viable count at 22^{0}C after 72 h incubation (saprophytic bacteria); [3] – Number of faecal coliforms; [4] – Degree of loading with organic substances which can be well decomposed by bacteria (TVC 22^{0}C) 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 samples investigated.

Conclusions

1. The numbers of pollution degree (TVC 22°C and TVC 37°C) and sanitary state (TC, FC, FS) indicator bacteria varied in the examined samples of Oświn Lake waters depending on the research station. As a rule, its lowest numbers were recorded in the waters of the bay (station 5), and the highest in the waters of the River Radwa (station no. 6).
2. High numbers of faecal coliforms in most of the examined samples indicate high faecal pollution of the reservoir's waters.
3. The FC:FS ratio has shown that mixed excreta with a prevalence of human faecal pollution were the main cause of pollution of the examined waters of Lake Oświn.

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