Arch. Ryb. Pol.	Archives of Polish Fisheries	Vol. 8	Fasc. 1	75-93	2000

MICROBIOLOGICAL EVALUATION OF POND WATER DURING CARP AND IDE REARING

Izabella Zmysłowska, Dorota Lewandowska, Janusz Guziur

Warmia and Masuria University in Olsztyn

ABSTRACT. Common carp and ide were reared in polyculture from March to October 1995, in the Fish Farm Ostróda-Warlity. The fish ponds were supplied with water from Lake Szel g Wielki (599 ha) classified as vendace-type lake. Microbiological studies of pond water and bottom sediments and of lake water were carried out during fish rearing. Bacterial contamination, sanitary state of water, nitrogen-transforming microorganisms and fungi were studied at the background of thermal conditions, DO content and zooplankton abundance in the ponds.

Keywords: POND AND LAKE WATER, BOTTOM SEDIMENTS, BACTERIA, FUNGI, COMMON CARP, IDE

INTRODUCTION

Common carp is the main product of fish farming. Sometimes additional species are reared in polyculture with the carp. Polyculture improves fishery results as common carp alone is not able to utilize all food resources available in the ponds. Various food organisms are more efficiently utilized in polyculture. Additional fish species must be selected and their number calculated in such a way that they would not compete with common carp and reduce its growth (Stegman 1969). The following species may be reared with carp: tench, crucian carp, phytophagous fish, pike-perch, pike, and sometimes also wels, largemouth bass or rainbow trout (Guziur 1991, 1997).

The ide (*Leuciscus idus* L.), often reared in polyculture with common carp, is a riverine species, sometimes found also in flow-through lakes and dam reservoirs. It attains 80-100 cm and 6-8 kg, but the average size is 30-50 cm and 1-2 kg. Golden variety is sometimes reared in ponds, so-called golden orfe (*Leuciscus idus* var. *orpha* L.) (Guziur 1991). Young ide initially feed on phytoplankton and the larvae of ephemeropterans, caddis-flies and cladocerans. They consume mainly aquatic vegetation in the first and the second year of life, also zooplankton, with some addition of benthos, so they do not compete with adult carp (Guziur 1976, Brylińska 1986).

Non-consumed food and feces add nutrients to pond water, thereby accelerating eutrophication and promoting bacterial growth. Bacterial activity plays an important

role in nutrient cycling and energy flow in a water ecosystem and its trophic chain.

There are a lot of studies on microbiological issues in aquaculture systems (Schroeder 1978, Ram et al. 1982, Sugita et al. 1985, 1987, Fang et al. 1989, Jana and De 1990, Shiranee et al. 1993, Markosova and Jezek 1994, Niewolak and Tucholski 1995, Zmysłowska et al. 2000). The results usually indicate an important role of heterotrophic bacteria in various systems of fish culture. These bacteria are involved in organic matter decomposition, thus also in nutrient recycling and fish feeding. From an ecological point of view, microorganisms involved in nitrogen transformations are especially important,. Another important issue of fish culture is the sanitary state of water (Geldreich 1976).

The present study was undertaken to evaluate microbiological contamination (total number of bacteria growing in 20 and 37°C, and of fungi), sanitary state (total number of coliforms, fecal coliforms, fecal Streptococci, *Clostridium perfringens*, and *Pseudomonas aeruginosa*), and development of nitrogen-transforming microorganisms in two ponds in which carp and ide were reared in polyculture. Water analyses of Szeląg Wielki Lake were also performed. Water from this lake was used to supply the fish ponds.

MATERIAL AND METHODS

1. **Sampling site**: The study was carried out in the Ostróda-Warlity Fish Farm Ltd. (Warmia and Masuria District), from March to October 1995. Two ponds were used of similar area: No 12 of 0.71 ha, and No 26-P of 0.68 ha, and the mean depth 1.2 m. The ponds were drainable and could be dried completely. They were well cultivated, weed-free, with independent water supply. Water of purity class I was pumped from the nearby vendace-type lake (α-mesotrophic) Szeląg Wielki (599 ha).
2. **Experimental design and materials**. The fish: common carp K_1 (*Cyprinus carpio* L.) and ide J_1 (*Leuciscus idus* L.) fingerlings were reared in polyculture in two ponds having different stock density. Pond No 12 was stocked with 2000 ind. ha^{-1} of carp and 450 ind. ha^{-1} of ide, and pond No 26-P with 1000 ind. ha^{-1} of carp and 150 ind. ha^{-1} of ide. Individual body weight at the time of the first (12 April) and the second (16 May) stocking was 60 g · ind. for carp and 42 g · ind. for ide. At first the fish were preyed on by the cormorants. The fish were fed grain (barley or corn) 3 times a week. Microbiological analyses of water were performed monthly during fish

TABLE 1

Mocro-organism groups and conditions of their development

Microorganisms	Medium and incubation	References
1. Heterotrophic bacteria (TVC 20°C)	Standard agar (Bacto-agar DIFCO) 20°C / 72 h	Burbianka, Pliszka 1983
2. Heterotrophic bacteria (TVC 37°C)	Standard agar (Bacto-agar DIFCO) 37°C / 48 h	Burbianka, Pliszka 1983
3. Coliforms (TC)	Eijkman (MERCK) 37°C / 48 h	Burbianka, Pliszka 1983
4. Fecal coliforms (FC)	Eijkman (MERCK) 44.5°C / 24 h	Burbianka, Pliszka 1983
5. Fecal Streptococci (FS)	Enterococci broth (DIFCO) 37°C / 72 h	Pawlaczyk-Szpilowa 1980
6. Sporaceous anaerobes (*C. perfringens*)	Wilson-Blair 37°C / 18 h samples pasteurized for 10 min. (80°C) before inoculation	Przesmycki 1953
7. Proteolytic bacteria	Frazier's gelatin medium 20°C / 48 h	Burbianka, Pliszka 1983
8. Ammonifying bacteria	Broth-agar with 3% peptone 25°C / 72 h	Rodina 1968
9. Nitrifying bacteria of I phase	Vinogradski's medium 28-30°C / 14 days	Rodina 1968
10. Nitrifying bacteria of II phase	Vinogradski's medium 28-30°C / 14 days	Rodina 1968
11. Denitrifying bacteria	Giltay's medium 25°C / 7 days	Rodina 1968
12. Azotobacter sp.	Fiodorov's medium 25°C / 3 days	Rodina 1968
13. Clostridium pasteurianum	Vinogradski's medium 25-28°C / 7 days	Rodina 1968
14. Pseudomonas fluorescens	Kinga B 25°C / 72 h	Burbianka, Pliszka 1983
15. Pseudomonas aeruginosa	Kinga A 42°C / 48 h	Burbianka, Pliszka 1983
16. Aeromonas sp.	mA 37°C / 48 h	Rippey, Cabelli 1979
17. Fungi	Sabouraund (BIOMED) 28°C / 7 days	Pawlaczyk-Szpilowa 1980

In points 1, 2, 6, 7, 8, 12, 14, 15, 16, 17 – colony-forming units (CFU) per 1 ml of water or 1 g of bottom sediment were calculated.

In points 3, 4, 5, 9, 10, 11, 13 – the most probable number (MPN) per 100 ml of water or 100 g of bottom sediment was determined.

rearing, and water temperature, pH, DO content and zooplankton abundance were evaluated. The fish were measured and weighed in spring, in summer and after their harvest in august to calculate production indices.

3. **Sampling**. Water was sampled at the depth of 0.3 m. from Szeląg Wielki Lake and the two ponds (No 12 and 26-P) on March 20, May 10, and then monthly until October 10, 1995, at the site of fish sampling. Water samples were taken to sterile glass bottles of 200 cm^3.

   Bottom sediments were sampled once, on Oct. 10, 1995, from surface bottom layer (5 cm) of the two ponds using Kajak's sampler. Samples were transferred into sterile glass jars.

4. **Microbiological analyses.** Quantitative microbiological analyses were performed of lake and pond water using 0.85% physiological NaCl solution to dilute the samples.

   Sediment samples were weighed, diluted 10 times with 0.85% physiological NaCl solution, shaken for 10 minutes and diluted again.

Each analysis involved quantitative evaluation of various physiological groups, genera and species of micro-organisms cultured on appropriate media at optimum temperatures and for the required time, according the scheme shown in Tab. 1 and methods reported in the references.

Inoculations were made in three replicates. In the case of quantitative analyses carried out using plate method the colonies were counted and recalculated for colony-forming units (CFU) per 1 ml of water or 1 g of bottom sediment. The most probable number (MPN) of bacteria was determined in three tube sets for each dilution. MPN values were read from McCrady's tables after incubation of the cultures, and recalculated per 100 ml of water or 100 g of sediment (Meynell and Meynell 1970).

To identify the species of bacteria (*P. fluorescens*, *P. aeruginosa*), the colonies were isolated from selective media for further analyses: Gram staining, cytochrome oxidase test, motility test, glucose oxidation on Hugh-Leifson's medium, **TTC** reduction, pigment production, and other tests, according to Shewan et al. (1960).

RESULTS

The results of microbiological analyses of water and bottom sediments from the two ponds and Szeląg Wielki Lake, collected from March 10 to October 10, are shown in 10 semilogarithmic scale graphs, and in two tables (tab. 2 and 3).

TABLE 2

Numbers of selected groups and species of bacteria in pond and lake water

Date 1995	Site	CFU per 1 ml of water			MPN per 100 ml of water	
		Pseudomonas fluorescens	*Pseudomonas aeruginosa*	Aeromonas sp.	Phase I nitrifying bacteria	Phase II nitrifying bacteria
20.03	pond 12	65	0	0	0	0
	pond 26-P	53	0	0	0	0
	L. Szeląg W.	7	0	0	0	40
10.05	pond 12	31	1	0	9	40
	pond 26-P	32	0	0	0	110
	L. Szeląg W.	20	0	0	25	70
10.06	pond 12	80	0	37	0	4
	pond 26-P	28	0	11	0	0
	L. Szeląg W.	1	0	3	0	0
10.07	pond 12	6	0	0	25	4
	pond 26-P	21	0	0	4	40
	L. Szeląg W.	69	0	0	0	40
10.08	pond 12	5	0	0	4	40
	pond 26-P	10	0	0	40	95
	L. Szeląg W.	10	0	0	40	40
10.09	pond 12	2	2	0	4	0
	pond 26-P	5	0	0	0	0
	L. Szeląg W.	2	0	0	4	0
10.10	pond 12	29	0	0	40	0
	pond 26-P	3	0	0	9	0
	L. Szeląg W.	32	0	0	9	0

No Clostridium perfringens and Clostridium pasteurianum were found

WATER

Numbers of bacteria determined on standard agar after 72 h in 20°C (TVC 20°C) ranged from 370 to 3500 in the pond No 12, from 185 to 950 in the pond 26-P, and from 125 to 2000 in 1 ml of water in Szeląg Wielki Lake (Fig. 1).

Numbers of bacteria growing on standard agar for 24 h in 37 ^{o}C (TVC 37 ^{o}C) were lower and less variable: 10-480 in the pond No. 12, 7-110 in the pond 26-P, and 4-85 in 1 ml of water of Szeląg Wielki Lake (Fig. 2).

Dynamics of the most probable number (MPN) of coliforms (TC) is shown in Fig. 3. The curves for the pond 12 and Szeląg Wielki Lake are similar. MPN values were, however, higher in the pond 12, ranging from 3 (May) to 450 (October), than in the lake, where they ranged from 1 to 250 per 100 ml of water. The highest values of MPN

TABLE 3

Numbers of bacteria of various physiological groups and species in bottom sediments of the ponds (Oct. 10, 1995)

Microorganisms	Units	10^3 CFU 1 g^{-1} lub 10^3 MPN 100 g^{-1}	
		pond 12	pond 26-P
1. Bacteria TVC 20 °C	CFU	240	420
2. Bacteria TVC 37 °C	CFU	41	180
3. TC	MPN	25	110
4. FC	MPN	4.5	9.5
5. FS	MPN	25	4.5
6. Proteolytic bacteria	CFU		
7. Ammonifying bacteria	CFU	130	390
8. Phase I nitrifying bacteria	MPN	2	2.5
9. Phase II nitrifying bacteria	MPN	0	0.4
10. Denitrifying bacteria	MPN	9.5	1.5
11. Azotobacter sp.	CFU	0	0.15
12. *Clostridium pasteurianum*	MPN	0.9	2.5
13. *Pseudomonas fluorescens*	CFU	0.4	0
14.*Pseudomonas aeruginosa*	CFU	0.01	0
15. Aeromonas sp.	CFU	0.01	0.25
16. *Clostridium perfringens*	CFU	0.15	0.04
17. Fungi	CFU	160	370

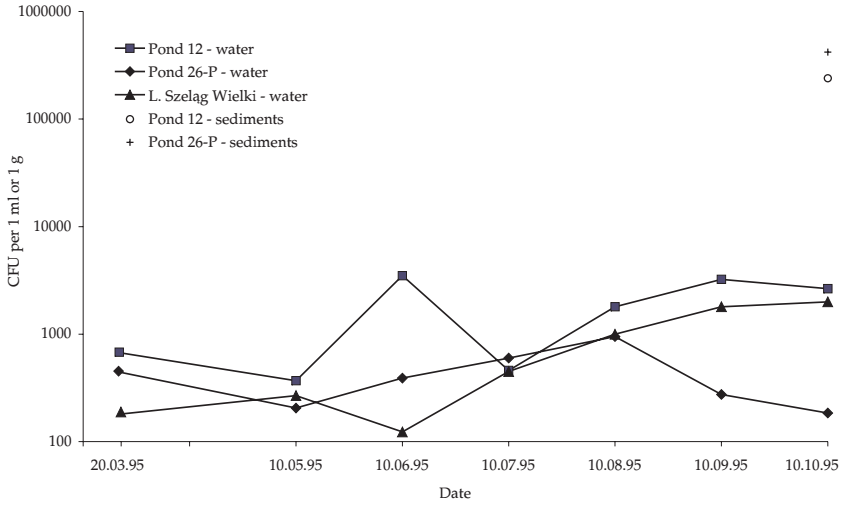

Fig. 1. Dynamics of bacteria grown on standard agar in 20°C (TVC 20°C) per 1 ml of water or 1 g of bottom sediments.

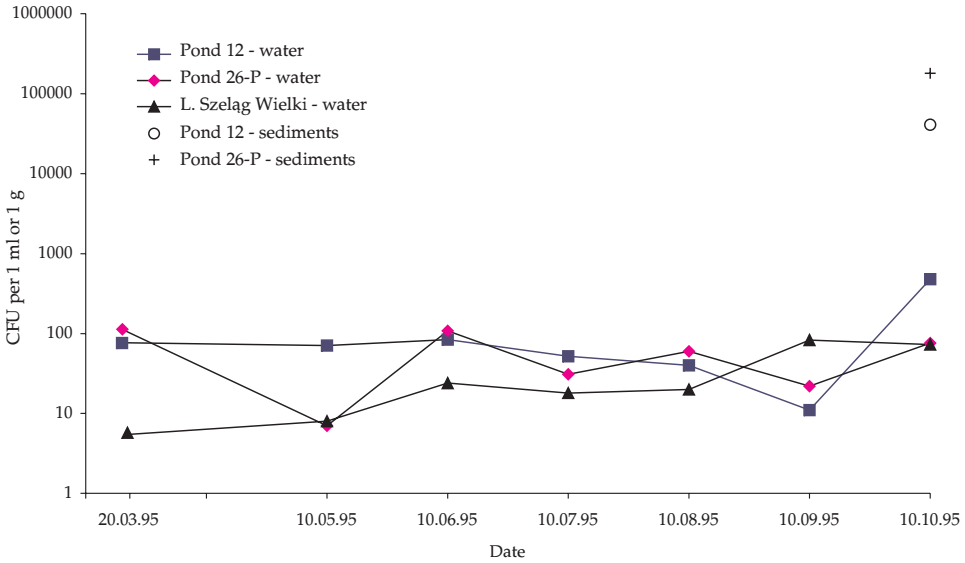

Fig. 2. Dynamics of bacteria grown on standard agar in 37°C (TVC 37°C) per 1 ml of water or 1 g of bottom sediments.

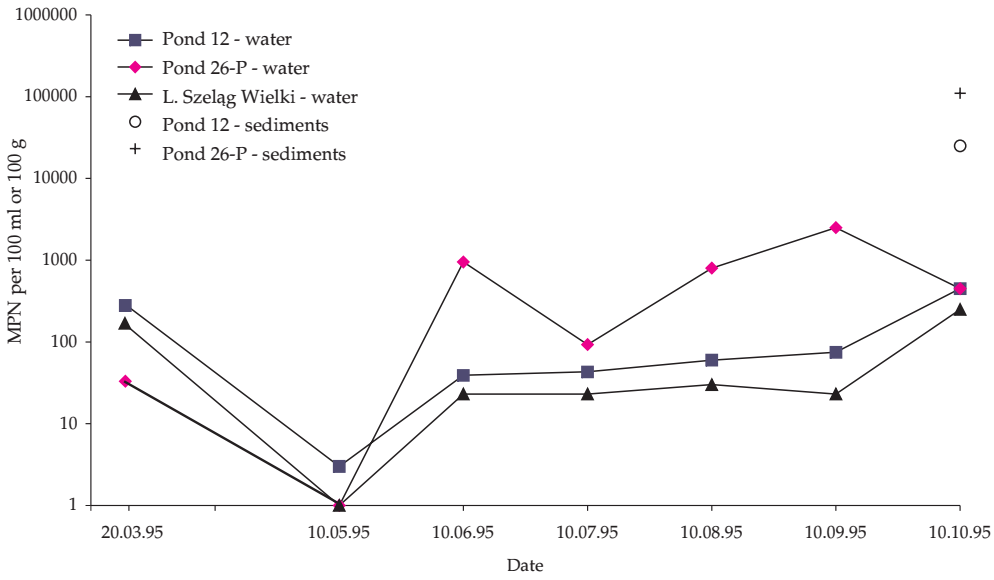

Fig. 3. Dynamics of the most probable number (MPN) of total coliforms (TC) per 100 ml of water or 100 g of bottom sediments.

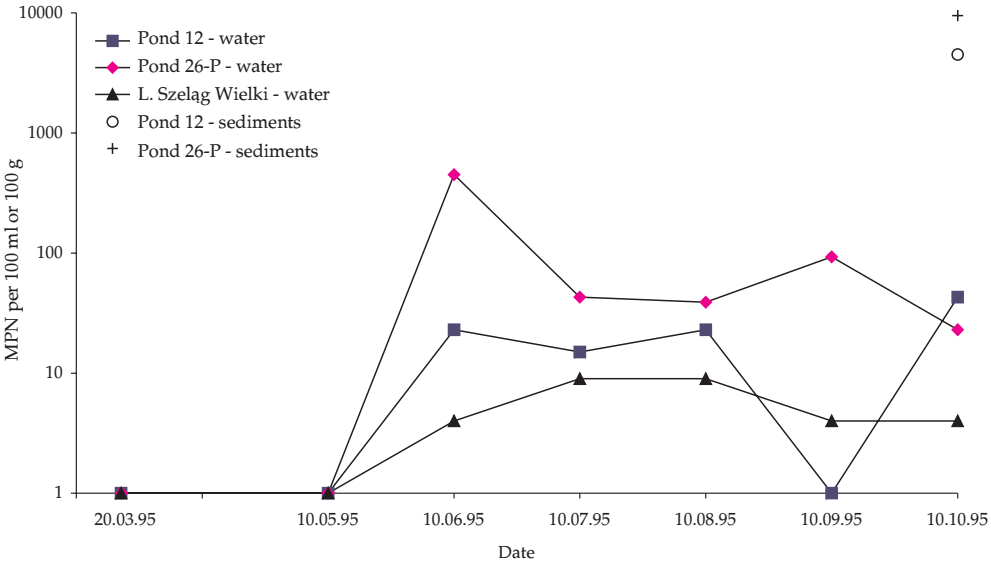

Fig. 4. Dynamics of the most probable number (MPN) of fecal coliforms (FC) per 100 ml of water or 100 g of bottom sediments.

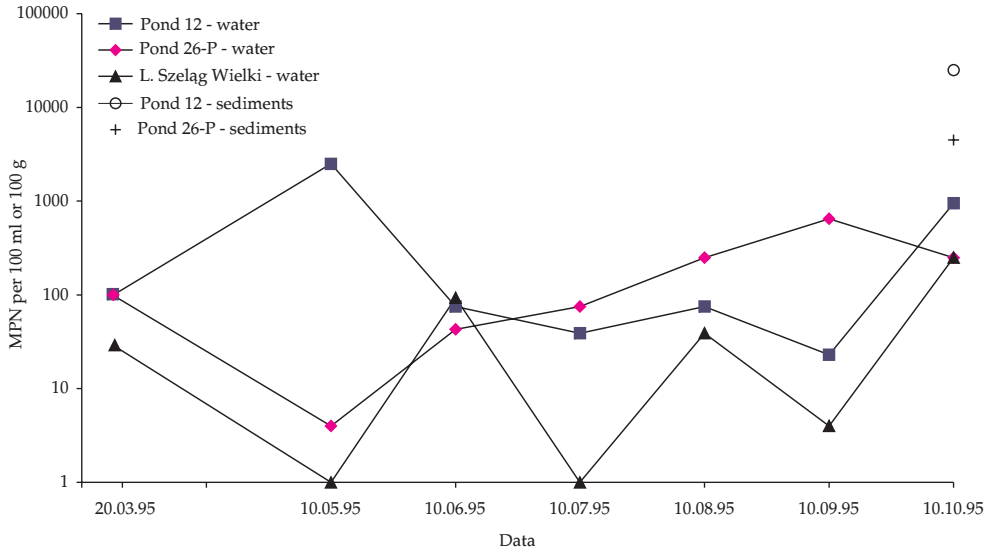

Fig. 5. Dynamics of the most probable number (MPN) of fecal Streptococci (FS) per 100 ml of water or 100 g of bottom sediments.

were observed in the pond 26-P. They ranged from 1 to 2500 cells per 100 ml of water, with the minimum also in May, and the peak in September.

The lowest MPN for fecal coliforms (FC) per 100 ml of water (Fig. 4) occurred in Szeląg Wielki Lake, and the highest in pond 26-P. Minimum values (1 cell per 100 ml of water) were observed in March and May, and in the pond No. 12 - also in September. Peak values were noted in June in the pond 26-P (450), in October in the pond No. 12 (43), and in July and September in Lake Szeląg Wielki (10 cells per 100 ml of water).

MPN for fecal Streptococci (FS) (Fig. 5) showed considerable and irregular fluctuations throughout the experiment. The lowest and the least variable numbers of fecal Streptococci were noted in Szeląg Wielki Lake (1-250), while in the pond 26-P they ranged from 4 to 650, and in the pond No. 12 from 23 to 2500 in 100 ml of water.

The density range of proteolytic bacteria (Fig. 6) was the widest in Szeląg Wielki Lake – from 1 to 2000 colonies in 1 ml of water. Their number fluctuated within 35-1700 in 1 ml in pond No. 12, and from 15 to 100 cells in 1 ml of water in pond 26-P.

Numbers of ammonifying bacteria varied slightly over the experimental season (Fig. 7). The smallest changes were observed in pond 26-P: from 100 to 500 colonies in 1 ml of water. Numbers of these microorganisms ranged from 310 to 3000 in pond No. 12, and from 45 to 2040 in 1 ml in Szeląg Wielki Lake, showing a distinct minimum in October.

Dynamics of the MPN of denitrifying bacteria is shown in Fig. 8. The lowest values of this parameter were noted in Szeląg Wielki Lake (4000-25000 in 100 ml of water). Similar changes took place in pond 26-P, the values were, however, higher than in the lake (7500-45000 in 100 ml of water). The highest numbers of denitrifying bacteria and their widest ranges were observed in pond No. 12 (9500-140000 in 100 ml of water).

Numbers of Azotobacter sp. (Fig. 9) in pond 26-P varied from 10 to 60 in 1 ml. Similar fluctuations but higher values were observed in pond No. 12 (1-123), and in Szeląg Wielki Lake (1-21 in 1 ml of water), with a distinct minimum in June and a peak in March.

Densities of fungi in water are shown in Fig. 10. The curves are similar for both ponds, but different for the lake. Numbers of fungi in pond No. 12 ranged from 57 to 440, in pond 26-P from 63 to465, and in the lake from 18 to 670 in 1 ml of water.

Densities of some bacterial groups and species in water of the two ponds and Lake Szeląg Wielki are shown in Table 2. *Pseudomonas fluorescens* were present in all samples: 2-80 in pond No. 12, 3-53 in pond 26-P, and 2-69 per 1 ml in Szeląg Wielki Lake. Single cells of *Pseudomonas aeruginosa* were observed only in May and

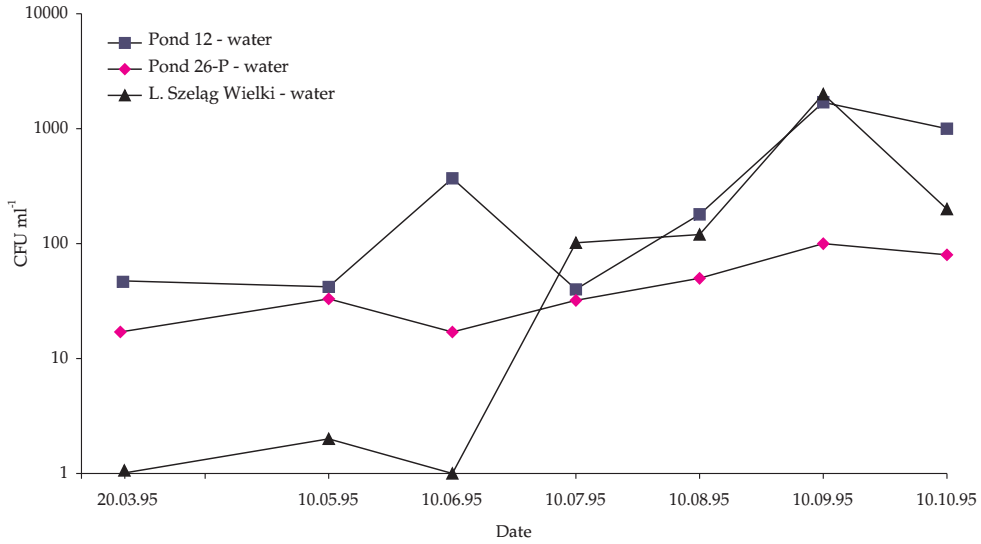

Fig. 6. Changes of the density of proteolytic bacteria per 1 ml of water.

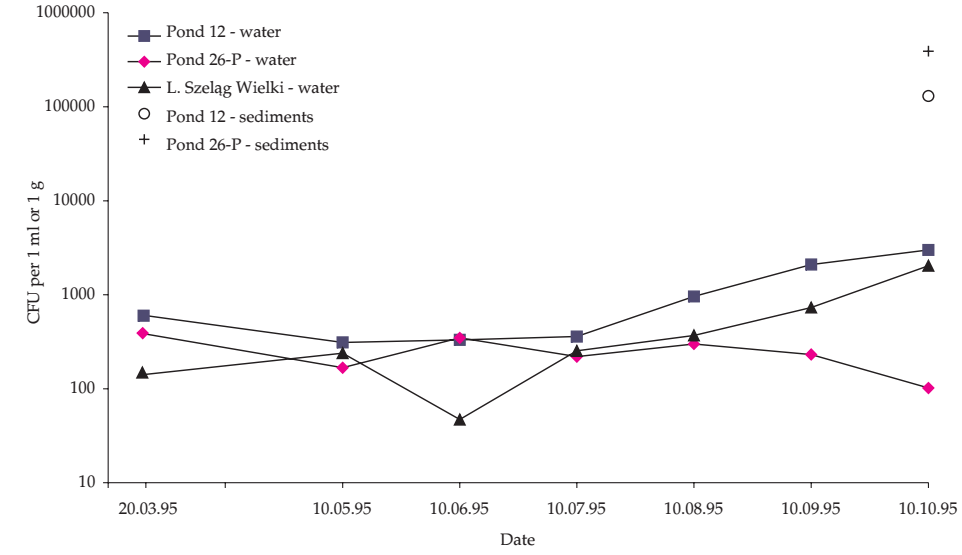

Fig. 7. Changes of the density of ammonifying bacteria per 1 ml of water or 1 g of bottom sediments.

September in pond No. 12, and Aeromonas sp. in the density of 3-37 cells per 1 ml of water were found in June. No sporaceous anaerobic *Clostridium perfringens* or *Clostridium pasteurianum* were noted in any sample, thus no data are shown. No phase I nitrifying bacteria were observed in March and June, and phase II ones - in

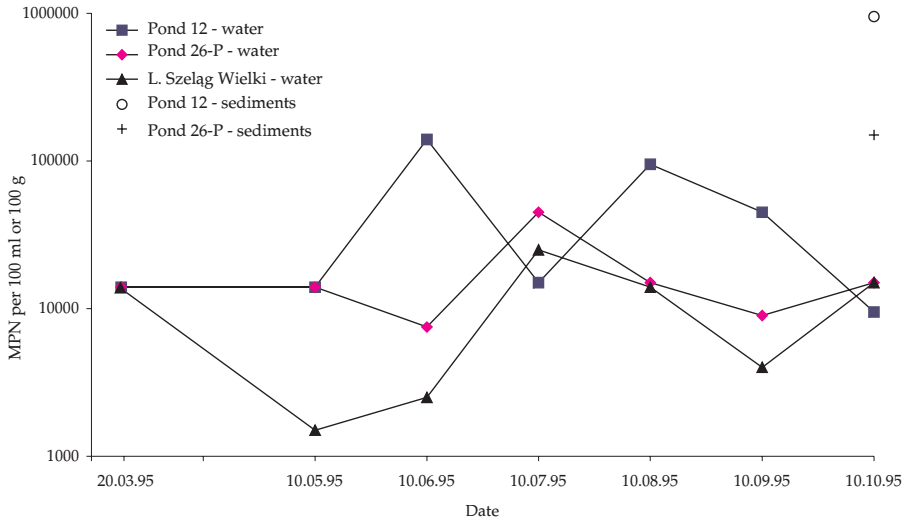

Fig. 8. Dynamics of the most probable number (MPN) of denitrifying bacteria per 100 ml of water or 100 g of bottom sediments.

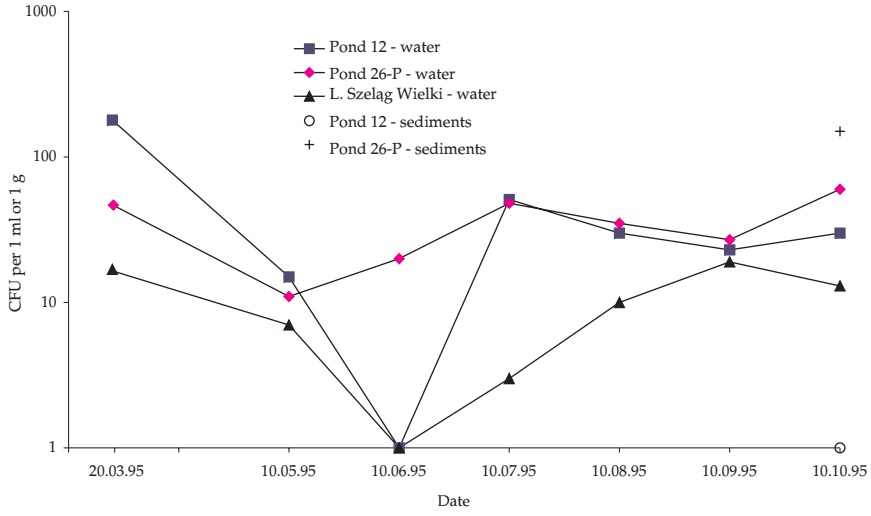

Fig. 9. Changes of the density of *Azotobacter sp.* per 1 ml of water or 1 g of bottom sediments.

September and October. In other months the MPN of phase I bacteria ranged from 4 to 40, and of phase II – from 4 to 110 in 100 ml of water.

Dynamics of temperature, DO content in the water, and pH are shown in Tab. 5. Environmental conditions were favorable for the two warm water fish species cultured.

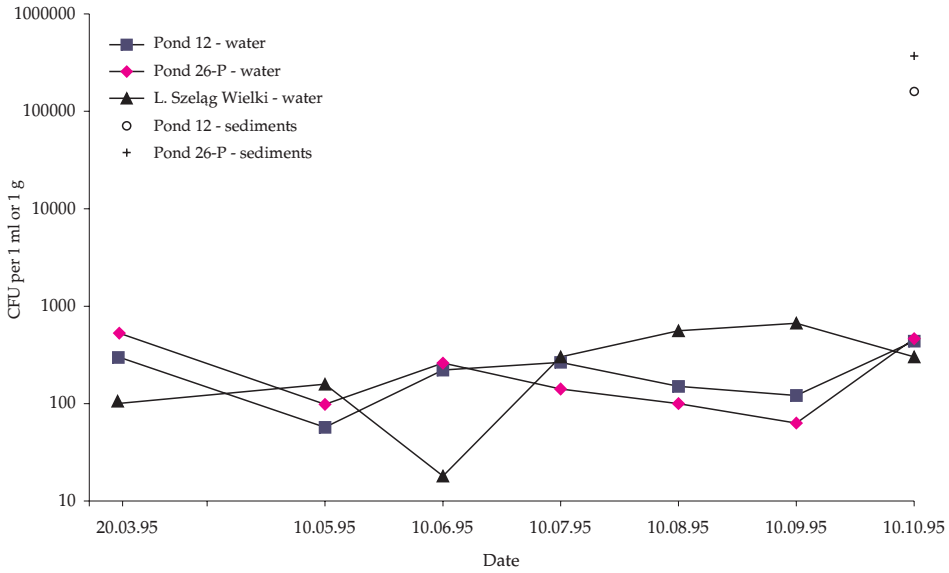

Fig. 10. Changes of the density of fungi per 1 ml of water or 1 g of bottom sediments.

The average zooplankton biomass (Fig. 11) was lower in pond 26-P (9.98 mg dm^{-3}) compared to pond No. 12 (22.95 mg dm^{-3}) from March to October 1995.

BOTTOM SEDIMENTS

Abundance of various physiological groups and species of bacteria in the bottom sediments of the ponds and Szeląg Wielki Lake in October 1995 is shown in Tab. 3. Some results are also shown in Figs. 1-10 (except Fig. 6) to compare with the values obtained for water samples. From among all bacterial groups, microorganisms grown

TABLE 4

Stock densities and production of common carp and ide in polyculture ponds in 1995 (per 1 ha)

Pond		Stocking				Harvest				Survival*		Ind. weight increment		In this ide (kg ha^{-1})	
		Carp (K_1)		Ide (J_1)		Carp (K_2)		Ide (J_2)							
No.	ha	ind.	g $ind.^{-1}$	ind.	g $ind.^{-1}$	ind.	g $nd.^{-1}$	ind.	g ind^{-1}	K_2	J_2	K_2	J_2	kg ha^{-1} (index)	Total fish production
		per 1 ha								P (%)		g ind^{-1}			
12	0.71	2000*	60	450	42	1044	245	288	106	52.2	64	145	64	147 (100)	12 (8.2 %)
26-P**	0.68	1000*	60	150	42	246	1650	43	226	24.6	28.7	1590	184	349 (237)	3 (0.9 %)

* *Second stocking - second half of May 1995*
** *26-P - Pond near the lake*

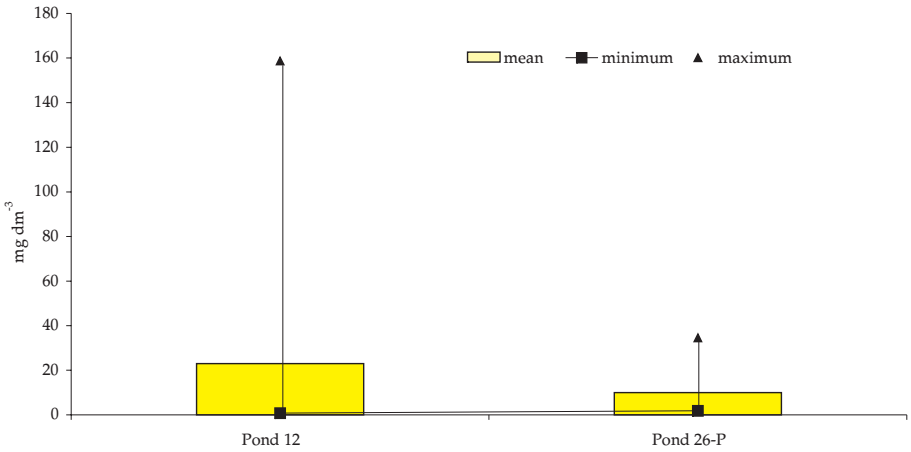

Fig. 11. Average zooplankton abundance in pond No. 12 and 26-P over March-October 1995 period.

TABLE 5

DO content, water temperature and pH in the ponds and Szeląg Wielki Lake.

Site	Index	Sampling period		
		spring (III - V)	summer (VI - VIII)	autumn (IX - X)
Lake Szeląg Wielki	oxygen (mg dm^{-3})	12.8 - 15.7	9.6 - 10.7	13.6 - 14.4
	temperature (°C)	5.5 - 9.9	19.7 - 22.0	15.8 - 21.8
	pH	8.0 - 8.4	8.55 - 9.1	8.5 - 9.4
Pond No. 12	oxygen (mg dm^{-3})	11.4 - 13.6	8.5 - 11.6	6.4 - 12.2
	temperature (°C)	6.3 -13.7	20.4 - 24.4	15.8 - 19.7
	pH	8.15 - 8.55	8.0 - 8.6	8.0 - 9.5
Pond No. 26-P	oxygen (mg dm^{-3})	12.9 - 13.4	10.4 - 11.2	11.5 - 14.4
	temperature (°C)	5.6 - 13.7	20.8 - 24.0	15.3 - 19.5
	pH	8.0 - 8.5	8.55 - 9.45	8.6 - 9.4

on standard agar for 72 h in 20°C (TVC 20°C) were the most numerous: 2.4 x 10^5 in pond No. 12, and 4.2 x 10^5 per 1 g of the sediment in pond 26-P. Ammonifying bacteria were slightly less numerous: 1.3 x 10^5 in pond No. 12, and 3.9 x 10^5 in pond 26-P. Numbers of bacteria cultured on standard agar in 37°C (TVC 37°C) were 4.1 x 10^4 and 1.8 x 10^5 per 1 g of the sediments respectively.

Fungi were less abundant than bacteria and their densities were: 1.6 x 10^3 in pond No. 12, and 3.7 x 10^3 per 1 g of the sediment in pond 26-P.

Samples from pond No. 12 contained no phase II nitrifying bacteria or Azotobacter sp., and no *P. fluorescens* or *P. aeruginosa* were found in the sediments from pond 26-P. Majority of the microorganisms were more numerous in pond 26-P than in pond No. 12.

Numbers of microorganisms were also from 10 to 2000 fold higher in the sediments than in water (Fig. 1-10), except for Azotobacter sp., found in very low numbers (1 cell per 1 g of the sediments) in pond No. 12, and 150 cells in pond 26-P.

DISCUSSION

Microbiological state of fish ponds depends on many factors, mainly on organic matter content (authochthonic and allochthonic), water temperature, pH, DO content, zooplankton, phytoplankton, fish species and stock density. Heterotrophic bacteria play an important role in fish ponds (Fang et al. 1989, Jana and De 1990, Shiranee et al. 1993, Markosova and Jezek 1994).

The results of microbiological analyses of water carried out from March to October 1995 revealed differences among the two ponds, No. 12 and 26-P, and Lake Szeląg Wielki. More eutrophic pond No.12 contained higher numbers of bacteria, except sanitary indicators such as fecal coliforms (FC) or fecal Streptococci (FS), compared to pond 26-P. Pond No 12 showed also higher abundance of zooplankton (Fig. 11) which represented food resources for the fish, especially for ide. Despite higher productivity of this pond, fish growth rate was higher in pond 26-P, and so was fish production (+137%). Higher growth rate of the fish undoubtedly resulted from lower stock density in pond 26-P (it was even more reduced during the experiment by the cormorants). Stock density of carp was twice lower and of ide 3 times lower than in pond No. 12 (Tab. 4).

Fluctuations of bacterial densities are closely related to the abundance of zooplankton which feeds on bacteria. Zooplankton development is important for fish feeding on natural food in the ponds. Fish production reached 147 kg per ha in pond No. 12 and 348 kg per ha in pond 26-P (twice higher).

Bacteria grown on standard agar in 20°C (TVC 20°C) were most abundant among the microorganisms determined in water and bottom sediments, accompanied by proteolytic and ammonifying microorganisms decomposing proteins.

These bacteria are heterotrophic and their number is an indicator of organic matter content. Their development and heterotrophic activity are involved in transformation and mineralization of organic matter. The highest abundance of these

bacteria was usually noted in pond No. 12, indicating the highest trophy of this pond. The highest fluctuations within this group of bacteria were observed for proteolytic microorganisms, while bacteria grown on standard agar for 72 h in 20°C, and ammonifying microorganisms were less variable. This might have resulted from temperature increase in summer and periodic increase of sewage discharge to the lake. Proteolytic activity is usually fairly labile and depends on environmental conditions, such as temperature, DO and pH. Proteolytic bacteria are numerous in domestic sewage, thus their number is an indicator of biodegradable organic matter content. Ammonifying bacteria were more abundant than proteolytic ones; this might have been related to high rate of mineralization of nitrogen compounds, especially amino acids.

Microbiological transformations of nitrogen compounds in aquatic environment are related to mineralization of organic nitrogen compounds, so they involve development of the relevant bacteria.

Nitrifying bacteria participating in the processes of nitrification did not play an important role in the water bodies under study, and they were found irregularly. Nitrifying bacteria, as obligatory aerobes, are particularly sensitive to DO content fluctuations and other environmental conditions which might have limited their development.

The ponds were rich in denitrifying bacteria. Average numbers of 47500 in pond No. 12 and 17070 in pond 26-P were noted, while there were 10860 cells per 1 ml in the lake. These results indicate the highest content of organic matter in pond No. 12. Studies on nitrogen cycling in aquatic environments indicate that about 1/3 of nitrogen input from various sources is lost to the atmosphere due to denitrification. This process is particularly intensive in oxygen deficient, strongly polluted waters. Denitrifying bacteria participate under aerobic conditions in organic matter decomposition, and they usually occur in highly productive waters.

Atmospheric nitrogen binding by Azotobacter did not play an important role in the ponds, this being indicated by low numbers of these bacteria, usually under 100 cells per 1 ml of water.

P. fluorescens is commonly found in majority of surface waters, and densities of these bacteria are related to the abundance of organic matter. In the case of water bodies under study, all the samples contained these bacteria, and their numbers ranged from several to 80 cells in 1 ml of water. Common presence of *P. fluorescens* is related to their high adaptive abilities (Niewolak 1973, Gennari and Dragotto 1992).

Also fungi played an important role in the mineralization of organic matter. Their average numbers in all samples were high, both in the ponds (220 cells per 1 ml in pond No. 12, and 210 in 26-P) and the lake (300 cells per 1 ml). The fungi were about 1000 times more abundant in the sediments than in water. This may be explained by sedimentation of organic matter before it was decomposed in water (Donderski 1983).

Evaluation of organic contamination and sanitary state of the ponds and the lake according to various classification systems indicates low level of sanitary-bacteriological pollution of lake water supplying the ponds, and of pond water during fish rearing. Most of the samples showed the values of contamination indices typical of clean or slightly polluted water.

According to the classification by Cabejszek et al. (1960), numbers of bacteria grown on standard agar in 20°C were typical of non-polluted waters (under 300 cells per 1 ml) in 14% of the samples, and indicated slight pollution (300-5000 cells per 1 ml) in the remaining 86%. Numbers of bacteria cultured on standard agar in 37°C were typical of non-polluted waters (under 200 cells per 1 ml) in 95.5% of the samples, and only 4.5% of the samples showed values indicating slight contamination (200-1000 cells per 1 ml).

According to the classifications by Kohl (1975), and Kavka (1987) as modified by Albinger (1992), taking into consideration TVC 20°C and the number of fecal coliforms, 71.4% and 95.2% of samples from the ponds and Lake Szeląg Wielki were very slightly or slightly contaminated with easily decomposed organic matter and faecas.

Comparison of the results of the present study with the criteria of the U.S. Department of Interior Federal Water Pollution Control Administration (1968) as regards total number of coliforms and fecal coliforms reveals that 95.2% of the samples met the requirements of water used for recreational purposes.

Some authors showed correlations between the content of indicatory bacteria and *P. aeruginosa* (Vicente et al. 1991) and Aeromonas (Rhodes and Kator 1994), but only for sewage-contaminated environments. In the present study, single cells of *P. aeruginosa* were found in May and September in pond No.12. Aeromonas were observed occasionally and *C. perfringens* were absent. These results also confirm low level of pollution of the fish ponds and the lake.

Microbiological analysis of the bottom sediments of the two ponds in October showed higher densities of bacteria compared to water. This should be explained by sedimentation to the bottom of the bacteria developing on plant and animal detritus.

This is consistent with the data obtained by various authors (Zmysłowska 1987, Ram et al. 1982, Donderski 1988, Jana and De 1990). Micro-organisms were more abundant in the sediments of pond 26-P than pond No. 12 (except FS), contrary to the results obtained for water. This suggests higher development rate of the micro-organisms in water of pond No. 12 which contained more organic matter. This resulted in reduced sedimentation of non-mineralized particles to the bottom. In the case of pond 26-P, organic matter decomposition in water was slower, the particles sunk, and bacteria developed at the bottom.

CONCLUSIONS

1. Pond No 12 was more productive than pond 26-Pm, as indicated by higher numbers of heterotrophic micro-organisms, especially those cultured on standard agar in 20°C (TVC 20°C), proteolytic, and ammonifying bacteria, as well as higher zooplankton biomass.
2. Despite lower productivity (zooplankton abundance) compared to pond No. 12 and lower fish stock density, higher fish production was obtained in pond 26-P. Reduced common carp and ide survival, especially in pond 26-P, resulted from remote location of the pond and predation by cormorants.
3. Polyculture of common carp and ide did not cause any deterioration of microbiological water quality in the ponds compared to lake water used to supply them. This is true for all groups of microorganisms: indicators of organic pollution and sanitary state, nitrogen-transforming bacteria, and fungi.
4. The results of the present study indicate correct fishery management of polyculture ponds 12 and 26-P with common carp and ide in the Ostróda-Warlity Fish Farm.

REFERENCES

Albinger O. 1992 - Bacteriological investigations of water and sediment of the River Danube between stream kilometers 16 and 1868 from March, 3rd - 17th, 1988 - Arch. Hydrobiol. Suppl. 84 (Verff. Arbeitsgemeinschaft Donauforschung 8), 2-4: 115-130

Brylińska M.1986 - Ryby słodkowodne Polski - PWRiL, Warszawa

Burbianka M., Pliszka A. 1983 - Mikrobiologia żywności - PZWL, Warszawa

Cabejszek J., Kołaczkowski B., Łuczak J. 1960 - Projekt ujednoliconych wytycznych do klasyfikacji zanieczyszczeń wód powierzchniowych - Gaz, Woda i Technika sanit., 34: 18-21

Donderski W. 1983 - Tlenowe bakterie heterotroficzne jezior o różnej trofii - Wyd. UMK, Toruń

Donderski W. 1988 - Numbers and activity of proteolytic bacteria in the water and bottom sediments of two lakes of different trophy - AUNC Toruń, Prace limnologiczne 16: 39-49

European Economic Community (EEC). 1976 - Commission of the European Communities. Council Directive of 8 December 1975 concerning The Quality of Bathing Waters -Official Journal of the European Communities. Febr. 1976, 1-31. 7 February 1976

Fang X., Guo X., Wang J., Fang Y., Liu Z.1989 - The preliminary study of heterotrophic bacteria in a high yielding fish pond - J. Fish.China.13 (2): 101-107

Geldreich E. E. 1976 - Fecal coliform and fecal *Streptococcus* density relationship in waste discharge and receiving waters - Crit. Rev. Environ. Control. 6: 349-369

Gennari M., Dragotto F. 1992 - A study of the incidence of different fluorescent *Pseudomonas* species and biovars in the microflora of fresh and spoiled meat and fish, raw milk, cheese, soil and water - J. appl. Bacteriol., 72: 281-288

Guziur J.1976 - The feeding of two years old carp in rendace Lake Klawój - Ekol. Pol.24 (2): 211-235

Guziur J.1991 - Rybactwo w małych zbiornikach śródlądowych- PWRiL, Warszawa

Guziur J.1997 - Jaź - także ryba hodowlana - Materiały III Konferencji Hodowców Karpia w Kazimierzu D. 15-16.03.1997, 48-63

Jana B.B, De U.K. 1990 - Spatial and seasonal distribution of heterotrophic bacteria in pond water and sediments under different management practices - Int. Revueqes. Hydrobiol. 75(5): 639-648

Kavka G. 1987 - Die bakteriologische Wasserbeschaffenheit der sterreichischen Donau - Wasser und Abwasser, 31: 305-344

Kohl W. 1975 - Ber die Bedeutung bakteriologischen Untersuchungen fr die Beurteilung von Fliessgewssern, dargestelt am Beispiel der sterreichischen Donau - Arch. Hydrobiol. Suppl., 44 (Donaforschung), 392-461

Markošowa R., Ježek J. 1994 - Indicator bacteria and limnological parameters in fish ponds - Wat. Res. 28 (12): 2477-2485

Meynell G.G., Meynell E. 1970 - Theory and practice in experimental bacteriology - Cambridge Univ. Press.

Niewolak S. 1973 - Wzajemne stosunki grup mikroflory w jeziorach iławskich (bakterie - bakterie i bakterie - glony) - Rocz. Nauk roln. Olsztyn, 95-H-3:149-159

Niewolak S., Tucholski S. 1995 - Sanitary and bacteriological study of common carp reared in ponds supplied with biologically pretreated sewage - Arch. Ryb. Pol. 3(2): 203-215

Pawlaczyk-Szpilowa M. 1980 - Ćwiczenia z mikrobiologii wody i ścieków - PWN, Warszawa

Przesmycki F. 1953 - Zarys bakteriologii praktycznej - PZWL, Warszawa

Ram N.M., Zurr O., Avnimelech Y. 1982 - Microbial changes occurring at the sediment water interface in an intensively stocked and fed fish pond -Aquaculture 27 (1-4): 63-72

Rhodes M. W., Kator H. 1994 - Seasonal occurrence of mesophilic *Aeromonas* spp. as a function of biotype and water quality in temperate freshwater lakes - Wat. Res., 28: 2241-2251

Rippey S. R., Cabelli V. J. 1979 - Membrane filter procedure for enumeration of *Aeromonas hydrophila* in fresh waters - Appl. Environ. Microbiol. 38: 108-113

Rodina A. 1968 - Mikrobiologiczne metody badania wód - PWR i L, Warszawa

Schroeder G.J. 1978 - Autotrophic and heterotrophic production of microorganisms in intensely manured fish ponds and related fish yield - Aquaculture 14: 303-325

Shewan J. M., Hobbs G., Hodggkiss W. 1960 - A determinative scheme for the identification of certain genera of Gram-negative bacteria, with special reference to the Pseudomonadaceae - J.appl. Bacteriol., 23: 379-390

Shiranee P., Natarajan P., Dhevendran R. 1993 - The role of gut and sediment bacterial flora in the nutrition of cultured pearl spot (*Etroplus suratensis*, Bloch)- The Israeli Journal of Aquaculture - Bamidgeh 45 (2): 45-58

Stegman K.1969 - Obsady stawów karpiowych - PWRIL, Warszawa

Sugita H., Ushioka S., Kihara D., Deguchi Y. 1985 - Changes in the bacterial composition of water in a carp rearing tank - Aquaculture 44: 243-247

Sugita H., Oshma K., Fushino T., Deguchi Y. 1987 - Substrate specificity of heterotrophic bacteria in the water and sediment of a carp culture pond - Aquaculture 64: 39-46

U.S Department of Interior, Federal Water Pollution Control Administration. 1968 - Water Quality Criteria: Report of the Committee on Water Quality Criteria - U.S. Government Printing Office, Washington, 235

Vicente A., Codina J. C., Romero P. 1991 - Relationship between *Pseudomonas aeruginosa* and bacterial indicators in polluted natural waters - Wat. Sci. Tech., 24: 121-124

Zmysłowska I. 1987 - Wpływ usuwania wód hypolimnionu na mikroflorę bakteryjną Jeziora Kortowskiego - Acta Acad. Agricult. Tech. Olst., Protectio Aquarum et Piscatoria, 14, Suppl. C, Wyd. ART, Olsztyn

Zmysłowska I., Lewandowska D., Pimpicka E. 2000 - Microbiological studies of tench (*Tinca tinca* L) and water of Dgał Wielki Lake - Arch. Ryb. Pol., 8(1):107-117

STRESZCZENIE

STAN MIKROBIOLOGICZNY STAWÓW PODCZAS WYCHOWU KARPIA I JAZIA

W sezonie od marca do października 1995 r. w Gospodarstwie Rybackim Ostróda-Warlity przeprowadzono wspólny wychów jazia i karpia (polikultura). Stawy zasilano wodą z jeziora sielawowego (-mezotrof) Szeląg Wielki (559 ha). W trakcie wychowu ryb wykonano ilościowe badania mikrobiologiczne wody i osadów dennych dwóch stawów - nr 12 (0,7 ha) i nr 26-P (0,68 ha) oraz (porównawczo) wody jeziornej.

Wykonano siedem analiz mikrobiologicznych, które obejmowały oznaczenia: bakterii stanu zanieczyszczenia (TVC 20 °C i TVC 37 °C) i sanitarnego (TC, FC, FS, *Cl. perfringens*), drobnoustrojów biorących udział w przemianach związków azotu, *P. fluorescens*, *P. aeruginosa* i grzybów. Badania przeprowadzono w tle układów termiczno-tlenowych i zasobności stawów w zooplankton.

W okresie badawczym nie stwierdzono wyraźnego pogorszenia stanu mikrobiologicznego wody w obu stawach w stosunku do jakości wody jeziornej zasilającej je. Dotyczy to wszystkich badanych grup drobnoustrojów. Uzyskane wyniki badań świadczą o prawidłowo prowadzonym chowie ryb w polikulturze karpia z jaziem w stawie nr 12 i nr 26-P w Gospodarstwie Rybackim Ostróda-Warlity.

ADRESY AUTORÓW:

Dr hab. Izabella Zmysłowska prof. UWM
Dr Dorota Lewandowska
Uniwersytet Warmińsko-Mazurski w Olsztynie
Katedra Mikrobiologii Środowiskowej
10-957 Olsztyn-Kortowo

Prof. dr hab. Janusz Guziur
Uniwersytet Warmińsko-Mazurski w Olsztynie
Katedra Biologii i Hodowli Ryb
10-957 Olsztyn-Kortowo