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SANITARY AND BACTERIOLOGICAL EVALUATION OF WATER QUALITY DURING CAGE CULTURE OF WELS (*SILURUS GLANIS* L.) IN COOLING WATER

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ABSTRACT. The organic pollution and the sanitary state of cooling water used in intensive fish rearing were evaluated. The study was carried out at the cage station of the Olsztyn Fish Farm located in the northeastern Mazurian Lake District of Poland. The water was sampled monthly from April 1 to September 30, 1999. Quantitative analyses included a total count of the bacteria cultured on a common agar medium at 20 and 37°C (TVC 20°C and TVC 37°C), the total count of coliforms (TC) and fecal coliforms (FC), a count of fecal streptococci (FC) and spore-forming anaerobes (*Clostridium perfringens*). The results obtained indicate that cage fish culture did not considerably affect the bacteriological properties of the water.

Key words: SANITARY INDICES, ORGANIC POLLUTION INDICES, COOLING WATER, FISH REARING

INTRODUCTION

It is commonly believed that rearing fish in cages suspended in rivers or channels is extremely dangerous to aquatic ecosystems. The most abundant source of nitrogen and phosphorus water enrichment is considered to be fish feed. Moreover, some fish farms use heated (physically polluted) cooling water which is, in itself, dangerous to the environment as it causes changes in the natural habitat of aquatic organisms. This results in a shift from cold-water to warm-water species. Temperature also modifies trophic relationships.

Changes in the aquatic environment caused by fish rearing have been studied extensively (Sugita et al. 1985). Mamcarz and Lossow (1995) found that cage fish culture in a lake did not significantly affect the water chemistry. It was also observed that proper and responsible fish rearing had no adverse impact on the sanitary and bacteriological status of pond water (Zmysłowska et al. 2000).

Since the use of cooling water in fish culture is common and the possibility exists of transferring pathogenic bacteria to the surface water, it is important to obtain more information on the sanitary and bacteriological impact of commercial fish cage culture on the aquatic environment.

The aim of the current paper was to identify the impact of the feed of European wels *Silurus glanis* L. in the cooling water had on the sanitary state of the aquatic environment.

MATERIAL AND METHODS

The study was carried out at the cage station of the Olsztyn Fish Farm in the northeastern Mazurian Lake District of Poland. Fish with an initial body weight of 335 g were reared in cages that were suspended in the heated water discharge channel of the Ostrołęka electro-heating plant. The stocking density was 600 individuals per cage. A floating platform with 48 wire-mesh cages was used. Each cage had a total volume of 20 m³, a water volume of approximately 15 m³, and was equipped with an automatic feeder. The fish were fed to satiation with SAFIR Aller-Aqua feed (90%), KRAFT – Futter FM 44/20 (5%) and Aller-Aqua 37/12 (5%).

After it had been utilized for fisheries purposes, the heated water was discharged into the Narew River. Water samples were taken monthly from April 1 to September 30, 1999 at the following sites:

- I - the cooling water inlet;
- Ila and I Ib - from the cages at depths of 30 cm and 120 cm;
- III - downstream from the cages;
- IV – the Narew River at the cage culture water discharge site.

Surface samples from a depth of 0.3 m were taken directly into sterile glass bottles with cut glass stoppers. Water from the deeper layers was sampled using a Ruttner sampler.

The bacteriological analyses included:

1. evaluating the total count of bacteria cultured on a common agar medium at 20°C for 72 hours (TVC 20°C). The results were recalculated into colony forming units per 1 ml (CFU ml⁻¹);
2. evaluating the total count of bacteria cultured on a common agar medium at 37°C for 72 hours (TVC 37°C). The results were recalculated into CFU ml⁻¹;
3. evaluating the most probable total number of coliforms (TC) grown on an Eijkman medium for 48 hours at 37°C (MPN 100 ml⁻¹);
4. evaluating the most probable number of fecal coliforms (FC) grown on an Eijkman medium for 24 hours at 44.5°C (MPN 100 ml⁻¹);

5. evaluating the most probable number of fecal streptococci (FS) grown on a Burzyńska medium (Burbianka and Pliszka 1983) for 72 hours at 37°C (MPN 100 ml⁻¹);
6. evaluating the count of spore-forming sulfite-reducing anaerobes (*Clostridium perfringens*) grown on a Wilson-Blair medium for 18 hours at 37°C (after the sample had been pasteurized for 10 min at 80°C). The results were recalculated into CFU ml⁻¹ (Zmysłowska et al. 2000).

The results were statistically analyzed (Platt 1974) to determine the correlation between the counts of various groups of indicatory bacteria.

RESULTS

Considerable differences were found among the various sampling sites and dates in the numbers of indicatory bacteria in the cooling water.

The highest total TVC 20°C and TVC 37°C counts were observed at all the sites in summer. The values of TVC 20°C ranged from 60 CFU ml⁻¹ (June 30, 1999, site III) to 11,300 CFU ml⁻¹ (September 30, 1999, sites IIa and IV) (Fig. 1), and those of TVC 37°C from 40 CFU ml⁻¹ (April 1, 1999, site III) to 2,000 CFU ml⁻¹ (July 30, 1999, sites IIb and IV) (Fig. 2). The TVC 20°C and TVC 37°C counts at site I (cooling water inlet) were similar to those recorded at site III (downstream from the cage complex). Compared to sites I and III, the total counts of these bacteria were higher at sites II and IV. Statistical analysis revealed that there was a significant, positive correlation between the counts of both types of bacteria ($r = 0.651$; Table 1).

TABLE 1

Correlation coefficient values for the relationships between various groups of bacteria

Groups of bacteria	TVC 20°C	TVC 37°C	TC	FC	FS
TVC 20°C	•	0.651*	-0.141	-0.245	-0.317
TVC 37°C		•	0.043	-0.217	-0.182
TC			•	0.613*	0.531*
FC				•	0.306
FS					•

TVC 20°C – total count of bacteria grown on a common agar medium at 20°C

TVC 37°C – total count of bacteria grown on a common agar medium at 37°C

TC – total count of coliform bacteria

FC – count of fecal coliform bacteria

FS – count of fecal streptococci

* - statistically significant correlation coefficient values

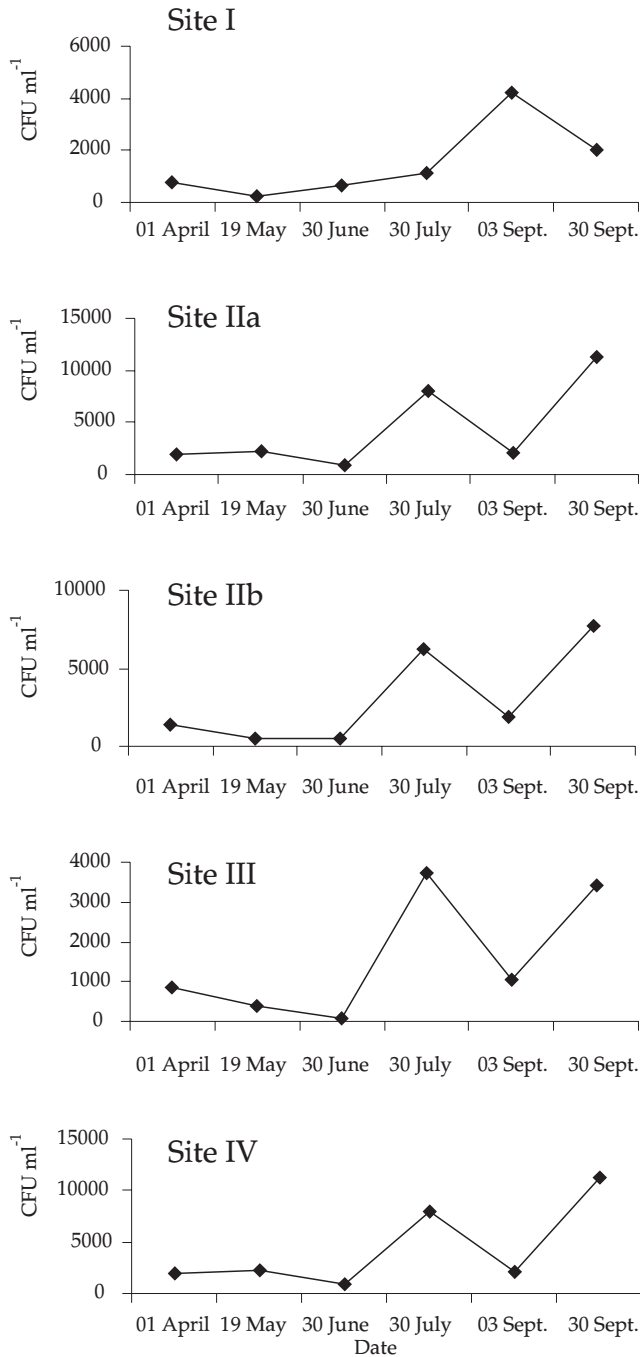


Fig. 1. Seasonal dynamics of TVC 20°C (CFU ml⁻¹) at various sampling sites.

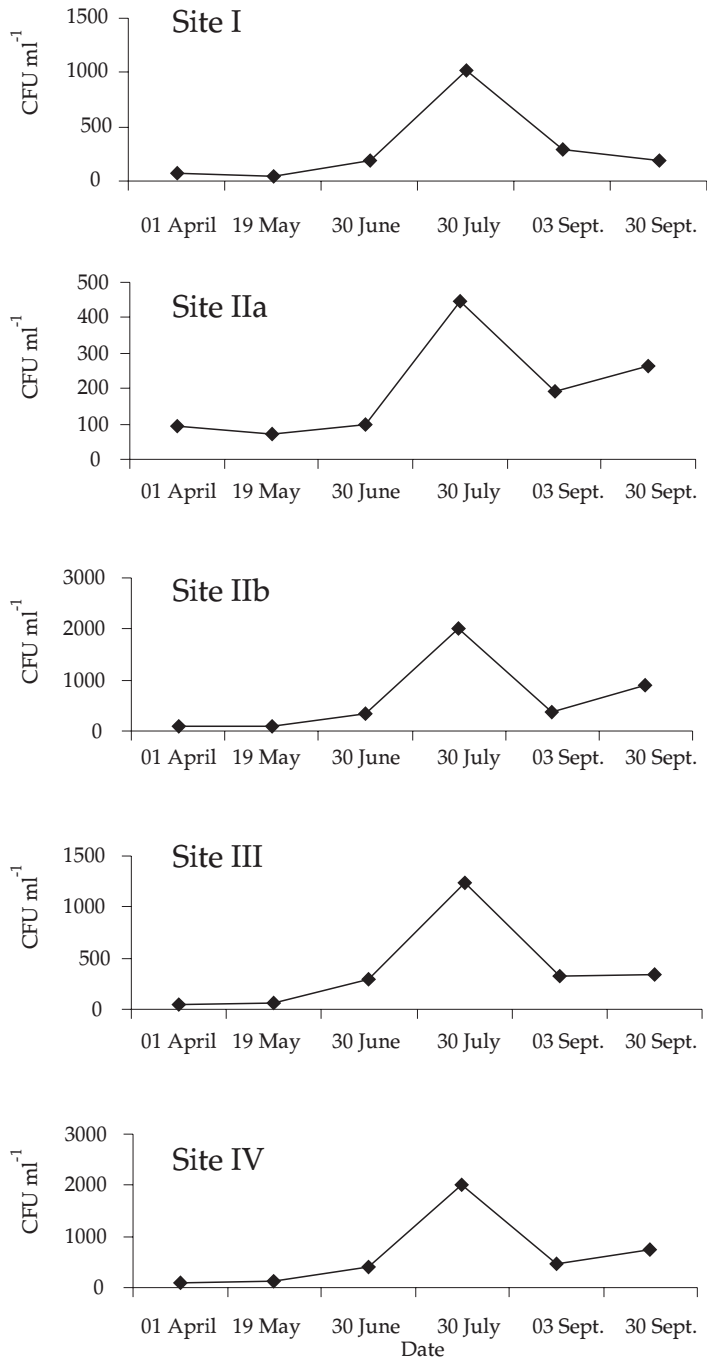


Fig. 2. Seasonal dynamics of TVC 37°C (CFU ml⁻¹) at various sampling sites.

All the sanitary indices (TC, FC, FS) showed the highest values (MPN 100 ml⁻¹) on June 30, 1999. TC values ranged from 250 to 14,000 per 100 ml of water, and the maximum counts were recorded in May and June at site IV, while the lowest abundance of these bacteria occurred on September 3 at site IIa (Table 2). No correlation was found between the TVC 37°C and TC counts (Table 1).

TABLE 2
Most probable numbers (MPN) of coliform bacteria (TC) per 100 ml of water

Site	Date					
	01 April	19 May	30 June	30 July	03 September	30 September
I	2,500	1,500	2,500	950	950	950
IIa	750	750	4,500	300	250	300
IIb	4,500	2,500	11,000	9,500	450	450
III	2,500	2,000	2,500	950	450	450
IV	2,500	14,000	14,000	750	2,500	750

FC counts did not exceed 2,500 per ml (June 30, site I). No fecal coliforms were found in the samples taken on June 30, September 3, or September 30 from site IV (Table 3). This site, however, had the highest numbers of FC in the first three months of the study. A positive correlation was found between total counts of coliforms and fecal coliforms ($r = 0.613$) (Table 1).

TABLE 3
Most probable numbers (MPN) of fecal coliform bacteria (FC) per 100 ml of water

Site	Date					
	01 April	19 May	30 June	30 July	03 September	30 September
I	250	60	2,500	30	90	70
IIa	250	70	150	40	90	90
IIb	750	650	950	300	250	250
III	250	200	200	90	90	90
IV	1,500	1,600	2,000	0	0	0

FS counts ranged from 0 (September 3 and 30, site IV) to 2,500 per ml (June 30, site IIb) (Table 4), with site IIb (cage water) showing the highest bacterial contamination and site I (cooling water inlet) and IV (Narew River) showing the least contamination. A positive correlation was established between TC and FS counts ($r = 0.531$; Table 1).

TABLE 4

Most probable numbers (MPN) of fecal streptococci (FS) per 100 ml of water

Site	Date					
	01 April	19 May	30 June	30 July	03 September	30 September
I	950	90	90	90	90	90
Ila	250	350	450	90	90	90
I Ib	950	1,500	2,500	250	250	300
III	450	350	450	250	90	90
IV	200	400	950	150	0	0

The numbers of TC, FC and FS in spring (April, May and June) were usually higher in comparison to the subsequent months. On the contrary, bacteria grown on a common agar medium at 20 and 37°C were most abundant in July.

Spore-forming anaerobes (*Clostridium perfringens*) were only found in single samples taken in May and July and their counts did not exceed 3 CFU ml⁻¹ (sites I and IV). No *C. perfringens* were found in the other samples.

DISCUSSION

The microbiological status of water used in aquaculture depends on its organic matter content, temperature, pH, and dissolved oxygen level as well as on the fish species, density, and feeding (Fang et al. 1989, Markosova and Ježek 1994).

The results of the study presented here indicate that intensive cage fish rearing in cooling water did not adversely affect its sanitary and bacteriological properties. The counts of organic pollution indicator bacteria (TVC 20°C and TVC 37°C) at the discharge of cooling water from the electro-heating plant (site I), and downstream from the complex of 48 fish cages (site III) were similar. Higher numbers of these bacteria were found in the cages and in the Narew River. In the case of the cages, this probably resulted from a high concentration of nutrients from unconsumed feed and fish feces (Świątecki 1994a). The high numbers of TVC 20°C and TVC 37°C bacteria in the Narew River might have been related to runoff pollution. The total counts of heterotrophic bacteria TVC 20°C and TVC 37°C were usually the highest in summer. This was related to an increase in temperature which is the principal factor which affects the density of heterotrophic bacteria in cooling and heated waters. The results obtained by Świątecki (1994b) for the heated waters of the Konin lakes revealed a four-fold increase in the heterotrophic bacteria count when there was a water temperature rise of 6°C.

The presence of fecal coliforms in the cooling water discharge channel throughout the study period indicates domestic sewage contamination. According to Geldreich (1970), *Salmonella* sp. are found in 100% of the waters containing over 2,000 cells of fecal coliform bacteria per 100 ml. Such a high contamination level was observed in only 6% of the samples, but it suggests the dangerous possibility of the pathogen spreading.

Fecal streptococci were also present in the channel throughout the study period, reaching maximum densities at site IIb (cage water from a depth of 1.2 m). This was probably caused by animal feces contamination. The FC/FS ratio is reliable at cell counts over 100 per 100 ml (Geldreich 1976). A value over 0.7 was found in 50% of the samples which indicates contamination of both human and animal origin. Of the samples taken, 43% had values below 0.7 which are typical for animal feces contamination.

CONCLUSIONS

1. Cage fish culture did not have a remarkable adverse effect upon the sanitary and bacteriological status of the water discharged into the Narew River.
2. Statistical analysis revealed a positive correlation between the TVC 20°C and TVC 37°C counts, total coliform count and fecal coliform count, and between the coliform count and fecal streptococci.

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STRESZCZENIE

STAN SANITARNO-BAKTERIOLOGICZNY WODY W CZASIE PROWADZENIA TUCZU SADZOWEGO SUMA EUROPEJSKIEGO (*SILURUS GLANIS* L.) W WODACH POCHŁODNICZYCH

Wykorzystywanie wód pochłodniczych do celów gospodarki rybackiej oraz możliwość przenoszenia bakterii potencjalnie chorobotwórczych z wód powierzchniowych, skłoniło do podjęcia badań sanitarno-bakteriologicznych dotyczących tego środowiska w trakcie chowu ryb w sadzach. Badania prowadzono w bazie sadzowej Gospodarstwa Rybackiego Olsztyn. W obiekcie tym prowadzony był sadzowy chów ryb w kanale zrzutowym wód pochłodniczych Elektrociepłowni Ostrołęka. Ogrzane wody po eksploatacji rybackiej były odprowadzane do rzeki Narwi. Próby wody do badań pobierano w okresie od 1.04 do 30.09. 1999 roku.

Oznaczano: ogólną liczbę bakterii hodowanych na podłożu agarowym zwykłym w temperaturze 20 i 37°C, ogólną liczbę bakterii z grupy coli (TC) i z grupy coli typu kałowego (FC) oraz liczbę paciorkowców kałowych (FS) i beztlenowców przetrwalnikujących redukujących siarczyny (*Clostridium perfringens*). Na podstawie uzyskanych wyników nie stwierdzono wyraźnego wpływu tuczu ryb na pogorszenie się stanu sanitarno-bakteriologicznego wody odprowadzanej do rzeki Narwi (rys. 1, 2, tab. 1-4).

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