УДК 579.68

ECOLOGICAL AND SANITARY CONDITION OF FISHERY PONDS WITH COMPLEX INTENSIFICATION

ЭКОЛОГО-САНИТАРНОЕ СОСТОЯНИЕ РЫБОХОЗЯЙСТВЕННЫХ ВОДОЕМОВ С КОМПЛЕКСНОЙ ИНТЕНСИФИКАЦИЕЙ

I.Yu. Kireeva
И.Ю. Киреева

National University of Life and Environmental Sciences of Ukraine, 19, General Rodimtsev St, Kiev, 03041, Ukraine
Национальный университет биоресурсов и природопользования Украины, Украина, 03041, Киев, ул. Генерала Родимцева, 19

E-mail: kireevaiu@mail.ru

Key words: bacteria plankton, microorganisms, heterotrophic, oligotrophic, index of purity, index of trophicity, ponds, fish, number, feeding.
Ключевые слова: бактериопланктон, микроорганизмы, гетеротрофы, олиготрофы, индекс чистоты, индекс трофности, пруды, рыба, численность, кормление.

Resume. The analysis of data for the study of basic and integrated indicators of bacterial plankton productive fishery ponds with complex intensification (the total number of morphological structure, the number of heterotrophic and oligotrophic bacteria, the index of purity, and the index of trophicity) is represented. The dependence of the total number of bacteria plankton on the intensity of fish feeding and water temperature. The size of the bacterial cells varied with increasing anthropogenic load on the pond. Maximum heterotrophic (saprophytic) bacteria was observed in the middle of the vegetation period and coincided with the total bacteria plankton. The absolute number of oligotrophic bacteria was increasing as the intensity of fish feeding, and their total number of saprophytes was decreasing. Minimum values of the coefficient (K) and the index of trophicity (I) were observed at the end of the vegetation period. Used microbiological indicators help to educe the borderline ecological status of water bodies and therefore they can be recommended as indicator characteristics of processes under the pond and anthropogenic influence on them.

Аннотация. Представлен анализ данных по изучению основных и интегрированным показателей бактериопланктона производственных рыбохозяйственных водоемов с комплексной интенсификацией (общая численность, морфологический состав, численность гетеротрофных и олиготрофных бактерий, индекс чистоты, индекс трофности). Выявлена зависимость общей численности бактериопланктона от интенсивности кормления рыбы и температуры воды. Размеры бактериальных клеток варьировали при увеличении антропогенной нагрузки на водоем. Максимум гетеротфорных (сапрофитных) бактерий отмечался в середине вегетационного периода и совпал с таковым тотального бактериопалнктона. Абсолютное число олиготорофных бактерий возрастало по мере увеличения интенсивности кормления рыбы, а их доля в общем количестве сапрофитов снижалась. Минимальные значения коэффициента чистоты (К) и индекса трофности (I) наблюдались в конце вегетационного периода. Использованные микробиологические показатели позволяют выявить пограничное экологическое состояние водоемов и потому их можно рекомендовать как индикаторные характеристики внутриводоемных процессов и антропогенного воздействия на них.

Introduction

The main parts of the modern water quality assessment system are microbiological indicators, which characterize the gravity of the state of the environment (water bodies) to aquatic organisms, including human [Drachev, 1964; Zhukinsky, Wen et al., 1981; Antipchuk, 1983; Grigorieva, Wen et al.,1985; Shitikov, Wen et al.,2003; Ashikhmina, 2006]. Advantages of micro-organisms as an indicator of the ecological status of waters don't raise doubts because they have the shortest life cycle in the hierarchy of living beings; and they are characterized by high sensitivity, registering even the occasional short or contamination, and therefore occupy a special place among the indicators [Kuznecov, 1940; Winberg, 1973; Shitikov, Wen et al.,2003]. With the help of the structural and functional parameters of microbial communities it is possible to estimate the degree of anthropogenic impact especially in the setting of controlled fish-breeding process [Antipchuk, Kireeva, 2005]. Due to the special sensitiveness of bacterial plankton as indicators of environment of dwelling it is possible to distinguish the directed changes of forming the quality of water under the action of anthropogenic factor from the recurrence of natural biological processes [Romanenko, Kuznecov, 1974; Romanova, Hurynovich,1983; Oleinik, Starosila, 2005; Kireeva, 2010.].

Research methods

Microbiological studies were carried out by conventional methods in aquatic microbiology selection of an average sample of water-bottle sampler every ten days with a 20-centimeter layer of

surface water; membrane filter method - determination of total microbial count and morphological structure; method of sowing depth in 3-fold repetition - definition heterotrophic (meat-and-peptone agar, MPA) and oligotrophs (MRA 1:10) [Razumov, Korsch, 1962; Korsch, 1969; Antipchuk, Kireeva, 2005]. The index of cleanness (coefficient K, according to S. Kuznecov) was counted to the total number of bacteria to the number of heterotrophic [Kuznecov, 1940]. Index of trophicity (coefficient I, according to N. Gavrishova) was counted to oligotrophic bacteria, which are growing on dilute (1:10), to the number of heterotrophic, which are growing on MPA [Gavrisheva, 1986]. The results are processed statistically (mean, mean error), the difference was considered at a confidence level – 0.95 (p <0.05)

Experimental part

The bacteria plankton of nursery fishing ponds of the fish farm in Chagan (Astrakhan area; Russia the sixth area of fish-farming, 2009) was the object of the research. The carp was growing in condition of complex intensification (polyculture, close-settled landings, fertilizers, feeding) in that fish farm. The main difference of experimental reservoirs was in intensive fish feeding (pond №1-baiting, pond №2 – semi-intensive, pond №3 – intensive). The purpose of researches is an estimation of ekological-sanitary state of reservoirs with the different level of anthropogenic load on the basic and computer-integrated indexes of total bacterial plankton (general quantity, morphological composition, quantity of heterotrophic and oligotrophic bacteria, index of cleanness and index of trophicity).

Results and Discussion

Analysis of the given data showed that the total number of microorganisms in the water of the researched ponds ranged from 0.7 to 19.8 million cells/ml (table).

Table

Microbiological indicators of the sanitary condition of the experimental fishery ponds (average)

Таблица

Микробиологическая характеристика экспериментальных рыбохозяйственных водоемов (среднее)

Months	Microorganisms thousand cells / ml			K	I
	The total number	MPA	MPA 1:10		
Pond № 1					
June	860.0±0.19	5.0±0.10	10.5±0.20	172.0±0.42	2.1±0.11
July	5 995.0±0.31	107.0±0.37	220.0±0.22	56.0±0.27	2.1±0.13
August	7 975.0±0.42	250.0±0.29	450.0±0.51	31.9±0.30	1.8±0.20
September	8 009.0±0.40	285.0±0.48	390.0±0.35	28.1±0.24	1.8±0.23
The average for the season	5 709.8±0.34	186.8±27	242.6±0.41	70.2±0.19	2.0±
Pond № 2					
June	700.0±0.40	4.2±0.16	9.9±0.14	166.7±0.33	2.4±0.15
July	11 291.1±0.33	319.0±0.51	430.0±0.30	35.4±0.20	1.4±0.12
August	15 001.0±0.50	575.0±0.33	760.0±0.32	26.1±0.25	1.3±0.16
September	17 650.0±041	660.0±0.42	515.0±0.27	19.6±0.18	0.9±0.13
The average for the season	11 160.0±0.37	324.6±0/50	428.3±0.26	62.0±0.30	1.6±0.23
Pond № 3					
June	858.0±0.54	5.5±0. 10	11.0±0.13	156.0±0.22	2.0±0.18
July	14 184.0±0.51	560.0±0.38	680.0±0.22	25.3±0.14	1.0±0.13
August	19 802.0±0.31	1070.0±0.41	870.5±0.36	21.1±0.17	0.8±0.10
September	21 443.0±0.45	970.0±0.36	400.0±0.21	32.0±0.25	0.4±0.11
The average for the season	14 071.8±0.36	476.4±0.27	508.0±0.28	58.6±0.23	1.2±0.14

Received indicators of the total microbial count show the transition of the surveyed ponds into dirty category. We have found that the dynamics of the total number of bacteria repeated any permanganate oxidation and temperature. The maximum number of bacteria plankton was observed at the maximum heating of water (29°C) followed by a decrease of the concentration of dissolved oxygen in it to the minimum.

The content of organic matter in the pond with the highest anthropogenic load reached 30.5 mg O/l, which significantly exceeded the permissible limits for fish-farms. It should be pointed out that in the pond with intensive fish feeding (throughout the growing season) the largest values of the total number of bacteria plankton were observed that on average in the season was 14 071 8 cells / ml and indicated the transition of this reservoir in the category of dirty ones.

In ponds №1 and 2 the total number of microorganisms on the average was 1.5 times less than in the pond № 3. The most favorable microbiological conditions were observed in the pond with the lure, the water of which during the whole period of fish cultivation was characterized as polluted, that is permissible under a complex intensification of fish-breeding process.

Thus quantitative changes in of bacteria plankton during the growing season were determined by complicated factors, the main of them was the introduction of organic matter in the form of the fish feed. With the accumulation in reservoirs residues of uneaten feed and the fish metabolic products the total bacterial count was increasing. The dependence of the total intensity of the bacterial feeding fish and water temperature was determined.

In total number of bacterioplankton rod-shaped form was – 76.3%. Their sizes varied of 0.2 to 2.0 μ dominated was reiteled in the morphological composition of bacterioplankton. Proportion of cocci the average size of 0.6 μ did not fall below 11.5%, and the spores – 3.8%. The presence of Galionella ferrugenia in the amount of 0.1% of total microbial number was idicated in the composition of bacterioplankton in the first year of reservoirs operation. It should be noted that sizes of coccus cell decreased and bacillus with a scheme change of reservoirs operation. Such changes in the morphological structure of bacterialplankton recorded in the seasonal and long-term dynamics, can serve as an indirect indicator of processes inside the reservoirs and human impact on them.

As bas as the number of saprophytic bacteria concerned their amount in the water of reservoirs varied widely – from 4.2 to 1070.0 thousand cells/ml. Maximum number of saprophytes was observed in the pond with the highest anthropogenic load. A general conformity for all reservoirs - a gradual increase of the number of heterotrophs from the beginning of the growing season to the middle (august), with a further decline was observed. The population dynamics of this group of bacteria repeated the dynamics of the total bacteria plankton. The peaks of their number coincided with the maximum value of permanganate oxidation of water (pond number 1 – 12.8 mg O/l; pond number 2 – 19.4 mg O/l; pond № 3 – 31 mg O/l), which is quite natural as permanganate acid capacity characterizes the presence of easily decomposed organic matter and a saprophytic bacterium plays a major role in its transformation [Korsch, 1969; Gavrisheva, 1986].

Analyzing the calculated coefficient K it should be noted that in the early summer the water of all experimental ponds was characterized by a sufficient number of labile organic matter, relatively equal degree of purity (R = 156–172) and belonged to the category of β-mezosaprobic. The analyzed parameters decreased i 3–8 times with an increase of the intensity of fish-breeding process and the heating of water (July–August) decreased in3–8 times, which could indicate a shift of reservoirs into category of polysaprobic. At the end of the growing season the value of the coefficient K reached the minimum value since the reservoirs have accumulated a large amount of organic matter in the form of fish, remains of uneaten feed and dead phytoplankton that indicates a high anthropogenic load. Saprobic increase can lead to the appearance of reservoirs with a lack of oxygen in the future.

The comparison of the inspected reservoirs outman oligotrophic bacteria showed, that their absolute number had increased as far as the increase of feeding load, and a stake in the general amount of saprophytes went down. The least of oligotrophic bacteria (9.9–11.0 thousands of cells / ml) registered in all ponds at the beginning of summer, when the amount of organic matter was small in reservoirs.

With the introduction of feed into ponds easily decomposed organic substance was accumulating and it is used by this physiological group of microorganisms. Maximum number of them was observed in the pond with intensive fish feeding. The number of oligotrophes was declining to the end of the vegetation period in all experiment ponds; it is an indirect measure of increase of total content of organic substances in the water.

An assessment of the ecological status of water bodies was carried out on the index of trophicity (I), which is also decreased with increasing number of saprophytes in water, reaching lows (0.4) by the end of the growing period of fish, especially in the pond with intensive fish feeding – 5 times. It is necessary to consider a factor of the trophicity index while planning stocking densities of fish and feed costs for its cultivation because a high level of intensification of fish farming increases the organic load on the body of water, degrades a microbiological situation in the water and leads to secondary (bacterial) contamination

The obtained microbiological data confirmed the findings that the pond as stagnant closed system has a certain, but limited ability to cleanse itself [Kuznecov, 1940; Razumov, Korsch, 1962; Korsch, 1969; Romanenko, Kuznecov,1974; Oleinik, Starosila, 2005]. Thus, both basic and integrated

microbiological indicators assess the ecological status of water bodies, indicate the need to take measures to normalize the hydrochemical and sanitary regime of the reservoir to prevent the deterioration of water quality and as a result, farmed fish production. In addition the used microbiological indicators can be recommended as indicator characteristics of inside reservoirs processes and human impact on them [Kireeva, 2010].

References

Antipchuk A.F. 1983. Mikrobiologiya rybovodnykh prudov.M., Legkaya i pishchevaya promyshlennost'S, 212. [Microbiology fish ponds]. Moscow, Light and food industryS, 212. (in Russian)

Antipchuk A.F, Kireeva I.Y. 2005. Vodna mikrobiologiya. Kiiv, KondorS, 256. [Water microbiology]. Kyiv, KondorS, 256. (in Ukrainian)

Ashikhmina T.Y 2006. Ekologicheskiy monitoring. [Environmental monitoring]. Moscow, Academic ProjectS, 416. (in Russian)

Drachev S.M. 1964. Bor'ba s zagryazneniem rek, ozer, vodokhranilishch promyshlenno-bytovymi stokami [Pollution of rivers, lakes, reservoirs industrial and domestic sewage]. Moscow–Leningrad]. Publishing House of the USSR AcademyS, 274. (in Russian)

Gavrisheva N.A. 1986. Distribution of heterotrophic bacteria and oligokarbofilnyh in lakes and rivers of Ukraine. In: Struktura i funktsionirovanie soobshchestv vodnykh mikroorganizmov. [Distribution of heterotrophic bacteria and oligokarbofilnyh in lakes and rivers of Ukraine. In.:The structure and functioning of aquatic communities mikroorganizmov]. Novosibirsk, Siberian Branch of the USSR Academy of Sciences: 211-215. (in Russian)

Grigorieva L.V, Kasyanenko A.I, Korczak G.I.1985. Sanitarnaya mikrobiologiya evtrofnykh vodoemov [Sanitary microbiology eutrophic reservoirs]. Kiev, Zdorov'eS, 224.(in Ukrainian)

Kireeva I.Y. 2010. Evaluation of the ecological state of the fishery ponds of various categories of microbiological parameters. In: Regiony v usloviyakh neustoychivogo razvitiya (Kostroma-Shar'ya, 28-30 aprelya 2010), Materialy mezhdunarodnoy nauchno - prakticheskoy konferentsii [Regions in terms of unsustainable development. Materials of international scientific-practical conference. (Kostroma-Sharia, 28-30 April 2010), V.2. Kostroma, Publishing House of Kostroma State University named after N.Nekrasov: 408 - 413. (in Russian)

Korsch L.Zh. 1969. Direct method for determination of bacteria in the study of sanitary water bodies. Gigiena i sanitariya [Hygiene and sanitation], 9: 85 - 87. (in Russian)

Kuznecov S.I. 1940. The use of microscopic techniques to the study of organic matter in water bodies. Mikrobiologiya. [Microbiology], XVIII, 3:203-214. (in Russian)

Oleinik G.N., Starosila E.V. 2005. Microbiological characterization of reservoirs with high anthropogenic load. Gidrobiologicheskiy zhurnal [Hydrobiological journal], 4:15-17. (in Ukrainian)

Razumov A.S, Korsch L.Zh. 1962. The use of phase-contrast microscopy for counting of bacteria by direct methods in the study of water quality. Mikrobiologiya. [Microbiology], 2: 257-361. (in Russian) Romanenko V.I., Kuznecov S.I. 1974. Ekologiya mikroorganizmov presnykh vodoemov. [Ecology of freshwater organisms]. Leningrad, NaukaS, 194. (in Russian)

Romanova A.P, Hurynovich T.G 1983. On the relation between bacterial abundance and biomass in the calculation of its products. In: Writings State Research Institute Lake and River Fisheries. Vyp. 196. [Proceedings State Research Institute Lake and River Fisheries. Edition 196]. State Research Institute Lake and River Fisheries: 72-80. (in Russian)

Shitikov V.K, Rosenberg G.S, Zinchenko T.D. 2003. Kolichestvennaya gidroekologiya: metody sistemnoy identifikatsii. [Quantitative hydroecology: system identification techniques]. Togliatti, Institute of the Volga ekologii bassenya Russian Academy of SciencesS, 463. (in Russian)

Winberg G.G., 1973. Introduction. In: Biologicheskie protsessy i samoochishchenie na zagryaznennykh uchastkakh reki (na primere verkhnego Dnepra). [Vvedenie. In: Biological processes, and self-cleaning of the contaminated river sections (for example, the upper Dnieper]. Minsk, Belarusian State University Publishing House: 12-13. (in Russian)

Zhukinsky V.I, Oksiyuk O.P, Oleynik G.N. 1981. Printsipy i opyt postroeniya ekologicheskoy klassifikatsii i kachestva poverkhnostnykh vod sushi. [Principles and experience of construction of ecological classification and quality of surface water]. Hydrobiological journal, 2:38. (in Ukrainian)