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ZOOPLANKTON AS AN INDICATOR OF RIVER ECOLOGICAL CONDITION

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Abstract

Long-term studies (2013-2015) of Kazanka river ecological state were performed. In order to evaluate the water quality the zooplankton community indicators were used. The physical-chemical indicators of the river Kazanka water were studied. Zooplankton samples were selected and analyzed using standard hydro biological techniques. The quantitative indicators (abundance and biomass) of zooplankton were revealed and biotic indices were calculated. The analysis of zooplankton community structure showed the decline of species diversity during the study period. The values of saprobity index in most cases allowed to include the river into β-mesosaprobic zone (moderately polluted water). Physical and chemical indicators of water demonstrated the river pollution as the result of untreated sewage income of various origin, including storm water runoff from the city. The river pollution in the city makes an impact on the zooplankton community, it causes the decrease of quantity indicators and the decline of species diversity.

Keywords: Zooplankton, Pollution, Indicator, Small river.

Introduction

The problem of preservation and the rational use of natural resources is becoming increasingly important. Water resources occupy an important place among the natural resources of Russia. Surface fresh waters are one of the major sources which meet the diverse human needs for water resources, but the river water quality deteriorated significantly during the past decades.

Kazanka River - the left tributary of the river Volga, the river mouth is located within the city of Kazan, in the zone of Kuibyshev Reservoir, a large part of the river floodplain is flooded or filled up. An anthropogenic impact on the river is very high. The wastewater of Kazan industrial enterprises of Kazan and stormwater drains are discharged there. During the preparation for the World Summer Universiade of 2013, new sports facilities were constructed in

the river floodplain. The construction of the promenade continues around the stadium "Kazan - Arena". All this led to the increase of an anthropogenic load on the river. However, the river is one of the Kazan green frame elements, an important recreational object. In August 2014 the high diving World Cup was held in the river waters, and in 2015 the World Championships in aquatics was performed. Due to these facts the constant monitoring of the water quality in the river Kazanka and the state of hydrobiont communities is necessary.

The purpose of this paper is to estimate the degree of Kazanka river anthropogenic pollution and its impact on the zooplankton community.

Zooplankton community, being the part of the river ecosystem, is related to other components of the aquatic ecosystem, and is able to reflect the changes with the ecosystem as a whole [1]. Currently the zooplankton community indicators are widely used in the monitoring system to assess the state of ecosystem different types [2].

The species composition of water body zooplankton is fairly constant and can not be changed for many decades and even for many centuries, but it changes during the pollution and eutrophication. The impact of anthropogenic factors leads to the fact that the species living in clear waters as a rule, disappear from the community. Their place is taken by other types, resistant to pollutants impact, low oxygen content and hydrogen sulfide presence. They tend to become dominant ones. Therefore, during the assessment of the ecological status of water bodies the identifying of zooplankton species composition, as well as the quantitative characteristics of individual species and groups of zooplankton (abundance and biomass) is of great importance. In order to assess the degree of water body pollution, various indexes are used based on the indicator properties of organisms, which allow to assess the water quality according to these indicators [1, 3, etc.].

One of the most informative indicators during pollution and eutrophication is the Shannon index of species diversity. The pollution and eutrophication of water bodies and water courses leads to a simplification of hydrobiont community structure. This fact is reflected in the reduction of their diversity. The reduction of Shannon index value indicates the structural and functional restructuring of animal plankton community [4]. During the hydrobiological monitoring of water bodies such indicator as saprobity index is applied calculated on the basis of indicator species list [5].

The pollution of water bodies and watercourses due to wastewater income causes the changes in the structure of zooplankton communities. The number of species, the amount and biomass decreases with pollution degree increase [6, 7, etc.].

Methods

Kazanka river basin makes 2600 km^2, its total length makes 140 km, the slope of the river makes 0.06 m/km. The river originates in the forest-covered hill and flows into the Kuibyshev reservoir in the city of Kazan. Under the influence of reservoir the water level in the lower part of the river is increased, and the river fills the floodplain.

The studies were carried out on the river Kazanka in the city of Kazan in June-August 2013-2015. The selection and the analysis of samples was performed according to standard hydrobiological techniques [8]. Samples were taken from the surface layers of water (the level of depth made 0.5-1 m) by filtering50-100 liters of water withthe 65 μm mesh-size Apshtein plankton net. Collected samples were fixed in 4% formalin. Three subsamples (at the volume of 2.5 ml) from each sample were examined by microscope at 60-400-fold magnification. The purpose of the qualitative study was to identify Rotifera, Cladocera and Copepoda taxons.

We calculated the abundance and the biomass of zooplankton at each station. The abundance was calculated in 1 m^3 of water. Biomass was calculated according to degree equations relating the length of an organism with its weight [8].

The species diversity of zooplankton was assessed using the Shannon index [9] according to the following formula:

$H=-\sum_{i=1}^{k} p_i \log_2 p_i$, where H – Shannonindex, p_i - $\frac{N_i}{N}$ or $\frac{Bi}{B}$, where N_i and B_i –the number and the biomass of i-th type, N and B - the number and the biomass of all individuals in the sample, respectively.

Water quality assessment is performed according to structural indicators of zooplankton community, as well as by the value of saprobic index.

Pantle and Bukka saprobic index in Sladechek modification was calculated using the following formula: **S=** $\frac{\sum(sh)}{\sum h}$,

Where **S** - saprobic index, **s** - conditional value of saprobity, h - the frequency of occurred individuals [10].

Together with the taking of zooplankton samples the physical and chemical indicators of water were measured. The water temperature was measured with the thermometer, the dissolvedoxygen (DO) was measured by oxygen analyzer (oximeter) "Marc-302E", the electrical conductivity was measured by conductometer Hanna. The water for chemical analysis was collected in plastic bottles of 1.5 liters. The water sample analysis was carried out by a certified laboratory.Chemical oxygen demand (COD), biological oxygen demand (BOD) (5 days), the amount of ions in nitrates (NO_3^-), nitrites (NO_2^-), phosphates (PO_4^{3-}), ammonium (NH_4^+), chlorides (Cl^-) sulphates (SO_4^{2-}), bicarbonates

(HCO_3^-), calcium ions (Ca^{2+}),rigidity petroleum products, total Cu and Fe were measuredin laboratory. The water quality assessment was conducted by comparing the values of indicators with the MPC[11].

Results

The water in the river Kazanka is very tough. The conductivity varied from 1120 to 1670 mS/sm. The water demonstrated the exceeding of the maximum allowable concentrations of sulphate and calcium ions content. However, high concentrations are conditioned by natural causes - the discharge of groundwaters, which is typical for this region (Table 1).

Table 1. Physical and chemical indicators of water in Kazanka river on the test site (± SD).

Parameter	June 2013	July 2013	August 2013	October 2015
Temperature, ^0C	20.6±0.1	21.7±0.4	20.5±0.6	3.36±0.46
pH	-	-	-	7.2±0
Conductivity, mS/sm	1240.0±80.0	1346.6±11.1	1426.6±0.68	1450±50
DO, mg/l	12.9±5.2	10.3±1.6	14.4±0.5	13.3±0.2
Suspended matters, mg/l	-	-	-	13.2±0.9
COD, mgO_2/l	10.5±1.0	16.5±1.3	57.1±18.7	15.5±0.8
BOD5, mgO_2/l	6.5±3.8	4.7±2.1	12.8±2.3	1.7±0
NH_4^+, mg/l	0.54±0.04	0.49±0.06	0.27±0.19	1.37±0.05
NO_2^-, mg/l	0.065±0.025	0.039±0.004	0.733±0.071	<0,020
NO_3^-, mg/l	0.1±0	0.1±0	2.88±1.72	21.53±1.32
PO_4^{3-}, mg/l	0.05±0	0.13±0.04	0.36±0.41	0.16±0.01
Cl^-, mg/l	16.5±0.8	22.5±1.5	21.8±2.7	29.6±0.8
SO_4^{2-}, mg/l	380.3±22.4	386.3±15.1	544.0± 84.6	685.1±9.1
Oil products, mg/l	0.059±0.049	0.02±0	0.022±0.003	0.025±0.005
HCO_3^-, mg/l	290.0±10.0	304±4.6	295.0±44.0	345.5±4/8
Ca^{2+}, mg/l	10.1±0.3	275.0±12.0	368.0±47.3	-
Rigidity, mg*eq/l	12.4±1.3	17.5±0.6	23.5±2.7	-
Fe, mg/l	-	-	-	0,175±0.005
Cu, mg/l	-	-	-	0,002±0.00

- The parameter was not analyzed.

According to the results of physical-chemical studies the exceeding of the maximum allowable concentrations was revealed established for fishery water bodies [11] according ammonium ions, nitrites, phosphates, petroleum products content, which is conditioned probably by the inflow of untreated sewage of domestic origin, as well as by the inflow of storm water from highways. The excess of copper and iron permissible concentrations was revealed which may be

caused both by natural and man-made factors. The concentrations of other heavy metals were below detection limits. According to the magnitude of water pollution index the water is referred to the 4-th class of water quality i.e. to a polluted one.

The zooplankton composition of the river Kazanka on the research area revealed 58 species of zooplankton, including Rotifera - 23 species (40%), Cladocera - 26 (45%), Copepoda - 9 (15%). Cladocera prevailed according to the number of species. The number of met species varied by year - from 34 to 42. These results in general are consistent with the results of previous studies during the same period [12].

The dominant species changed by stations, but most often the rotifers Brachionus calyciflorus Pallas,Asplanchna girodide Guerne,Asplanchna priodonta Gosse,Asplanchna sieboldi (Leydig),Keratellaquadrata (Muller) and Polyarthravulgaris Carlin were among the dominant or subdominanat ones numerically. The crustaceans Simocephalusvetulus (O.F. Muller), Daphniacucullata Sars, Polyphemuspediculus (Linne) and rotifer A. priodontawere dominated by biomass.

The abundance of zooplankton varied by stations from 1450 to 930 000ind./m^3. The highest values for the entire study period were recorded in June 2013. During other periods the values of zooplankton abundance were significantly lower. Biomass values ranged from 0.006 to 9.7 g/m^3. High values of zooplankton biomass were conditioned by the dominance in the community of large rotifers *A. priodonta*. The lowest values of population were recorded in 2014, and the lowest values of biomass were recorded in 2015 (Table 2).

Table 2. Average values of abundance (N, thousands of ind./m^3) and biomass (B, g/m^3) of Kazanka river zooplankton (M±m - standard error).

Group	Abundance			Biomass		
	2013	2014	2015	2013	2014	2015
Rotifera	114.5±73.8	64.2±46.3	22.4±15.4	1.07±0.84	0.06±0.03	0.08±0.04
Cladocera	41.4±21.4	3.0±1.63	3.9±1.8	0.67±0.31	0.02±0.007	0.21±0.11
Copepoda	31.5±17.5	7.3±5.5	5.9±3.2	0.29±0.16	0.01±0.01	0.02±0.006
Всего	187.4±100.9	74.6±53.5	32.1±16.1	2.03±1.07	0.10±0.05	0.26±0.12

The negative impact on the zooplankton community is revealed stronger in July and August, compared with June. It's probably related to the gradual decrease of water level from spring to autumn. Water blooming by phytoplankton in July and August makes a negative impact on zooplankton.

The tendencies of species diversity reduction according to Shannon index calculated both according to abundance and biomass (Fig. 1). The decline of species diversity index values is observed during the pollution and the eutrophication of water bodies and is usually associated with the changes in community structure, dominance concentration and the number of species reduction [4].

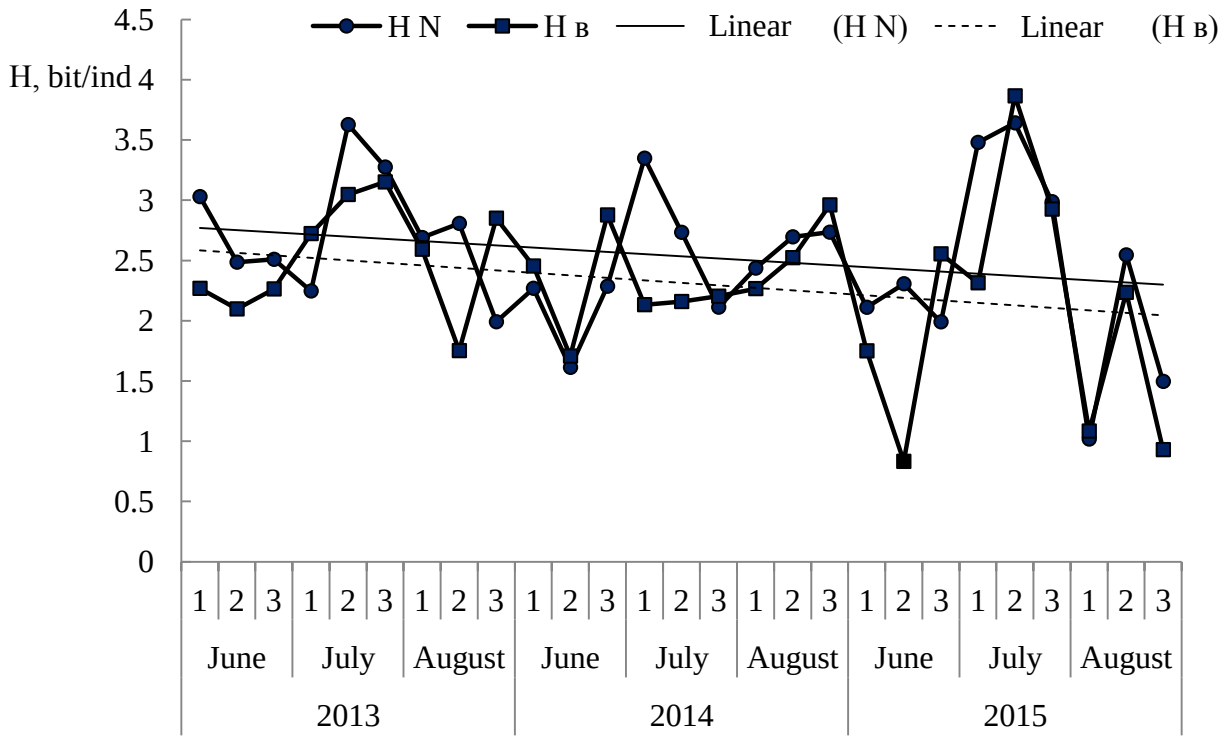

Fig. 1. The dynamics of Shannon index values (HN, HB) according to stations and sampling dates with trend lines.

Saprobity index values characterizing organic pollution level varied by 1.44 to 2.02, but in most cases they were within β- mesosaprobic zone (moderately polluted water). There were no reliable trends to index changes during the analyzed period. The reliable change of the index was not also revealed from station to station.

Discussion of results

Thus, our studies showed that the water in Kazanka river is polluted with oil products. The excess of maximum permissible concentrations of ammonium ions, nitrites, phosphates, as well as copper and iron are revealed. All this points to the river pollution due to the receipt of waste waters of various origins. Besides the water in the river is a hard one, which is associated with the groundwater discharge.

An elevated content of the biogenic element compounds and toxicants in water affects the zooplankton community, changing its structural characteristics. For Kazanka river it manifested in the reduction of zooplankton quantitative indicators (abundanceand biomass). During the study period, we identified the trends of species diversity index decline, calculated according to zooplankton number and biomass. Such index changes may be caused by the exposure to pollutants and were repeatedly noted in literature [4]. The values of saprobic index characterize the studied part of the river as a moderately polluted one, but in general, they proved to be less demonstrative, compared with the Shannon index.

Our studies also allowed us to make some recommendations concerning the effects of human impact reduction on the river. First of all it concerns the admission of untreated sewage of various origin into the river that bring the excessive amounts of biogenic elements and toxicants in the river and promote the eutrophication and pollution of watercourses. We may recommend the creation of artificial bioplato involving shellfish and higher aquatic plants to activate the self-cleaning capacity of the river. The control is required to observe water protection zone regime and the coastal zone improvement is necessary.

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