Effects of urbanization on phytoplankton and phytoperiphyton structure in the Lososinka river (Republic Karelia, Russia)

L'influence de l'urbanisation sur la structure du phytoplancton et du périphyton dans la rivière Lososinka (République de Carélie, Russie)

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RÉSUMÉ

L'aggravation de l'état de l'écosystème de la rivière Lososinka, qu'on observe depuis plusieurs années, est liée au rejet d'eaux ménagères, industrielles et de polluants avec des eaux torrentielles. En 2009 on a fait des recherches sur la rivière Lososinka, qui se jette dans la baie de Petrozavodsk du lac Onega, dans le cadre de la biosurveillance de l'état de la rivière sous l'influence anthropique chronique. On étudie le phytoplancton et le périphyton. Ces recherches ont prouvé que les modifications des indices de structure et de production de l'algocénose sont des indices sûrs de la qualité de l'environnement. Dans le phytoplancton de la rivière on a trouvé 110 espèces d'algues, qui représentent 6 embranchements. Les valeurs de biomasse variaient de 0,8 à 2,3 g/m³. Les concentrations de la chlorophylle *a* variaient de 3,4 à 4,9 g/m³. Dans le périphyton on a fixé 141 espèces d'algues, leur biomasse est de 0,1 à 21,8 mg/cm². La concentration de la chlorophylle *a* dans le périphyton constituait 10,7 mcg/cm² en moyenne, de 0,3 à 92,6 mcg/cm². Selon la quantité de la biomasse et la teneur en chlorophylle *a* dans le phytoplancton et dans le périphyton, le cours d'eau peut être caractérisé comme β-mésotrophe. Sur le territoire de la ville se passe la substitution du complexe *Tabellaria–Eunotia*, typique des rivières oligotrophes huminisées du nord européen et dominant dans le cours supérieur de la rivière, au complexe *Diatoma-Gomphonema-Nitzchia.*

ABSTRACT

Phytoplankton and periphyton were carried out on the Lososinka River, of Lake Onega urban tributare, in 2009. During the past years the river ecosystem are being subjected to multiple environmental stressors due to domestic, industrial and urban effluents. The results of the present study confirm that changes of structural and production features of algocenosis are reliable indicators of environmental quality. 110 species algae belonging to 6 departments are observed in the river phytoplankton. The phytoplankton biomass values varied from 0.8 to 2.3 g/cm^3, while chlorophyll a concentrations ranged from 3.4 to 4.9 g/m^3. 141 species of algae are identified in the river periphyton. The periophyton biomass values and chlorophyll a concentrations varied from 0.1 to 21.8 mg/cm^2 and from 0.3 to 92.6 mkg/m^3 correspondently. According to revealed values of biomass and chlorophyll a concentrations the river is characterized as β-mesotrophic. On the base of indicator organisms the river water quality assessed as polluted. On the territory of the city takes place the substitution of complex *Tabellaria-Eunotia*, typical of rivers oligotrophic humic of Northwest Russia in the upper lesson of the river, on complex *Diatoma-Gomphonema-Nitzchia*.

MOTS CLES

Dimensional structure of algocenosis, photosynthesis pigments, Phytoperiphyton, phytoplankton, of Lake Onega urban tributaries.

1 INTRODUCTION

The study of small rivers for a long time tended to be neglected in Russia, with phycological studies concentrated on the phytoplankton of large rivers. However, receiving pollution of various genesis (industrial, agricultural, public and domestic effluents), rivers accumulate toxic substance and carry them to lakes and seas. Small rivers have an important role in controlling the water balance, and are widely used for fish farming, water supply and recreational activities. Therephore, continuous ecological monitoring of fluvial water is needed. The river Lososinka (61° 47′ 13″ N, 34° 23′ 52″ E) is one of the biggest natural bodies of water in Petrozavodsk flow into the Petrozavodsk Bay of Lake Onega. The algal flora is the most sensitive constituent of aquatic ecosystems, and is responsible for the structure and functioning of its components. Phytoperiphyton can be helpful for assessing long-term changes in small rivers, such as those associated with eutrophication, river management, changes in land use at the scale of the watershed and in last years for monitoring in NW Russian rivers.The purpose of this paper is to assess how informative phytoperiphyton and phytoplankton structural parameters are, and to assess the feasibility of using them for biological monitoring of the river status. To achieve this objective the structure of algal attached communities in Lososinka river affected by human activities was analyzed.

2 METHODS

For analyses of species composition, biomass and abundance phytoplankton and periphyton of rivers water samples were carried out in 2009 according to the standard methods (Komulainen, 2004). Qualitative periphyton samples were collected in all seasons. Samples were collected at each site from 3-5 randomly chosen stones, removed carefully from a depth of 30-50 cm. The periphyton removed from a defined area by scraping the surface of rocks, stones and pebbles. Cell counts were used to calculate Shannon-Weaver diversity index (Shannon, Weaver, 1963). Periphyton biomass was estimated on each rock from chlorophyll *a* standing stock and ash-free dry mass (AFDM) (g/m^2).Water samples for plant pigment analysis of 0.5 or 1 l in volume, were taken with the Ruttner bathometer from the surface horizon. The plankton was concentrated using the membrane filter Vladipor, the optical density of 90 % acetone extract of the plankton was measured with the Super Aquarius spectrophotometer.The chlorophills a, b, c, carotinoides and pheopigments by means of a formula recommended by the working group of UNESCO (1966) and Pasons, Strikland (Strickland & Parsons, 1972). The pigment composition of river were sampled in 2009 and were analyzed using the method spectrophotometry.

3 RESULTS AND DISCUSSION

The 141 species of algae belonging to 7 departments are identified in the river periphyton. A list basis (> 90 %) make diatoms, green algae and cyanbacteria that reflects specificity phytoperiphyton river systems of a subarctic zone. The basis periphyton in the river of Lososinka is formed by a small amount of kinds. Dominate on number only diatoms *Tabellaria flocculosa* (Roth) Kütz., *Eunotia pectinalis* (Kütz.) Rab., *Cocconeis placentula* Ehr., *Gomphonema parvulum* (Kütz.) Kütz., and *Achnanthes minutissima* Kütz. The biomass is generated filamentous green algae *Ulothrix zonata* (Weber and Mohr) Kütz., *Zygnema sp*. and *Mougeotia sp*. The periophyton biomass values and chlorophyll a concentrations varied from 0.1 to 21.8 mg/cm^2 and from 0.3 to 92.6 mkg/m^3 correspondently.The influence of anthropogenic impacts on periphyton communities was analysed in terms of species richness, species diversity, species ecology values, biomass and chlorophyll concentration. The data obtained demonstrate that the phytoperiphyton communities in urban streams are dominated by broadvalent, pollution-tolerant and even saprophilic taxa. Substantial changes in periphyton structure were often caused by an enhanced mechanical impact by storm run-off, which retarded colonisation, rather than any chemical influence. The burial of algae by sand and silt resulted in the loss of species or entire algal assemblages were observed. As result the communities are dominated by a few species with high recolonization potential. Changes in the relative abundance of the dominant genera along the river at the edge of Petrozavodsk show that broadvalent, pollution-tolerant and even saprophilic species belonging to the genera *Diatoma*, *Gomphonema, Nitzschia*, *Surirella* and *Navicula* become were more abundant there. Leading rheophilous χ-saprobic diatoms of the genera *Achnanthes, Eunotia, Cymbella* were observed to drop out, and *Tabellaria* became less important. Simultaneously, chlorophyll *a* concentration in the total organic material attached to the substratum showed a general tendency to decrease. All these changes were more distinct in years when the flow, and hence water level, was lower. In addition to variations in species composition, there were changes in the ecological and geographic spectra of algal flora. Arctic-alpine species often remained dominant, but the ratio of groups changed in favour of boreal and cosmopolitan species**.** The halophobic-acidophilic-indifferent composition of diatoms was enriched in alkaliphilic and halophilic species. An increase in anthropogenic effect led to a slight increase in the proportion of non-attached organisms in the periphyton community (benthic, moving, dominated by Naviculaceae), based on both species abundance and frequency. Changes in periphyton structure result in altered values for diversity and saprobic indices. However, such changes were observed in a limited zone directly adjoining the site where sewage effluent entered. Substantial changes in periphyton structure were often caused by an enhanced mechanical impact, which retarded colonization, rather than any chemical influence. This impact became particularly noticeable when river channels were restructured, the riverbeds leveled and the amount of unconsolidated materials increased, this effect being enhanced by destruction of the riverbank vegetation. The most significant changes in the periphyton composition in some rivers were caused by mires being drained, leading to pieces of timber entering and floating in the river. Changes in flow and water level led to bark being deposited on the periphyton and the subsequent destruction of algal communities**.** The periophyton biomass values and chlorophyll a concentrations varied from 0.1 to 21.8 mg/cm^2 and from 0.3 to 92.6 mkg/m^3 correspondently.

110 species algae belonging to 6 departments are observed in the river phytoplankton. The basic dominants of a phytoplankton on a biomass were *Tabellaria fenestrata* (Lyng.) Kütz., *Fragilaria crotonensis* Kitton, *Aulacoseira italica* (Ehr.) Kütz., on number – *Anabaena spiroide* Klebahn. The phytoplankton biomass values varied from 0.8 to 2.3 g/cm^3, while chlorophyll a concentrations ranged from 3.4 to 4.9 g/m^3. For the river Lososinka prevalence in relation to acidity of the water environment of indifferent kinds is characteristic at a considerable share of the acidophile forms preferring sour with low values pH waters (Eunotia, Frustulia). Quality of water is estimated by the revealed saprob kinds-indicator of, the majority from which concerns to β–mezosaprob to forms. Bioindicacia on a phytoplankton has revealed species indicator of organic pollution (*Oscillatoria tenuis* Agardh., *Stephanodiscus hantzschii* Grunow). Also species activators of “bloom” of water *Anabaena spiroides*, *A. lemmermanii* are defined.. The last, as well as *Microcystis aeruginosa* (Kütz) Kütz., *M. wesenbergii kuetzingianum* Nag. The calculated saprobity index by Pantle and Buck were from 1,5 to 2,8.

4 CONCLUSION

Our observations have led to some important conclusions. Periphyton structure, which reacts to mineral- and organic matter-rich sewage water, was shown to reflect clearly reflect the trophic status of the waterbodies and their constituents. The taxonomic specificity of contaminated zones becomes more conspicuous in August-September. Analyis showing the similarity of species composition corroborated the effect of the anthropogenic factor. During spring and winter the species composition of the periphyton does not differ markedly from that occurring one formed under natural conditions. In July-September, taxonomic heterogeneity becomes obvious, as shown by the decreased value for the species similarity index. The taxonomic structure of the periphyton and phytoplankton shows a tendency for taxa to be concentrated in a small number of genera and families. Most of the mass algal species are typical of cold water oligotrophic basins. According to revealed values of biomass and chlorophyll a concentrations the river is characterized as β-mesotrophic. On the base of indicator organisms the river water quality assessed as polluted.

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