Complex assessment of urban rivers influence on the Petrozavodskaya Bay of Onego Lake

L'estimation complexe de l'influence des rivières urbanisées sur la baie de Petrozavodsk du lac Onega

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RÉSUMÉ

On a examiné l'influence des rivières Chouïa, Lososinka et Neglinka sur l'état de la baie de Petrozavodsk du lac Onega, qui est la source d'eau potable pour la grande ville de Petrozavodsk (sa population est de près de 260 000 habitants). On présente les données pour la période 1990-2008 sur la dynamique de la composition chimique de l'eau des rivières en considération de l'influence des facteurs naturels et anthropiques selon les indices de la composition ionique, des particules en suspension, des éléments biogènes, du composé organique, des produits pétroliers, des métaux lourds. On donne l'estimation de l'état actuel des rivières les plus polluées selon la teneur en micro-éléments dans les sédiments de fond, selon les indices microbiologiques (groupes fonctionnels microbiens), selon les données de la recherche toxicologique des prélèvements d'eau et selon l'état d'ichtyofaune (estimation de la santé des poissons à la base de l'analyse histopathologique). On a examiné l'état des secteurs différents de la baie de Petrozavodsk (selon les indices hydrochimiques et hydrobiologiques), soumis à l'influence des rivières.

ABSTRACT

The influence of the Shuya, Lososinka and Neglinka rivers on the state of the Petrozavodskaya Bay of the Onego Lake is studied. Petrozavodskaya Bay is a source of drinking water for the town of Petrozavodsk (population is 260 thousands of people). The data (for period 1990-2008) on the dynamic of chemical composition of rivers water taking into account the influence of seasonal and anthropogenic factors are presented (including data on ionic composition, suspended matters, nutrition elements, organic matters, oil, heavy metals). Using the data on the content of microelements in the bottom sediment, microbiological parameters of water (functional groups of bacteria), results of toxicological investigation of river water and the state of fish (histological analysis) the assessment of modern state of the most polluted rivers is carried out. The situation on the Petrozavodskaya Bay (using the hydrochemical and hydrobiological data) in the context of river influence is examined.

KEYWORDS

Geochemistry, hydrobiology, Lake Onego, rivers.

1 INTRODUCTION

The rivers Shuya (water-shed area 10300 km^2, length 279 km, water discharge 90.7 m^3/c), Lososinka (water-shed area 302 km^2, length 25 km, water discharge 3.2 m^3/c) and Neglinka (water-shed area 46 km^2, length 26 km, water discharge 0.47 m^3/c) flow into the Petrozavodskaya Bay of Lake Onego (The National Water Cadaster, 1986). These rivers differ strongly in the hydrological parameters and the water-shed characteristics. A great amount of allochthonous organic matters enter to the Bay with the rivers water due to high degree of peat formation on the water-sheds. Besides, the rives Lososinka and Neglinka are situated on the urban territory which causes the inflow of different pollution to the river and then to the Bay. As the Petrozavodskaya Bay is a source of drinking water for town Petrozavodsk (Russia, Karelia, 61°47' of north latitude and 34°36' of east longitude) it is important to study the influence of rivers on the Bay water quality.

2 METHODS

The analyses of the chemical composition of rivers water samples were carried out in 1990-2008 according to the standard methods (The State of Water Bodies of the Republic of Karelia, 2007). The bottom sediments of rives were sampled in 2009 and were analyzed using the method ICP-MS. The contents (ppm) of microelements in the sediment (Mn, Cu, Zn, Cd, Pb, Sn, Ag, Mo, As) were compared with the maximum permissible concentrations (MPC) of these elements in the soils and with the clarkes (the mean contents of elements in the Earth's crust). Microbiological, toxicological and histopahtological investigations on the urban rivers Lososinka and Neglinka were carried out in 2009-2011. The functional groups of bacteria in the water samples were determined. The toxicity of water samples collected from the mouths of rivers was evaluated. The crustaceans *Gmelinoides fasciatus* Stebbing (invasive species from Lake Baikal which wide spread in the water bodies of Karelia last ten years) and *Ceriodaphnia affinis* Lillijeborg (standard test) were used in the toxicological experiment with duration of 14 days. In the autumn of 2009, a similar number of stone loach (Barbatula Barbatula) individuals from Lososinka and Neglinka Rivers were caught. Gill, liver and kidney of fish were examined histopahtologically (Bucke, 1994).

3 RESULTS AND DISCUSSION

3.1 The chemical composition of water and bottom sediments of rivers

The content of the total dissolved solids in the rivers water differ significantly: in the water of the river Shuya – 24 mg/l, in the river Lososinka – 50 mg/l, and in the river Neglinka – 176 mg/l. According to ionic composition rivers waters belong to calcium hydrocarbonate class. Due to high degree of peat formation on the water-sheds (10-20%) the rivers water are characterized by high colority (80-160 grad. of Pt-Co scale) and total ferrum concentrations (0.94-0.73 mg/l). The contents of organic matters in the rivers water are great: biochemical oxygen demand (BOD_5) – 1.39-1.67 mgO_2/l; chemical oxygen demand with permanganate as the oxidant – 19-20 mgO/l; chemical oxygen demand with dichromate as the oxidant – 30-43 mgO/l. The maximum concentration of organic matters in the river water is observed in early spring due to snow melt flood. The concentrations of suspended matters are varied in the limit of 3.6-5.3 mg/l. The concentration of the total phosphorous in the river waters may arrive to 34-93 µgP/l; the total nitrogen – 1.4-2.7 mgN/l. The values of pH change in the limit of 6.8-7.5. The concentrations of oil reach 0.02-0.17 mg/l. The heavy metal levels in the water are lower than the maximum permissible concentrations.

It was determined that the bottom sediments of the river Lososinka were most polluted. The contents of the following elements were higher that MPC: Mn (3 times higher), Cu (1.5 times) and Zn (2times). It was found that concentrations of these elements in sediments were higher than their clarkes: Mn (4.5 times), Cu (1.8 times), Cd (20 times), Pb (2.6 times), Sn (7.4 times), Ag (4.6 times), Mo (3 times) and As (7 times). The sediments of the river Neglinka were polluted less. The exceedence of clarkes were observed for the elements: Cd (10 times), Pb (1.6 times), Sn (1.6 times) and Ag (3 times). The sediments of the river Shuya were the least polluted.

3.2 The microbiological assessment of the rivers Lososinka and Neglinka state

In the water of the river Lososinka the amount quantity of oligotroph bacteria (0.7-18.7 thousands of colony-forming unit per ml) and actinomycetes (0.4-17.5 thousands of colony-forming unit per ml) were found. These kinds of bacteria destroy the humic substances in the water. In the river Neglinka the

content of these bacteria was 2-3 times higher. The abundance of saprophyte bacteria (1.9-3 thousands of colony-forming unit per ml) testify β-mesosaprobic status of two rivers. Especially high content of bacteria resistance to phenol (2.6-9.5 thousands of colony-forming unit per ml) and hydrocarbon oxidizing microorganisms (1.2-1.3 thousands of cells per ml) reflected the presence of great amount of oils and phenols. The high values of Coli-index (more than 10000 cells/ml) were observed in the years with high temperature and low levels of water. The main sources of bacterial pollution of these rives were waste waters.

3.3 The assessment of toxicity of the rivers Lososinka and Neglinka water

During summer period (in 2010-2011) the water samples were characterized by high toxicity: the death-rate of invasive species *Gmelinoides fasciatus* in undiluted rivers water varied in the limits of 43-86%. In the water samples diluted in10 times the death-rate decreased to 14-40%. At the same time the toxicity of water samples for standard test-organism *Ceriodaphnia affinis* was less; the death-rate of *C. affinis* in undiluted rivers water was only 0-30%. In was explained by more tolerance of *C. affinis* to pollution.

3.4 Histological analysis of fish tissues

Histological analysis of fish tissues revealed a variety of progressive, regressive and inflammatory alterations, neoplastic changes and circulatory disturbances. Also several cases of unspecified parasite invasions were diagnosed. Histopathological changes observed in the present study indicate that the fish were responding to the direct effect of the contaminants as much as to the secondary effects caused by stress. The results of the study correspond to the prior research devoted to ascertain tissue changes in different fish species taken from urban streams and confirm chronic pollution of the Lososinka and Neglinka Rivers.

4 CONCLUSION

The Petrozavodskaya Bay (the square 125 km^2, the average depth 18 m, the maximum depth 32 m) is characterized by low concentration of the total dissolved solids (32 mg/l) and high colority (80-140 grad. of Pt-Co scale) due to influence of rivers waters, first of all, due to the river Shuya. It explains the low quality of the Petrozavodskaya Bay water. The least quality of water is observed in the winter when the volume of the river Shuya water may reach to 60% of all volume of water Bay. The water supply intake is situated in the zone of rivers influence. Only in the summer and early autumn the situation improves due to income of water from Lake Onego from the open part of the Bay. According to hydrochemical parameters of the Bay bottom sediments (redox potential) and ration of biomass of bottom relict crustacean and oligochaeta the most polluted zones of the Petrozavodskaya Bay associate with the mouths of rivers. Totally influence of the rivers determined the mesotrophic status of the Bay.

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