Dynamics of Pechora basin river communities under influence of accident-related oil contaminations

Dynamiques des espèces d'un bassin du Petchora sous l'influence des contaminations accidentelles par les hydrocarbures

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RÉSUMÉ

Cette étude porte sur les dynamiques à long terme du zooplancton et du zoobenthos à la suite d'une rupture de pipeline dans un cours d'eau du nord du pays. Cette étude montre que les hydrocarbures avaient à la fois des effets négatifs et positifs sur les communautés de plancton et s'intéresse au rôle des bassins récepteurs dans l'autoépuration d'un réseau fluvial. L'augmentation de la quantité de zooplancton dans les eaux polluées et les modifications de sa structure peut servir de témoin des perturbations affectant les interactions trophiques dans l'écosystème et de l'accroissement des réserves nutritives des organismes planctoniques. L'étude révèle, en outre, que les plans d'eau artificiels, creusés pour réguler les courants pollués dans le cours d'eau, revêtent une importance supplémentaire en tant que régénérateurs biologiques d'écosystèmes aquatiques. Les bassins des écluses, des plans d'eau chargés de retenir l'eau mélangée aux hydrocarbures, situés dans le bassin récepteur du cours d'eau étudié étaient non seulement des infrastructures de génie hydraulique, mais aussi des installations de récupération biologique. En été, ces plans d'eau permettent le développement d'espèces animales présentant d'excellentes capacités d'épuration par filtration. La pollution chronique par les hydrocarbures et la contamination accidentelle du cours d'eau étudié ont entraîné une baisse de la quantité de zoobenthos et une réduction de la structure dans le lit de la rivière. Les groupes benthiques les plus sensibles à la pollution se sont révélés être les cladocères, les trichoptères et les plécoptères.

ABSTRACT

The long-term dynamics of zooplankton and zoobenthos was studied following an oil pipeline break in a northern river. Oil has been shown to have both negative and stimulating effect on planktonic communities and the role of the catchment area in river system self-purification is studied. The increase in zooplankton amount in oil polluted waters and changes in its structure can serve as an indication to disturbance of trophic interactions in the ecosystem and an increase in the food reserves of planktonic organisms. Artificial settling water bodies, which had been formed by regulation of polluted flows in the river, have been found to have additional significance as biological regenerators of aquatic ecosystems. The ponds of hydraulic gates, detention basins of water mixed with oil, situated in the studied river watershed were not only engineering but also biological reclamation facilities. In summer, they were the place for the development of fauna, showing high ability to clear water by filtration. Chronic oil pollution and accident-related oil contamination of the studied river led to decrease of zoobenthos quantity and structure reduction in the river channel. The most sensitive to pollution benthic groups were Cladocera, Trichoptera and Plecoptera.

KEYWORDS

Hydraulic gates, oil pollution, river ecosystems, zoobenthos, zooplankton.

INTRODUCTION

Russian and international organizations that establish natural water quality criteria assess the hazard class of oil and oil products (OP) as relatively low. An ecological disaster is declared when the OP exceeds 15 times the recommended level for water bodies that support fisheries. The response of communities to the pollution of continental waters by OP has not been adequately studied because of the diversity of natural conditions under which it occurs. It is known, for example, that OP toxicity and the rate of their destruction by microorganisms depend on the temperature.

The Kolva River (a tributary of the Pechora River) runs mostly from the north to the south, crossing two natural–climatic zones: tundra and taiga. The length of the river is 387 km. Since 1988, the Kolva River has been subjected to the impact of OP pollution caused by numerous spills from the oil pipeline. A series of breaks of this pipeline in autumn 1994 caused a spill of 103 to 126 thousand t OP onto the riverside and into the tributaries. A series of measures were taken to eliminate and mitigate the aftereffects of this emergency, including the containment of spilled OP, its collection, and technical and biological reclamation of lands. Dams were mounted on polluted creeks and small rivers, and hydraulic gates with settling ponds (totaling more than 100 on the river drainage basin) were used to contain the spilled OP and protect water from pollution. The ponds of those dammed areas are river type reservoirs, where the habitat conditions radically differ from those in other biotopes. It is important to study the response to oil spills of zooplankton and zoobenthos as the river ecosystem components and food resources for fish. We assessed the composition, abundance, biomass and dynamics of zooplankton and benthic communities following oil spills in the Kolva River, its tributaries (including mouths and regulated reaches), and other water bodies in their basins as river system components and independent ecosystems.

METHODS

Hydrobiological samples were taken in July 1995–1998, 2000, 2005, and 2007 from (1) the main channel of the Kolva River in the oil spill zone within the reach 0–150 km from the mouth, (2) at the mouths of left tributaries, and (3) at 10-100 m downstream of left tributary mouths. Samples were also collected from the ponds upstream of hydraulic gates on the tributaries in September 1995–1998 and 2000 and in July of 1997, 2001 and 2005.

Zooplankton samples were taken by passing 50–100 L of water from the surface layers of water bodies through plankton net. Benthic samples were collected with a hydrobiological scraper (0.3 m blades) and a Petersen grab.

RESULTS AND DISCUSSION

In the period before the industrial development of the Kolva River catchment area, zooplankton in the River was poor. As little as 15 rotifers (Rotifera) and crustaceans (Crustacea) species were identified in zooplankton in the 1950s. The rotifers zooplankton included only two species. The values of zooplankton abundance in the river did not exceed one thousand specimens/m^3. Between 1995 and 2007, 83 rotifers species and forms, belonging to 18 families, and 48 species and forms of crustaceans, belonging to 10 families, were recorded in the Kolva River. The maximal number of taxa was recorded in the Kolva zooplankton in 2000; their number was steadily increasing before this year and decreased after it. Only five rotifer and three cladoceran species and immature cyclopides were presented in the Kolva River in all periods. The dynamics of zooplankton in the Kolva River showed its trophic status to have change from oligo-mesotrophic to eutrophic. The abundance and biomass of zooplankton in the river channel in the first summer season after the accident (1995) were low and comparable with the background characteristics recorded in 1955. In 2000, the abundance and biomass were 1500 and 14000 times greater, respectively. In this year, the characteristics of zooplankton quantitative development in the Kolva River were largest in all years of studies and were comparable with the characteristics in oligo-mesotrophic lakes of the Pechora basin. Ninety two species were recorded in zooplankton of the examined left tributaries of the river: 61 species in the mouths and 79 species in the ponds of hydraulic gates. Zooplankton species composition in these reaches of the left tributaries and other water bodies in Kolva floodplain were specific. The communities at the mouths of creeks and in the ponds in front of hydraulic gates were most similar in terms of composition to the communities of the main channel in 2000 and 2005. Pond species of

rotifers and crustaceans (~25% of zooplankton species composition) developed in the upper pools; these species showed the ability to penetrate into river mouth and develop at the mouths of tributaries. One of the examined small water bodies (a stagnant pond on the side of a motor road), whose surface was completely covered by an OP film several millimeters in thickness, only unidentified Bdelloida were recorded. Hydraulic gates played important role in the formation of planktonic communities in the left tributaries of the Kolva River in the period after accident. From 1998 to 2005, lentic fauna penetrated into the main stream and dominated in terms of abundance in some its parts. The increase in zooplankton amount in OPpolluted waters and changes in its structure can serve as an indication to disturbance of trophic interactions in the ecosystem and an increase in the food reserves of planktonic organisms. Both experiments and field studies of the water bodies (e.g., Werner et al, 1985) have shown that the impact of crude OP did not suppressed their bacterial population, which increased its diversity and abundance. The effect of zooplankton stimulation in the Kolva River caused by its OPpollution was different in periods 1995–1997 and 1998–2000. The cause of this difference is the change in the methods of clearing and reclamation works in the river and the role of tributaries in the formation of conditions in the main channel in those periods (Fefilova, 2011).

Twenty two groups (large taxa of insects, worms and other) of zoobenthos were recognized in the Kola River. From the groups identified to species ones were more diverse and richer: Chironominae – 266 species and forms, Oligochaeta – 43. Decreases of zoobenthos quantity and structure reduction were observed in 2-3th years after damage of the oil-pipeline in the River channel. The most sensitive to pollution benthic groups were Cladocera, Trichoptera and Plecoptera. The most resistant to oil contamination of the river were Nematoda, Oligochaeta and Cyclopiformes.

CONCLUSIONS

The main factors determined dynamics of invertebrates communities in the Kolva River are weather conditions and a complex of anthropogenic factors, associated with oil pipeline functioning and accident: from variations in pollutant concentration, including noncyclic and seasonal, to changes in the hydrological regime. The contribution of zooplankton to selfpurification manifested itself both at the level of refugium and floodplain water bodies, as independent ecosystems, on at the level of the river system as a whole. The role of biotopes–refugiums in an OPpolluted river was the same as in a river system under extreme natural (e.g., seasonal) phenomena. The regulation of the Kolva River tributaries and the creation of low flow water bodies in the ponds in front of hydraulic gates were found to have additional significance. Those water bodies play special role in both maintaining the diversity of planktonic fauna in the polluted river and the production of additional biomass.

Chronic OPpollution and accident-related oil contamination of the studied river leaded to decrease of zoobenthos quantity and structure reduction in the river channel.

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