RR 2004

3rd European Conference on River Restoration
R I V E R   R E S T O R A T I O N   2 0 0 4
Zagreb, Croatia, 17-21 May 2004

The Pechora river: a natural-functioning river ecosystem or needs for restoration?

Vasily Ponomarev, Olga Loskutova, Ludmila Khokhlova, Harald Leummens

ABSTRACT: The Pechora, the largest river in North Europe, preserves almost natural ecosystem conditions. The Pechora river is crossed by only one bridge, and has one dam in an upstream tributary. The Pechora basin is one of the most sparsely populated areas in Europe, 0.5 million inhabitants on 322,000 km^2

The Pechora river is of utmost importance for fishery, hosting 36 fish species from 13 families, depending on a dense network of large and small tributaries. The river is inhabited by all 12 species of European Salmonidae. At the same time, throughout the Pechora basin, an ever-increasing local but persistent human impact is observed. Many watercourses are intersected by oil & gas pipelines and communications. The exploration and exploitation of valuable oil, gas and mineral resources locally causes physical and chemical, terrestrial and aquatic disturbance and pollution. In the central Pechora basin vast areas are subjected to intensive forestry. Industrial developments cause considerable structural and functional aquatic ecosystems changes. In addition, especially Salmonidae populations significantly decreased, a result of widespread poaching.

Within the framework of Russian-Netherlands project "Pechora River basin Integrated System Management" (PRISM), supported by the Partners for Water Programme of the Netherlands Government, integrated studies were performed on a number of Pechora tributaries, characterised by different types and levels of human impact. Based on the results of those and earlier research, the needs for aquatic ecosystem restoration are discussed, and a concept for actions at different scales is proposed.

KEYWORDS: Pechora river, natural ecosystems, impact, integrated field research, restoration needs

Introduction

The Pechora river is located in the far north-eastern part of European Russia. With a length of 1809 km and a basin area of 322,000 km^2 it is the largest river in the European North. The Pechora river springs from the North Urals mountains, crosses taiga, forest-tundra and tundra landscape zones in the Pechora lowland plain, and forms an extended delta to end in the Barents Sea. The latitudinal and longitudinal extension of the river basin, its dense network of large and small tributaries as well as its geological and geomorphological heterogeneity provide for a large diversity in physical conditions, creating patchy patterns in aquatic biology [26]. The Pechora river is crossed by only one railway bridge and only one dam occurs in an upstream tributary. The Pechora basin is also one of the least populated regions in Europe, inhabiting about 0.5 million permanent residents. The majority of its ecosystems therefore still preserve their almost intact natural characteristics [9] [21], with only locally some industrially contaminated sites [20] [21] [24].

However, local but persistent industrial pollution sources can be found in the Pechora watershed. Hundreds of watercourses are crossed by oil and gas pipelines and commu-

nications. Clear cutting of forests is widespread, especially in the central part of the basin. Some recent publications therefore highlight the Pechora basin as a severely polluted area [8] [15].

Within the Russian-Netherlands project PRISM, integrated studies of several Pechora tributaries were executed in 2002-2003. Selected tributary basins were characterised by intensive logging in the past, oil industrial developments, or by the occurrence of extended surfaces of virgin boreal forests, recognised in 1995 as a UNESCO World Natural Heritage site.

Analyses of field data on hydrology, hydrochemistry, hydrobiology and ichthyology, combined with previously collected information on other regions of the Pechora basin, allows to review the pollution state, to discuss whether the Pechora river system is still intact or in need of restoration.

RESULTS

Hydrology

The Pechora river can be divided into three main sections, i.e. the upstream section between the source and the Volosnitsa tributary, the middle stream section between the Volosnitsa and Usa tributaries, and the downstream section between the Usa tributary and the Pechora delta.

The discharge regime of the Pechora river and its tributaries depends mainly on snow melting water, determining 60-80% of the total annual discharge of on average 120 km^3 [2] [10]. Snow melt in spring causes large peak discharges in May and June. Related extensive flooding of the riverine floodplains is worsened by the northern flow direction of the river, as the melting water from the South is obstructed in its flow to the north by ice dams. During the 3-month summer low water period river water levels depend on groundwater discharges, with heterogeneity caused by infrequent intensive rain storms.
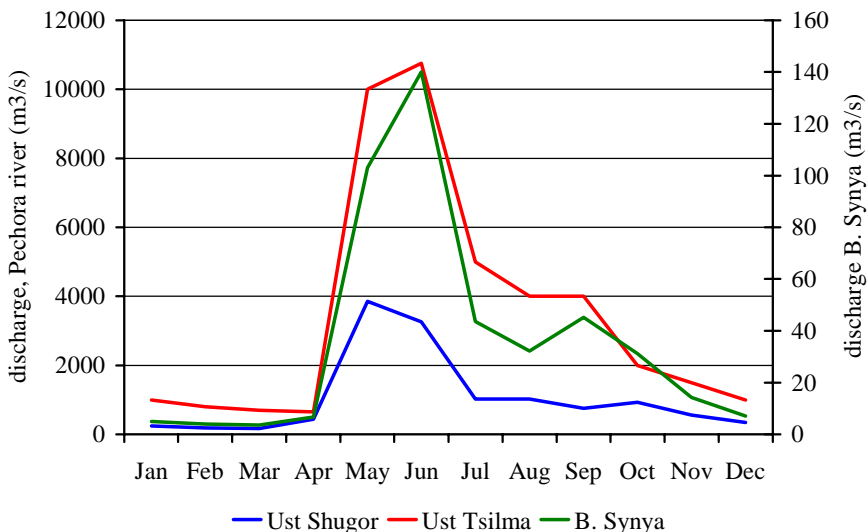

Figure 1 Discharge characteristics of the Pechora river and the Bolshaya Synya tributary

Discharge volumes reach an all-year low at the end of the winter period in April (figure 1). Depending on the inter-annual variation in climate conditions, the maximum temporal variation is the passing of the flooding amounts to 20 days.

Surface water chemistry

The chemical composition of surface water in the Pechora basin is monitored by the Centre for Hydrometeorology and Environmental Monitoring of the Komi Republic. Control gauge alignments are situated near the villages of Yaksha, Troitsko-Pechorsk, Kyrta, Pechora town, Ust-Kozhva, Ust-Tsilma and Oksino. Repeated hydrochemical studies of the Pechora main stream, from its upper reaches till Naryan-Mar, additionally were executed by the staff of the Institute of Biology [11] [12] [13] [22] [23] within special scientific programmes.

The mineral content of the Pechora water varies between 15.2 and 630.6 mg/dm^3. Maximum values occur in winter - with minimal water discharge, no (sub)surface runoff from the watershed and an increased dependence on groundwater. Minima occur during spring flood and rapid snowmelt. HCO_3^{2-} ions and Ca^{2+} cations dominate the chemical composition. The total mineral content as well as the ratios of bulk ions vary along the Pechora river, being higher in the middle stream river section (between Troitsko-Pechorsk and Vuktyl).

Ural tributaries in the upstream and middle stream sections of the basin as well as tributaries originating in bogs show in general low mineral contents (< 100 mg/dm^3). Left tributaries of the Izhma tributary, from the eastern slopes of the Timan Ridge, show increased SO_4^{2-} concentrations, varying between 250-450 mg/dm^3 during the summer low water period, exceeding 600 mg/dm^3 in winter. In the Ukhta tributary the concentration of Cl^- can be high due to many local chlorine springs. The concentrations of Na^+ and K^+ ions increase with increasing mineral content. Maximal mineral contents (up to 1000 mg/dm^3) and the highest variability in chemical composition (HCO_3^{2-}- SO_4^{2-}- Ca^{2+}, HCO_3^{2-}- SO_4^{2-}—Na^+ and HCO_3^{2-}-Cl^-—Na^+) were registered in the Vorkuta tributary [11].

Ammonium (NH_4^+) is the main component of mineral nitrogen, concentration varying widely (0.01-3.03 mg/dm^3). In the Velyu tributary concentrations vary between 0.51-1.0 mg/dm^3, exceeding maximum permissible concentrations for fisheries 1.3-2.6 times. Both soils and aerial deposition can be sources of nitrogen substances entering the water system. Often maximum concentrations of NH_4^+ are associated with human activities. Mineral phosphorous typically occurs in low concentrations (0.002-0.030 mg/dm^3), due to active consumption by photosynthesizing plankton organisms. In the Velyu tributary, the maximum content of mineral P observed was 0.108 mg/dm^3.

Total iron content broadly varies in the Pechora basin, with increased values (till 2.27 mg/dm^3) typical for surface water in boggy watersheds, with alpine and sub-alpine tributaries typically poor in iron. In the Velyu, Fe varied between 1.0-1.3 mg/dm^3. Iron concentrations mainly depend on natural factors.

Dissolved humic substances originating from bogs strongly affect water colouring in right tributaries of the Izhma, increasing up to 132^0, the permanganate oxidizability to 19.9 and the bichromate oxidizability to 63.6 mg/dm^3. In contrast, waters originating from the Urals or the Timan Ridge have low colour indices ($<9°$), low permanganate oxidizability (1.5-6.0) and low bichromate oxidizability (6.0-10.0 mg/dm^3).

Oxygen conditions are favourable as long as the water surface is not ice-covered, deficits occur in wintertime. Along the Pechora river, the amount of dissolved oxygen de-

creases from the source to the mouth, from a maximum oxygen saturation of 59% near Yaksha to only 21% near Oksino.

A number of Pechora tributaries - the Usa, the Izhma, the Ukhta, the Vorkuta, the Inta and the Kolva - are influenced by industrial activities in their basin. Waste water amounts entering the Pechora in the Komi Republic averages 450,000 m^3/year, a significant part (26%) of which is discharged into the Usa tributary [5] [6]. Although no official environmental disaster zones or zones with extreme environmental conditions were assigned, accidents can create tense environmental conditions on the secondary tributaries (mining waste water in the Vorkuta and the Bolshaya Inta, oil spills in the Kolva, industrial wastewater in the Ukhta).

Water quality deterioration in the Pechora is shown by oxygen deficits, increased values of BOD and the presence of pollutants. The most widespread and persistent pollutants are petroleum, phenols, copper, rarely zinc. Increased contents of petroleum and phenols were observed in the Ukhta and the Kolva tributaries, while copper exceeded maximum permissible levels at locations in the Vorkuta, the Kolva and the Ukhta tributaries.

A persistent excess of maximum permissible concentrations of ammonium nitrogen, petroleum, phenols and copper was registered throughout 1992 in several river sections within the Pechora basin, in particular in the Pechora river near Troitsko-Pechorsk, Pechora town and Ust-Tsilma; in the Usa river near the Seida railway station; in the Izhma river near Izvail village and downstream of Sosnogorsk town [11]. When assessing pollution, one must keep in mind that in surface water of the Pechora basin some components (iron compounds, phenols, copper and zinc) show high natural background concentrations.

Zoobenthos

Following the publishing of Zvereva [26] on zoobenthos of the Pechora river almost no new information was published. Although many watercourses were studied to various degree, an inventory of aquatic fauna populations in water bottoms was completed only for several second-order tributaries – the Usa, the Kozhim, the Shugor [1] [3] [16] [18] [19]. In 2002, repetitive research of aquatic bottom fauna was executed in the middle section of the Pechora river (Figure 2).

In the Pechora river, the degree of mobility of bottom substrates determines riverbed bottom productivity [26]. Mobile sands in the main riverbed are poorly inhabited by
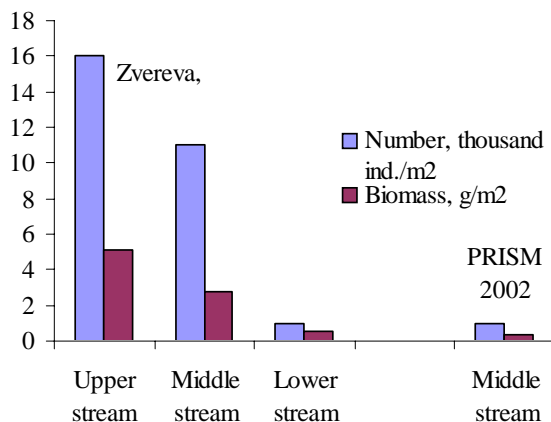

Figure 2 Quantitative indices of benthos communities in the Pechora in 1969 and 2002
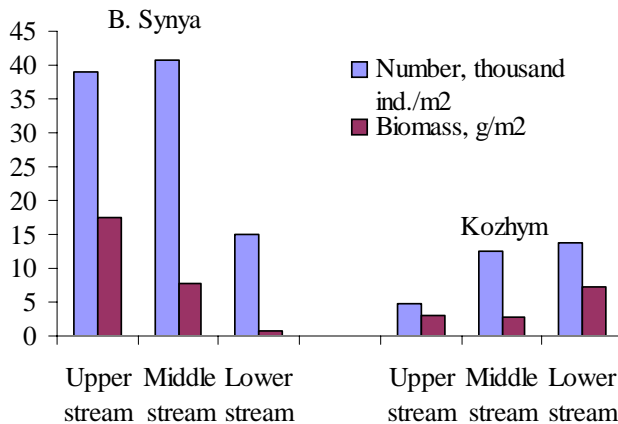
Figure 3 Quantitative indices of benthos communities in a natural and disturbed tributary

aquatic organisms - dynamic processes of erosion and sedimentation suppress their development, being even more limited in zones were the streambed is artificially deepened. In mobile sands, bottom fauna consists of a few individuals of chironomids, nematodes and lower crustaceans, their biomass only a fraction of a gram per m². Benthos are better developed (16 groups) on the silty pebbled types of water bottoms, and in thickets of macrophytes. The aquatic water bottom population is more diverse in small tributaries of the Pechora river, especially when crossed by motorways and with summer cottages situated on their banks (10,400 inds./m² and 3.6 g/m²).

In a large tributary of the Pechora with still an almost natural regime - the Bolshaya Synya - research showed a great diversity of zoobenthos. The majority of benthos consists of amphibian insects – caddisflies, stoneflies and mayflies, with Diptera (chironomids and blackflies) determining the features of aquatic fauna water bottom populations in Pechora tributaries from the Urals. Quantitative indices of benthos development are high, the highest species diversity, number and biomass observed in the upper reaches of the river, declining towards the river mouth (Figure 3). It shows that the average number of bottom organisms in the upstream and middle stream sections was comparable, about 40,000 inds./m², decreasing in the downstream section to 15,000 inds./m². Benthos in the upstream section mainly consisted of chironomide larvae (22,400 inds./m², or 57.1% of the total number of organisms), mayflies (14.2%), blackflies and mites. In the middle stream section, the number of chironomids was even higher – 28,900 inds./m² (71%). The high benthos biomass (17.6 g/m²) of the upstream section mainly was formed by large caddisflies larvae, blackflies and mayflies; in the middle stream section the biomass decreased to 7.7 g/m² (dominated by chironomids larvae, molluscs and caddisflies larvae), further decreasing to 0.8 g/m² in the downstream section (dominated by the larvae of chironomids and mayflies). Bottom invertebrate fauna of the Bolshaya Synya river comprised 1.5 more species than the man-impacted Kozhim river. The fauna of undisturbed, clear rivers originating in the Urals also includes rare invertebrate species from the Red Data Book of the Komi Republic, and well as Siberian fauna species.

The Ukhta and the Kolva tributary basins are characterised by oil-and-gas industrial development, and consequently have the worst environmental situation. Bottoms of

these rivers consist of sands with a low adsorption capacity. Aided by rapid currents, sands impede petroleum sedimentation and accumulation in the river bed. Nevertheless, chronic and accidental oil spills result in reduced quantitative indices of benthos development – a decreased frequency of occurrence of most insect groups and a change in their species composition [14]. Towards the river mouth, with increasing pollution, the relative contribution of chironomids decreases and that of olygochets and blackflies correspondingly increases. A change in bottom biocenoses structure causes a direct change, a deterioration, of the food base for valuable commercial fish.

In 1992 the environmental situation in the Ukhta tributary was considered to be unsatisfactory, with the river suffering under intensive human pressure [25]. The bottom fauna population was devoid of typical inhabitants of unpolluted waters, in stead dominated by contamination-resistant species. In the late 1990s, the decline of industrial production, the reduction of liquid waste discharges and their better purification improved the general environmental conditions [7]. Research results in 2001 revealed a higher degree of productivity and diverse species composition of invertebrates.

Clear felling was a typical practice in watershed forests of numerous tributaries of the Pechora river, including the Velyu river, and many rivers suffered from long-term timber rafting. Today, oil and gas extraction are core businesses in the Velyu watershed, and many new oil and gas pipes are being built. During our research we registered 19 aquatic species groups in the Velyu basin, with, as shown in previous research [27], biomass and number of benthos on sandy bottoms of river stretches dominated by chironomids (over 80% of total benthos). However, previously also very high numbers of lower crustaceans – cladocers and copepods – were registered [27]. Nowadays, their number in the riverbed is low. On river rapids, the benthos are predominantly represented by chironomids (57.8 %), larvae of mayflies (9.4 %) and blackflies (6.3%). The benthos biomass is dominated by larvae of caddisflies (25.8 %) and chironomids (25.4 %). Quantitative indices of bottom fauna development in 2002 are lower than those registered in 1970s, with today numbers varying between 3,400 and 9,200 inds./m^2, compared to 4,700 – 45,000 inds./m^2 in the past. Biomass amounts now vary between 1.3 and 3.4 g/m^2, compared to 1.4 – 5.0 g/m^2 in the past. The benthos population of the riverbed downstream of oil and gas pipelines is the poorest, with biomass values of 1.1 g/m^2. In the brooks of the Velyu basin the benthos population is diverse enough, represented by 13-15 groups. Chironomids, nematodes and mayflies reach the highest number in brooks, and biomass is dominated by larvae of caddisflies, mayflies, sometimes *Diptera* or molluscs. In general, the number and biomass are low, 2,000-3,000 inds./m^2 and 1.7 g/m^2.

The industrial extraction of alluvial gold in the upper Kozhim basin in the 1980-1990s, using hydromechanized open-cast mining methods, strengthened erosion processes and increased the flow of large amounts of terrestrial sediments into the river. However, the water chemical composition did not significantly change due to these activities. Other effects included the increased content of suspended matter in the water, sand sedimentation covering primary soils, declining moss and algae cover. These effects caused changes in the structure of bottom biocenoses, decreased number and biomass of bottom organisms, and a declining benthos species composition [3]. Near extraction sites the benthos biomass decreased 5 –6 times, also the number of organisms, especially young, rapidly decreased. Low-productive biotopes formed on pebble-boulder soils covered with thick sandy alluvia, not inhabited by larvae of stoneflies, blackflies and

caddisflies, all of which are typical residents of boulders and serve as food for game fish. Intensive drifting of bottom organisms also testifies to unfavourable environmental conditions for water organisms. Main groups of bottom fauna still occur, but the most typical and rare invertebrate species inhabiting clean waters of the Ural rivers disappeared from the inventory lists. Nevertheless, the results of recent studies still confirm persistent and highly productive properties as well as benthos biodiversity in the middle and downstream sections of the river [16]. The average number and biomass of benthos in the upper section of the Kozhim river during the gold extraction period amounted to accordingly 4,700 inds./m^2 and 3 g/m^2. The same indices were higher in the middle and lower reaches (Figure 3).

Fish population

The Pechora river system is of great fishery value and unique in Europe in still serving as a habitat for practically all 12 European Salmonidae species. This value of the Pechora fish population is determined by diadromous species (Pink Salmon *Oncorhynchus gorbuscha* Walb., Atlantic Salmon *Salmo salar* L. and Arctic Cisco *Coregonus autumnalis* Pall.), by semi-diadromous fishes, sometimes occurring as settled forms (European Cisco *Coregonus albula* L., Siberian Whitefish *Coregonus lavaretus pidschian* Gm., Inconnu *Stenodus leucichthys* Guld. and European Smelt *Osmerus eperlanus* L.), as well as by local anadromous species (Taimen *Hucho taimen* Pall., Arctic Char *Salvelinus alpinus* l., Broad Whitefish *Coregonus nasus* Pall., Peled *Coregonus peled* Gm., European Grayling *Thymallus thymallus* L. and Arctic Grayling *Thymallus arcticus* Pall.). In literature further the occurrence of 36 fish species from 13 families is described [17].

In the recent years, the Salmonidae populations showed a large decrease in numbers, associated with increased human pressure on fish resources and their environment. Negative human activities include water pollution through industrial, agricultural and household waste water and, first of all, poaching. Data show fish population numbers in water bodies free of industry or agriculture (i.e. the Belaya Kedva, the Maliy Patok and the More-Yu river basins) exceed those in man-impacted water bodies (the Izhma river, and especially the Svetliy Vuktyl and the Kolva). Especially it is true for Salmonidae, in particular Whitefishes, while density of less economically valuable fishes in some cases even increased in the impacted water bodies.

Besides changes in population numbers, also the fish population structure is affected by human impact, most prominently in valuable game fish, through a decrease in the number of age groups and average age of caught fish (Figure 4). Due to migration behaviour effects also can be observed not only in the directly man-impacted rivers systems, but also in the rivers in protected areas, e.g. the Belaya Kedva and the Maliy Patok.

Research in 2002 showed the absence of Whitefish, Burbot, Pike, Perch and Roach in the main riverbed of the Velyu river. These fishes are typical inhabitants of the tributaries in the Pechora lowland plain, and previous research showed their common occurrence in the area 30 years ago. Afterwards the Velyu became intensively used by man, first widespread clear felling, more recently oil and gas exploration and transportation. Still present are Grayling, Whiskered Char and Sculpin.
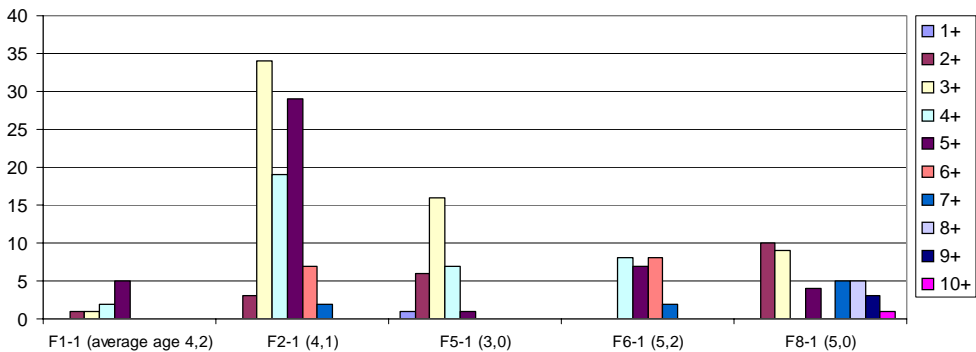
Note: F1 –Izhma, F2 – Belaya Kedva, F3 – Ortina, F4 – Neruta, F5 – Svetliy Vuktyl, F6 – Maliy Patok, F7 – Kolva, F8 – Moreyu.

Figure 4 Age structure of Thymallus thymallus catches in different rivers

Conclusions

The results of recent integrated research shows that the Pechora river still preserves almost natural hydrological, hydrochemical and hydrobiological conditions in major part of its watershed.

Observed disturbances of abiotic parameters, qualitative and quantitative indices of aquatic and amphibian invertebrate populations, are local, caused either by accidental and/or chronic industrial pollution or severe changes in the hydromorphological structure of water bodies.

Observed changes in the fish population structure are most prominent for protected or valuable game fishes - declining numbers, a decreasing number of age groups and the average age of populations. These changes occur almost everywhere, both in the impacted and natural water bodies. As such, conserving valuable Salmonidae populations through improving the efficiency of fish conservation activities largely depends on vigorous and original decisions taking the specific features of the species life cycle into account. This includes the search for alternative sources of livelihood for the local people in the Pechora basin.

A multi-level ecosystem recovery concept for the Pechora watercourses is suggested, including:

- Application of integrated activities to recover local fish populations in reserves: bringing the conservation regime in protected natural areas in accordance with legislation, in spite its status;
- Increasing the efficiency of fish conservation: establish a system of integrated environmental water systems monitoring, preserving natural abiotic regimes outside nature reserves, along migration routes of anadromous and semi-diadromous fishes;
- Develop and incorporate a program for hydrotechnical and biological recovery of water bodies (including small watercourses) damaged due to mining, logging and oil spills.

Acknowledgements

References

1. Anonymous, 1962. Fishes of the Usa basin and their food resources. Moscow-Leningrad. 276 pp. (in Russian);

2. Anonymous, 1972. Surface water resources of the USSR. Vol. 3 – Northern area. Leningrad, 662 pp. (in Russian);

3. Anonymous, 1994. Environmental impacts of the development of alluvial deposits in the Sub-Polar Urals. Syktyvkar,167 pp. (in Russian);

4. Anonymous, 1995. National Water Code - Annual data on inland water quality. Archangelsk, Vol. 1 (28), Issue 9 (in Russian);

5. Anonymous, 2000. National Report on the State of Environment in the Komi Republic in 1999. Syktyvkar, 260 pp. (in Russian);

6. Anonymous, 2001. National Report on the State of Environment in the Komi Republic in 2000. Syktyvkar, 190 pp. (in Russian);

7. Baturina M.A., 2001. Bottom invertebrates in surface water quality assessment (on the example of class Oligochaeta). Scientific reports; Issue 441, Syktyvkar, 21 pp. (in Russian);

8. Chernaev A.M. (Ed.), 1999. Russia: river basins. Yekaterinburg, Aerokosmoecology, 520 pp. (in Russian);

9. Eerden, M. van (ed.), 2000. Pechora Delta. Structure and dynamics of the Pechora Delta ecosystems (1995-1999). Lelystad, The Netherlands, 367 pp.;

10. Filenko, 1974. Mean annual water discharges. In: Atlas of the Komi ASSR. Moscow, p. 31-33 (in Russian);

11. Khokhlova L.G., 1990. The hydrochemical regime of the Izhma river and its tributaries. In: Biogeographic problems of development of the North. Komi Filial, Geographic Society of the USSR, manuscript deposited No. 1200-B-90, p. 25-36 (in Russian);

12. Khokhlova L.G., 1994a. Assessment of water quality in reservoirs of the Vorkuta industrial centre. Scientific reports, Komi SC UrD RAS, Issue 346, Syktyvkar, 24 pp. (in Russian);

13. Khokhlova L.G., 1994b. Assessment of surface water quality of the Pechora basin. Materials of intern. Congress "Water: Ecology and Technology ", Vol. 1, Moscow, p. 312-319;

14. Loskutova O.A., 2002. State of bottom biocenoses of the Arctic rivers under oil contamination. Materials of the 2nd Intern. Symp. AMAP "Environmental Pollution of the Arctic", Rovaniemi, Finland, p. X 10;

15. Lukin A.A., Dauvalter V.A., Novoselov A.P., 2000. Ecosystem of the Pechora river in modern conditions. Apatity, 192 pp. (in Russian);

16. Ponomarev V.I., Loskutova I.A., Yurkin I.I., 1996. α-biodiversity of water communities in the middle and lower reaches of the Kozhim river. In: Biological diversity of man-transformed landscapes of the European North-East of Russia. Works of the Komi Science Centre, UrD RAS, No. 149, Syktyvkar, p. 140-149 (in Russian);

17. Ponomarev V.I. & Sidorov G.P., 2002. Review of ichthyological and fishery researches in the Pechora river basin. In: Aquatic organisms in natural and man-transformed ecosystems of the European North-East. Works of the Komi Science Centre, UrD RAS, No. 170, Syktyvkar, p. 5-33. (In Russian);

18. Shubina V.N., 1986. Hydrobiology of a salmon river in the North Urals. Leningrad, Science, 157 pp. (in Russian);

19. Shubina V.N. & Estafiev A.A. 1998. Benthos of salmon rivers in the mountain part of the Sub-Polar Urals. Ecology, 4: 304-309 (in Russian);

20. Solovieva N., Jones V.J., Appleby P.G., Kondratenok B.M., 2002. Extent, environmental impact and long-term trends in atmospheric contamination in the Usa basin of East-European Russian Arctic. Water, Air, and Soil Pollution 139, p. 237-260;

21. Taskaev A., Fokkens B., Lavrinenko I., van Eerden M., Lavrinenko O., Ponomarev V., 1998. Actual state of the Pechora basin ecosystems: biological richness of an undisturbed river flow. In: Dealing with nature in Deltas: proceedings of Wetland Management Symposium. Lelystad, the Netherlands, p. 81-91.;

22. Vlasova T.A., 1966. Hydrochemistry of the Pechora and the Vychegda river basins in the area of the designed water storage pools. Review of Degree Paper, Cand. Biol. Sci. Syktyvkar, 26 pp. (in Russian);

23. Vlasova T.A.,1988. Hydrochemistry of the main rivers in the Komi ASSR. Syktyvkar, 150

24. Walker T.R., Young S.D., Crittenden P.D., Zhang H., 2003. Anthropogenic metal enrichment of snow and soil in north-eastern European Russia. Environmental Pollution, 121, p. 11-21;

25. Zakharov A.B., Ermakov A.A., Shubin Yu.P., Shubina V.N., Baranovskaya V.K., Ponomarev V.I., 1995. Biological communities of the Ukhta river basin under conditions of multi-factorial anthropogenic contamination. Scientific reports, Komi Science Centre, UrD RAS, Issue 349, Syktyvkar, 16 pp. (in Russian);

26. Zvereva O.S., 1969. Specific features of biology of main rivers of the Komi ASSR. Leningrad, 279 pp. (in Russian);

27. Zvereva O.S., 1971. General characteristics of benthos of the middle Pechora River and its left tributaries in relation to specific hydrographical features. Biological studies of northern rivers within the territory of ancient lake depressions, Syktyvkar, p. 44-59 (in Russian).

Authors:

Vasily Ponomarev, Institute of Biology, Komi Science Centre, Ural Division, Russian Academy of Sciences. Kommunisticheskaya street 28, 167982 GSP-2, Syktyvkar, Komi Republic, Russia. E-mail: ponomarev@ib.komisc.ru

Olga Loskutova, Institute of Biology, Komi Science Centre, Ural Division, Russian Academy of Sciences. Kommunisticheskaya street 28, 167982 GSP-2, Syktyvkar, Komi Republic, Russia.

Ludmila Khokhlova, Institute of Biology, Komi Science Centre, Ural Division, Russian Academy of Sciences. Kommunisticheskaya street 28, 167982 GSP-2, Syktyvkar, Komi Republic, Russia.

Harald Leummens, DHV Water BV, Storkstraat 8, 3833 LB Leusden, the Netherlands. E-mail: hleummens@rambler.ru