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The Anthropogenic Transformation of the Water Bodies of the European North of Russia

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Abstract — Water bodies of the European North of Russia are classified according to the water contamination level. The high degree of contamination of particular river sections in the European North is shown to be caused by the accumulation of toxic heavy metal compounds and other pollutants. The values of the anthropogenic-altered natural background of water bodies were estimated. It was shown the content of phenol and of copper compounds, of iron and of nickel to exceed the maximum allowable concentrations dozens of times.
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INTRODUCTION

The environmental changes, both natural lasting throughout the geological Earth history, and man-made occur constantly. Human intervention can lead to a sharp and quick change of the average state of the environment in the region [1] as well as to global environmental disruption. The water bodies greatly suffer from the anthropogenic economic activity, since almost all industrial and domestic human activity is connected with the large amounts of clean water consumption and discharges of polluted water into water bodies. In majority, wastewater of the enterprises included to economic activity is a powerful source for a variety of organic and inorganic pollutants discharged into water bodies and watercourses through surface and subsurface flow, that entails a significant change of the gas, hydrochemical and hydrobiological regime [2–4].

The survey on the changes caused by various types of anthropogenic activities has become quiet a topical subject in the present context.

Analysis of long-term regime observations of the water bodies environment in Russia,made by the State Observing Service (SOS) has shown that in recent years many water bodies in different regions were registered as the stably dirty ecosystems according to the water contamination rate [5–8]. The most polluted water bodies are within the so-called impact areas. The impact area [7] is taken to mean the area within the territorial-production complex where the negative environmental changes resulted to the man impact.

The impact regions of Russia include the European part of the North as well where the water bodies suffer from a strong anthropogenic impact and have varying degrees of contamination. The modern ecological state of water ecosystems of the European North significantly differs from the natural one, relevant to the period preceded by the intensive industrial development of the region.

The European North is located in the zone of complex natural conditions (permafrost, bogginess and harsh climate) while it is rich in natural resources. It is an important fuel and energy sector of the western part of Russia where more than half of its water and propellant reserves (oil, gas, coal, peat, shale rocks) and about half of the forest resources are concentrated. This region is rich with chemical raw materials, ores of nonferrous and ferrous metals and reserves of construction materials. The density of industrial enterprises is very high in this region [9, 10].

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The quality of surface waters in this region is strongly influenced by waste water of mining, coal, oil, timber and fish-processing industries. Specific character of the northern European industrial enterprises and the amount of wastewater in aquatic ecosystems are the main causes of the recently increased anthropogenic component composition transformation of the aquatic environment of the studied river ecosystems.

In addition, during the crisis economic transition of Russian economy the uncontrolled usage of natural and water resources of the northern region increased. This resulted in pollution focus formation and noticeable change in ecological state of water bodies of the European North. The main anthropogenic factors should include the chemical water pollution as a result of disposal of sewage and the air emission, as well as regulation of river flow, thermal effects, the various hydraulic engineering works [7, 8, 11].

The formation of the modern ecological state of water bodies is strongly influenced not only by anthropogenic but natural factors as well. The main natural determinants are the variability of runoff and stream loads, ice and thermal regimes, channel operation, volume and chemical precipitation composition, solar radiation.

The formation and the chemical composition of natural water bodies also depend on the intersystem (interbasin) agents, especially oxidation-reduction and production-destructive processes including the processes of pollutant transformation.

Component composition changes of the abiotic components tending to the expansion of interannual and intraannual fluctuations in the concentration ranges of many hydrochemical indices and the increasing frequency of recurrence of maximum allowable concentration (MAC) of priority pollutants are among the main long-term environmental effects caused by the anthropogenic impacts [7, 8]. In consequence of chemical composition transformation of aquatic medium the rearrangement of structure in aquatic biotic communities takes place.

Thus, the anthropogenic transformation of environmental condition and the formation a new anthropogenically-altered natural background are observed to develop in the water bodies of the European North of Russia [12].

MATERIALS AND METHODS

The research and calculations were based on the long-term regime monitoring of hydrochemical and hydrobiological information accumulated by the Federal Service (SOC) of Russia on Hydrometeorology and Monitoring of the Environment (RHM). The validity of the regime information used to identify major changes in hydrological-ecological status of water bodies provided by the RHM is determined by its complexity, regularity and sufficient duration of regime observations that allows to identify long-term trends in volatility state of water bodies. In addition, it is important that the above mentioned information is obtained by using the common methods of sampling and analysis practiced by RHM.

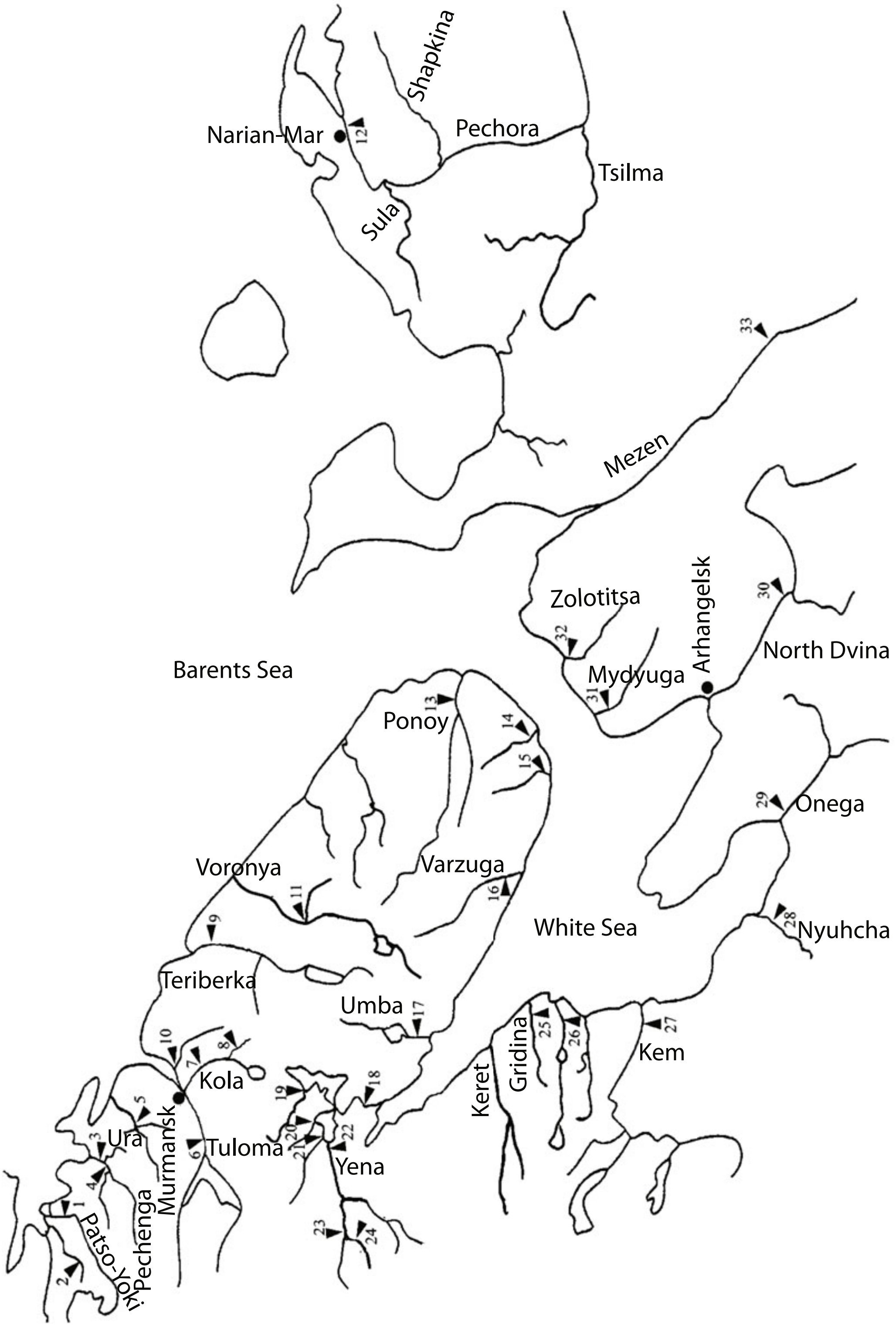
The baseline data set included observations on the stationary control points located in the river basins of the Barents and the White Seas, namely, long-term regime information of 34 observation stations of the RHM located on thirty North European rivers within the period of 1985–2007 (Fig. and Table 1).

The frequency of sampling for hydrochemical parameters averaged 6–10 times a year and for hydrobiological parameters 3–6 times. The variational series including at least 15–20 years of regime observations were accepted for the research as ecologically significant.

The pollution pattern and intensity assessment of the water environment of the tested rivers was carried out with the method of integrated assessment degree of surface water pollution by hydrochemical parameters which allows to assess simultaneously water pollution on a wide range of ingredients and water quality indicators and to classify the degree of contamination [13].

The anthropogenically-altered nature background for the biggest and the most important water bodies of the European North was estimated for 16 rivers according to hydrochemical index and for the largest 14 rivers of the Kola Peninsula according to hydrobiological index. Of all the variety of the rivers only rivers of the Kola Peninsula are subjected to a regular hydrobiological monitoring by the Murmansk Administration of Hydrometeorological Service (Murmansk AHMS).

Anthropogenically-altered natural background is a complex of basic natural background parameters, preserving a long-term stable change under the influence of anthropogenic factors [12]. Therefore, in order to determine the boundaries of anthropogenically-altered natural background, statistical data processing was carried out and intervals of the most common values of hydrochemical or hydrobiological index of the ecosystem were selected. The presence of stable variations of the main indicators of the natural background serves to



Location of observation stations of the State Observation Service network in the European North of Russia.

prove the formation of a new anthropogenically-altered background.

RESULTS AND DISCUSSION

Variation of degree of water pollution of rivers. Increasing pollution of water bodies is a result of additional input of organic and inorganic contaminants of wide range into the aquatic medium. Therewith, the assessment of distinct pollutants contribution into the overall pollution of the aquatic ecosystem is practically impossible for a variety of environmental and analytical reasons [14]. This predetermined the use of integrated assessment methods of surface water pollution estimation by hydrochemical indicators mentioned above [13].

Analysis of long-term hydrochemical information for the period 1985–2007 made it possible to assess the level and temporal dynamics of the degree of contamination of aquatic ecosystems of river basins of the Barents and the White Seas and to arrange them by the degree of contamination. The degree of contamination of the aquatic medium studied in the northern European rivers is shown in Table 1 and is classified as follows:

• transition from "slightly" to "rather polluted" for the rivers Patso-Yoki, Ura, Kitsa, Teriberka, Ponoy,

Table 1. Variability of the pollution rate of the water environment of the Barents Sea Basin[a]

Regime observation station[b]	Rate of pollution				
	1985–1989	1990–1994	1995–1999	2000–2004	2005–2007
r. Patso-Yoki, ts. Borisoglebsky (1)	rather and highly polluted	slightly and rather polluted	rather polluted	slightly polluted	slightly polluted
Kolos-Yoki, uts. Nickel (2)	dirty	dirty	dirty and highly dirty	dirty	dirty
r. Pechenga, ts. Korzunovo	rather and highly polluted	rather and highly polluted	highly polluted	rather and highly polluted	rather polluted
r. Pechenga, st. Pechenga (3)	highly polluted	rather polluted	highly polluted	rather polluted	rather polluted
r. Luottn-Yoki, 5th km up the outflow (4)	dirty	dirty	dirty	highly polluted and dirty	dirty and highly polluted
r. Nama-Yoki, 0.5th km up the outflow	highly polluted and dirty	highly polluted	highly polluted	rather and highly polluted	rather and highly polluted
r. Ura, vil. Ura-Guba (5)	rather and highly polluted	rather polluted	rather polluted	slightly and rather polluted	slightly polluted
r. Kola, uts. Vuhodnoy (7)	rather and highly polluted	rather polluted	rather polluted	slightly polluted	rather and slightly polluted
r. Kola, 0.8th km up the outflow	highly polluted	rather polluted	highly polluted	rather and highly polluted	rather polluted
r. Kitsa, 2.2th km up the outflow (8)	rather and highly polluted	rather polluted	rather polluted	slightly polluted	slightly polluted

Table 1. (Contd.)

Regime observation station	Rate of pollution				
	1985–1989	1990–1994	1995–1999	2000–2004	2005–2007
r. Rosta, Murmansk (10)	highly and extremely dirty	highly dirty and dirty	dirty	dirty	dirty
r. Tiberka, 60th km of Serebryanskaya Highway (9)	rather polluted	rather polluted	rather polluted	rather polluted	slightly polluted
r.Virma, vil. Lovozero (11)	highly polluted	highly polluted and dirty	highly polluted	rather polluted	rather polluted
r. Pechora, c. Pechora	dirty	highly polluted	rather polluted	rather polluted	rather polluted
r. Pechora, s. Oksino (12)	dirty	rather and highly polluted	rather and highly polluted	highly polluted	highly polluted
r. Ponoy, ts. Krasnoshchelye (13)	slightly and rather polluted	rather polluted	rather polluted	slightly polluted	slightly polluted
r. Umba, 3th km up the hatchery	rather and highly polluted	slightly pollute	rather pollute	slightly and rather pollute	slightly polluted
r. Nyuduay, 0.2d km above outflow(21)	highly and extremely dirty	highly poluted	highly poluted	dirty and highly dirty	dirty
r. Belaya, 1st km up the outflow (20)	dirty	highly polluted	highly polluted and dirty	rather and highly polluted	rather and highly polluted
r. Kovdor, c. Kovdor 4 km up the inflow of r. Mozhel	rather and slightly polluted	slightly and rather polluted	slightly and rather polluted	slightly polluted	condit. clean and slightly polluted
r. Kovdor, 7th km down the inflow of r. Mozhel (23)	dirty	rather and highly polluted	rather polluted	slightly and rather polluted	rather and slightly polluted
r. Mozhel, 0.25th km up the outflow (24)	highly polluted	highly polluted	rather polluted	rather and highly polluted	rather and slightly polluted
r.Yena, ts.Yena (22)	highly polluted	rather polluted	slightly and rather polluted	slighhtly polluted	no data
r. Niva, c. Kandalaksha (18)	rather polluted	slightly and rather polluted	rather polluted	slightly and rather polluted	no data
r. Vite, 0.5th km above outflow (19)	rather and slightly polluted	rather and slightly polluted	rather polluted	slightly polluted	no data

Table 1. (Contd.)

Regime observation station	Rate of pollution				
	1985–1989	1990–1994	1995–1999	2000–2004	2005–2007
r. Gridina, vil. Gridino (25)	slightly polluted	no data	no data	slightly and rather polluted	slightly polluted
r. Pongoma, vil. Pongoma (26)	transit. from rather to slightly polluted	no data	no data	slightly and rather polluted	slightly polluted
r. Kem, c. Kem (27)	slightly and rather polluted	slightly and rather polluted	no data	slightly polluted	slightly polluted
r. Nyuhcha, vil. Nyuhcha (28)	slightly and rather polluted	rather polluted	no data	rather polluted	rather polluted
r. Onega, vil. Porog (29)	rather and highly polluted	rather polluted	rather polluted	rather polluted	highly polluted
r. Northern Dvina, vil. Ust Tzilma (30)	highly polluted	rather polluted	rather and highly polluted	slightly and rather polluted	rather and highly polluted
r. Mudyuga, s. Patrikeevskaya (31)	transit. from slightly to rather polluted	slightly polluted	slightly and rather polluted	rather polluted	highly polluted
r. Zolotitsa, s. Upper Zolotitsa (32)	transit. from slightly to rather polluted	slightly and rather polluted	rather polluted	rather and highly polluted	rather polluted
r. Mezen, s. Malonisogorskaya (33)	rather and highly polluted	rather and highly polluted	rather and highly polluted	rather polluted	rather polluted

[a] Table 1 is based on ref. [6] and supplemented with the data of the author. [b] r. is river, c. is city, uts. is urban-type village, vil. is village, ts. is township, s. is settlement, st. is railway station. Numbers correspond to those in Fig.

Umba, Kovdor, Jena, Niva, Vite, Gridin Pongoma, Kem, Nyuhcha;

• transition from “rather” to “highly polluted” for the rivers Pechenga, Nama-Yoki, Kola, Virma, Mozhel, Pechora, Onega, Northern Dvina, Mudyuga, Zolotitsa, Mezen;

• transition from “highly polluted” to “dirty”for the rivers Kolos-Yoki, Luottn-Yoki, Belaya;

• “highly and extremely dirty” for the rivers Rosta and Nyuduay.

Water bodies with the same degree of contamination of the aquatic medium are characterized by the particular composition of priority pollutants.

For the rivers with the degree of the aquatic medium contamination corresponding to “slightly”, “rather” or “highly polluted” category the prior pollutants are: compounds of iron and of copper, phenols, and oil products which annual average concentrations may occasionally reach the levels exceeding the maximum allowable concentration 10–16 times (Table 2).

Increasing annual average concentrations of sulphates (up to 4.6 MAC) and nitrite nitrogen (up to 9.6 MPC) in addition to above mentioned priority pollutants rise the degree of water pollution of rivers and convert them into the category of “dirty” (Table 3).

The list of the prior pollutants in the aquatic medium of rivers with the degree of pollution “dirty”, “highly”

Table 2. Priority pollutants in the aquatic medium of "slightly", "rather" and "highly" polluted water bodies of the European North of Russia[a]

River	Regime observation station[b]	Priority pollutants	Excess of MAC, times
Patso-Yoki	ts. Borisoglebsky	copper compounds phenols	1.3 – 6.6 1.7 – 10.5
Ura	vil. Ura-Guba	iron compounds copper compounds phenols	0.6 -5.5 2.5 – 8.8 0.8 – 7.8
Kola	lake Kolozero ooutlet	copper compounds phenols zinc compounds	3.0 – 8.6 0.6 – 11.4 0.2 – 2.5
Kola	utv. Vuhodnoy	iron compounds copper compounds phenols	1.0 – 3.2 3.8 – 10.4 1.4 – 7.8
Kitsa	2.2[d] km above outflow	iron compounds copper compounds phenols	1.4 – 3.3 2.6 – 9.5 bdl – 9.0
Teriberka	60th km of Serebryanskaya highway	iron compounds copper compounds phenols	1.5 – 3.5 3.0 – 8.0 2.3 – 12.5
Ponoy	vil. Krasnoshchelye	iron compounds copper compounds phenols	3.6 – 10.9 3.1 – 10.8 2.3 – 10.3
Umba	hatchery	iron compounds copper compounds phenols	1.1 – 3.5 2.8 – 12.0 2.0 – 6.2
Niva	c. Kandalaksha	copper compounds phenols	2.7 – 9.4 0.4 – 7.9
Yena	uts. Yena	iron compounds copper compounds phenols	0.6 – 5.4 1.7 – 6.7 bdl – 12.3
Kovdora	c. Kovdor 4th km up the c.	copper compounds phenols	1.4 – 8.2 1.2 – 6.8
Vite	0.5th km up the outflow	copper compounds phenols	2.8 – 12.3 0.8 – 9.2
Gridina	vil. Gridino	iron compounds oil	2.5 – 4.4 1.1 – 11.0
Pongoma	vil. Pongoma	iron compounds oil	1.0 -7.4 1.0 – 4.4

Table 2. (Contd.)

River	Regime observation station	Priority pollutants	Excees of MAC
Kem	c. Kem	iron compounds oil	2.3 – 4.6 1.3 – 7.8
Nyuhcha	vil. Nyuhcha	iron compounds oil	3.6 – 10.9 1.7 – 8.0
Kolos-Yoki	uts. Nickel 14.7th km up the uts.	copper compounds nickel compounds phenols	2.0 – 7.4 1.1 – 4.3 1.1 – 9.0
Pechenga	st. Korzunovo	iron compounds copper compounds nickel compounds phenols	0.8 – 3.6 3.8 – 11.3 2.0 – 7.8 1.2 – 9.0
Pechenga	st. Pechenga	iron compounds copper compounds nickel compounds phenols	0.8 – 6.6 3.6 – 10.3 1.0 – 5.1 1.5 – 11.0
Nama-Yoki	0.5th km up the outflow	iron compounds copper compounds nickel compounds phenols	1.3 – 5.0 4.5 – 13.2 1.3 – 6.1 1.0 – 10.2
Kola	0.8th km up the outflow c. Kola	iron compounds copper compounds phenols	1.3 – 4.0 2.8 – 7.2 1.3 – 9.5
Virma	vil. Lovozero	iron compounds copper compounds phenols	2.7 – 13.9 2.0 – 12.9 1.3 – 6.4
Kovdora	7th km down the inflow of the r.Mozhel	nitrite-nitrogen copper compounds phenols	0.1 – 14.3 1.8 – 8.3 1.3 – 6.7
Mozhel	0.25th km up the outflow	iron compounds copper compounds phenols nitrite-nitrogen oil	0.1 – 4.4 1.2 – 7.3 1.5 – 5.6 bdl – 9.0 bdl – 13.7
Pechora	s. Oksino	oil iron compounds copper compounds	1.4 – 9.0 2.2 – 7.2 2.0 – 7.9
Onega	vil. Porog	iron compounds copper compounds zinc compounds phenols	2.1 – 5.8 2.2 – 20.1 1.2 – 4.4 1.3 – 3.9

Table 2. (Contd.)

River	Regime observation station	Priority pollutants	Excees of MAC
Mudyuga	s. Patrikeevskaya	iron compounds copper compounds zinc compounds oil	1.4 – 10.5 1.3 – 3.1 1.5 – 5.0 1.2 – 14.5
Mezen	s. Malonisogorskaya	iron compounds copper compounds zinc compounds oil phenols	1.4 – 5.4 1.3 – 9.9 1.1 – 5.3 1.3 – 9.7 2.1 – 5.0
Zolotitsa	s. Upper Zolotitsa	iron compounds copper compounds zinc compounds oil	2.8 – 10.5 1.4 – 5.2 1.3 – 8.6 1.4 – 10.3

[a] Table 2 is based on ref. [6] and supplemented with the data of the author. [b] Letters of references in Table 2 and 3 are the same as in Table 1.

and "extremely dirty" enlarges due to the exceeding of MAC in an average annual concentrations of easily oxidized organic matter (up to 11 MAC), of ammonia nitrogen (up to 15 MAC), of oil (up to 11 MAC), and of nickel compounds, the content of which occasionally reaches abnormally high values (Table 4).

Due to the above considerations, the significant influence of anthropogenic impact on the formation of pollution intensity of the water environment should be taken into account. Under a long-term anthropogenic impact on river ecosystems many of the ingredients normally presented in the aquatic medium along with their accumulation transfer into the prior pollutants. The degree of contamination of water bodies directly depends on the level of anthropogenic impact. The ecological hazard lies in more extensive and complex level of anthropogenic impact.

High contamination level of separate sections of the North European rivers remains high in the new millennium as well, which leads to the increasing tendency of anthropogenic component composition transformation of their aquatic medium. Accumulation of toxic compounds, heavy metals and other pollutants in river ecosystems takes place.

Anthropogenic-altered natural background of certain water bodies of the european north by hydrochemical parameters. Earlier studies [3, 4, 6–9] have shown that for many water bodies of the European North the anthropogenic component continues to determine the formation of hydrochemical regime. Anthropogenic transformation of their hydrochemical regime is expressed by a number of typical factors:

• violation of the oxygen regime through the increasing frequency of cases reducing its content in the aquatic medium to abnormally low values (the rivers Rosta and Nyuduay);

• violation of the natural intraannual changes in mineral forms of nitrogen and phosphorus with the total trend of periodic or continuous increase of their content in the winter–spring period to concentrations many times exceeding the established standards of maximum acceptable ecological concentration (MAEC) [15];

• accumulation of toxic compounds in the aquatic medium to concentrations exceeding the MAC dozens of times (heavy metals, phenols, petroleum products);

• typical for the region water medium content of significant amounts of easily labile organic matter determined by BOD_5.

As a result of long-term and the high leveled contamination, many river ecosystems of the European North transform with the transition to a new trophic

Table 3. Priority pollutants in the aquatic medium of "highly polluted" and "the most dirty" water bodies of the European North of Russia

River	Regime observation station	Priority pollutants	Excess of MAC
Kolos-Yoki	0.6^{th} km up the outflow	sulpfates	1.1–2.8
		iron compounds	0.5–17.1
		copper compounds	6.3–25.0
		nickel compounds	31.7–56.6
		phenols	1.7–12.6
Luottn-Yoki	0.5^{th} km up the outflow	sulpfates	0.3–1.8
		nitrite-nitrogen	0.5–8.6
		copper compounds	4.0–10.2
		nickel compounds	5.8–21.9
		phenols	1.5–11.8
Belayaя	c. Apatity	sulpfates	1.5–4.6
		nitrite-nitrogen	1.8– 9.6
		iron compounds	1.1–4.1
		copper compounds	2.0– 9.2
		phenols	2.7–8.0
Rosta	c. Murmansk	EOOM[a] (by BOD_5 [b])	1.3–10.8
		ammonium nitrogen	1.0–15.3
		nitrite-nitrogen	1.3– 7.0
		iron compounds	4.1–13.5
		copper compounds	4.1–10.2
		oil	2.1–11.2
		phenols	0.8–13.0
		nickel compounds	1.4–17.1
		sulpfates	6.9–11.6
Nyuduay	c. Monchegorsk	copper compounds	39.6–102 (458)
		nickel compounds	15.8–570
		phenols	bdl[c]–15.2

[a] EOOM (by BOD_5) is easily oxidized organic matter determined by BOD_5. [b] BOD_5 is the amount of dissolved oxygen consumed in five days by biological processes breaking down organic matter. [c] bdl means bellow the detection limit.

Table 4. Anthropogenically-altered natural background priority pollutants of water bodies of the European North of Russia (1980-2007)

Regime observation station	Fluctuations range of the most common values in MAC			
	iron compounds	copper compounds	zinc compounds	nickel compounds
“Rather” and “highly polluted” aquatic media				
Pechenga, st. Pechenga	0.0–2.3	1.0–14.0	0.0–2.9	1.0–4.9
Kola, 0.8th km up the outflow	0.0–2.5	2.0–10.0	0.0–2.0	0.0–1.5
Virma, vil. Lovozero	1.5–20	1.0– 9.0	0.0–1.9	0.0–0.8
Mozhel, 0.25th km up the outflow	0.0–3.0	0.0– 10.0	0.0–2.8	0.0–1.0
Nama-Yoki, 0.5th km up the outflow	1.0–5.8	2.0– 15.0	0.0–2.5	1.0–7.9
Mezen, s. Malonisogorskayaя	3.0–8.4	1.0– 10.0	0.0–3.9	0.0–1.0
Pechora, s. Oksino	1.0–9.8	1.0– 9.0	1.0–4.5	0.0–0.7
North Dvina, vil. Ust-Pinega	1.0–3.8	1.0–5.0	0.0–1.9	0.0–0.2
Onega, vil. Porog	2.0–5.6	1.0–5.0	0.0–2.9	0.2–0.4
Mudyuga, s. Patrikeevskaya	3.2–7.6	0.0–3.0	0.0–1.8	0.0–0.7
Zolotitsa. s. Verkhnaya Zolotitsa	1.0–8.0	0.0–9.0	0.0–4.8	0.0–0.8
“Highly polluted” and “dirty” aquatic media				
Luottn-Yoki, .5th km up the outflow	0.0–2.9	0.0–15.0	0.0– 2.4	0.3–18.4
Belaya, 1 km up the outflow	0.0–2.8	0.0–13.0	0.0–1.9	0.0–1.0
Kolos-Yoki, uts.Nickel	0.0–4.4	2.0–29.0	0.0–2.9	8.9–86.8
Transitional from “dirty” to “highly dirty” or “extremely dirty”				
Nyuduay, 0,2 km up the outflow	0.0–6.7	9.0–280	0.0–5.0	5.0–465
Rosta, c. Murmansk	0.0–15.0	1.0–6.0	0. 2– 4.0	0–8.0

Table 5. Anthropogenically-altered natural background in priority easily labile pollutants of water bodies of the European North of Russia (1980-2007)

Regime observation station	Fluctuations range of the most common values in MAC				
	EOOM (by BOD)[a]	ammonium nitrogen	nitrite nitrogen	phenol	OH[b]
“Rather”and “highly polluted” aquatic media[c]					
Pechenga, St. Pechenga	0.1–1.0	0.0–0.2	0.0–0.5	1.0–9.0	—
Kola, 0.8[th] km up the outflow	0.1–1.0	0.0–1.9	0.0–0.5	1.0–10.0	—
Virma, vil. Lovozero	0.12–1.2	0.0–2.5	—	0.0–9.0	0.0–1.2
Mozhel, 0.25[th] km up the outflow	0.2–1.5	0.0–0.6	—	0.0–14.0	0.0–1.8
Nama-Yoki, 0.5[th] km up the outflow	0.0–1.4	0.0–0.6	0.0–1.2	0.0–6.0	0.0–1.0
Mezen, s. Malonisogorskaya	0.8–1.4	0.0–1.0	0.0–0.2	—	0.0–2.0
Mudyuga, s. Patrikeevskaya	0.3–0.9	0.0–0.6	0.0–0.1	—	—
Zolotitsa, s.Verkhnaya Zolotitsa	0.3–1.0	0.0–0.8	0.0–0.3	—	0.0–1.4
Onega, vil. Porog	0.1–0.8	0.0–0.3	0.0–0.1	0.0–2.0	0.0–2.8
Pechora, s. Oksino	0.5–2.4	0.0–1.0	0.0–0.3	0.0–1.0	0.0–1.0
North Dvina, vil. Ust- Pinega	0.3–1.8	0.0–0.5	0.0–0.25	0.0–5.0	0.0–1.8
“Highly polluted” and “dirty” aquatic media					
Belaya, 1[st] km up the outflow	0.4–2.4	0.0–1.7	0.0–14.0	0.0–8.0	0.0–1.8
Luottn-Yoki, 0.5[th] km up the outflow	0.2–1.0	0.0–1.0	0.0–4.6	0.0–5.0	0.0–0.8
Kolos-Yoki, uts. Nickel	0.0–1.7	0.0–1.2	0.0–1.3	0.0–9.0	0.0–1.8
Transitional from “dirty” to “highly”or to “extremely dirty” aquatic media					
Nyuduay, 0.2[d] km up the outflow	0.4–4.4	0.0–1.5	0.0–3.8	0.0–7.0	0.0–3.2
Rosta, c. Murmansk	0.56–4.9	0.0–4.3	0.0–18.0	0.0–9.0	0.2–9.6

[a] EOOM (by BOD_5) is the same as in Table 3; [b] OH are oil hydrocarbons.

Table 6. Anthropogenically-altered natural background in biotic components indicators of the “rather” and “slightly” polluted water bodies of the European North of Russia

River basin and river	MFOQ of variational series of development indicators								
	Bacterioplankton		Phytoplankton		Zooplankton		Macrozoobenthos		
	Total, mil[a] cell ml^{-1}	Saprophytes, ths[b] cell ml^{-1}	Abundance, ths cell ml^{-1}	Species diversity	Abundance, ths cell ml^{-1}	Dominant group	Abundance, ths sp[c] m^{-2}	Dominant group	Species abundance of oligochaeta, %
Patso-Yoki, Patso-Yoki	0.50–1.60	0.10–1.50	0.18–0.78	6–15	0.20–2.52	*Cyclopoida Cladocera Rotatoria*	0.55–2.30	*Chironomids*	8–29
Ura, Ura	0.80–1.31	0.20–1.00	0.15–0.90	8–13	0.02–1.32	*Cyclopoida Cladocera Rotatoria*	0.15–1.96	*Chironomids*	3–27
Tuloma, Nota	0.98–1.30	0.30–1.10	0.11–0,71	11–18	0.17–0,72	*Rotatoria Cladocera*	1.15–2.60	*Chironomids*	5–28
Kola, Kitsa	0.50–1.50	0.20–1.50	0.11–0.59	5–20	0.05–1.00	*Rotatoria Cladocera*	0.15–2.10	*Chironomids*	0–26
Tiberka, Tiberka	0.80–1.20	0.10–0.50	0.20–2.00	7–18	0.06–0.66	*Rotatoria Cladocera*	0.53–2.70	*Chironomids*	7–25
Niva, Yena	0.90–2.50	0.90–3.50	0.22–1.63	9–20	0.10–1040	*Rotatoria Cyclopoida Cladocera*	0.50–2.63	*Chironomids*	7–29

[a] Mil is millions. [b] Ths is thouthands. [c] Sp is species.

Table 7. Anthropogenically-altered natural background in biotic components indicators of the water bodies of the European North of Russia with high level of anthropogenic impact[a]

Poillution intensity of the aquatic medium	River	MFOQ of variational series of development indicators								
		Bacterioplankton,		Phytoplankton		Zooplankton		Macrozoobenthos		
		Abundance		Abundance, ths cell ml^{-1}	Species diversity	Abundance, ths cell m^{-3}	Dominant group	Abundance, ths sp m^{-2}	Dominant group	Species abundance of oligochaeta, %
		Total, mil cell ml^{-1}	Saprophytes, ths cell ml^{-1}							
Transitional from «rather» to "highly dirty"	Pechenga	1.50–3.00	0.90–13.0	0.10–2.00	5–17	0.03–0.50	*Cyclopoida Rotatoria*	1.10–9.96	*Oligochaeta*	40–85
	Kola, outflow	1.00–2.50	0.50–6.80	0.20–2.00	10–25	0.01–0.87	*Cladocera Rotatoria*	0.16–2.75	*Chironomids*	0–29
	Virma	1.20–2.50	0.50–2.50	0.11–5.30	9–25	1.90–31.0	*Cladocera Rotatoria*	0.67–2.96	*Chironomids*	6–28
	Mozhel	1.00–2.50	2.50–10.0	0.16–1.20	5–15	0.24–10.0	*Rotatoria Cladocera*	0.55–5.90	*Chironomids*	35–89
Transitional from "highly polluted" to "dirty"	Luottn-Yoki	0.80–2.00	0.80–5.70	0.50–4.80	7–13	0.05–1.5	*Rotatoria Cyclopoida*	0.18–2.80	*Chironomids*	0–35
	Nama-Yoki	1.00–2.80	0.90–10.0	0.10–0.50	7–19	0.01–0.50	*Rotatoria Cladocera*	0.10–2.80	*Chironomids*	0–30
Transitional from "dirty" to "highly" and "extremely dirty"	Kolos-Yoki	1.30–4.00	1.30–33.0	0.01–0.60	4–12	0.08–0.30	*Cyclopoida Rotatoria*	1.0–19.4	*Oligochaeta*	60–100
transitional from "dirty" to "highly" and "extremely dirty"	Nyuduay	2.00–6.50	13–98.5	bld 0.19	3–8	0.01–0.22	*Rotatoria*	0.06–1.00	*Chironomids*	0–19
	Rosta	2.30–11.0	23–250	bld 0.22	0–9	0.02–1.20	*Rotatoria*	—	*Oligochaeta*	97–100

[a]Refernces are the same as in Tabs. 3 and 6.

status accompanied by new forms of anthropogenic-altered natural background, the upper limits of which significantly exceed the MACs in hydrochemical indices (Tables 6 and 7).

For water bodies with a high degree of water pollution the upper limits of anthropogenic-altered natural background exceed the MACs of some compounds many times. For instance, the exceeding of the MACs of nitrites is 14 and 18 times in the rivers Belaya, Rosta, the exceedings of the MACs of iron compounds are 15 times in the river Rosta and 20 times in the river Virma. The exceedings of the MACs of nickel compounds are 87 times in the rivers Kolos-Yoki and 465 times in the river Nyuduay.

It was registered that excess of the MAC of copper was 10–29 times in the rivers with different degrees of water pollution.

For the less polluted river ecosystems (the rivers Pechenga, Kola, Virma, Mozhel) a high anthropogenic-altered natural background of phenols was noted, which may be associated with the physical and geographical characteristics of watersheds.

It should be noted that characteristic feature of the tested water bodies of the Kola Peninsula is the presence of copper, iron and manganese compounds in natural uncontaminated waters. Elevated concentrations of these metals in the absence of effluent discharges and emissions of enterprises observed in the low-flow periods when the water recharge is carried out mainly by the groundwater.

It is important to mention that for the studied water bodies the greatest excess of natural background was detected for copper compounds and phenols. The abnormal high excess of natural background for nickel compounds was detected only for very dirty water bodies (the rivers Rosta and Nyuduay), which is certainly connected with the activities of non-ferrous metal industry in the region.

Antropogenic-modified natural background of some water bodies of the european north by hydrobiological parameters. Currently, the rise of information value about present and future data on ecological conditions of the river ecosystems including their regional formation characteristics that will significantly enhance the ecological validity of environmental activities is of primary importance. The study of any ecosystem is conducted over a range of hydrohemical and hydrobiological parameters.

For the water bodies of the European North with their high level of anthropogenic impact a new anthropogenically-altered natural background in connection with the above mentioned pollutants has been formed (Tables 4 and 5).

That sort of chemical composition transformation of the aquatic environment results in the reorganisation of aquatic organisms' community stuctures [16]. A new different from the natural modified background in hydgobiological parameters is formed in the ecosystem.

Comparative evaluation of variability of the most common values of the main quantitative and qualitative parameters of planktonic and benthic communities in the studied stream ecosystems shows their distinct volatility in proportion to the rising degree of water pollution.

Thus, in "rather" and "slightly contaminated" water bodies the most common rates of the total ammount of bacterioplankton, phytoplankton, zooplankton and macrozoobenthos do not significantly differ (Table 6).

The above mentioned differences become highly significant for the water bodies with a high degree of contamination (Table 7). Therewith, in order to solve many environmental problems it is necessary to determine the anthropogenically-altered natural background of water bodies on the parameters of aquatic organisms' community development.

Analysis of the received data shows that in the course of transition from less polluted waters bodies to the more polluted ones the bacterioplankton is increasingly developed. The range of the most frequent occuring quantities (MFOQ) of the total ammount of bacterioplankton and saprophytic microflora in the river Nyuduay reaches 2.00–6.50 mil cell ml^{-1} and 13−98.5 ths cell ml^{-1} and in the river Rosta 2.30–11.0 mln cell ml^{-1}, and 23–250 ths cell m l^{-1}, respectively.

Thus, in the above mentioned very dirty rivers the inhibition of phytoplankton was marked: the range of the most frequently found value of total phytoplankton and its species diversity decreased in the river Rosta up to 0.22 ths cell ml^{-1} (below the limits of observation), and 0−9 species, respectively.

The anthropogenically-altered natural background increased noteworthily to the total content of macrozoobenthos up to 1.0–19.4 ths sp m^{-2} (the river Colos-

Yoki) with the raising level of oligochaetes' development (60–100% of their abundance).

Thus, the operation of the water body in the new anthropogenically-altered natural background results in significant structural changes in distinct communities of aquatic organisms, which should be also considered as a negative consequence of anthropogenic impact.

SUMMARY

Under the present conditions of the anthropogenic impact on water bodies the latter suffer from conversion and violation of the natural course of development. A lot of intrawater body processes have an anthropogenic form, and their rate increases many times. The water bodies of the European North operate within a new formed anthropogenically-altered background, upper limits of which can be ten times higher than the established water quality indicators (MAC and MAEC).

A new natural background is formed both for abiotic and biotic cvomponent of aquatic ecosystems and directly depends on the way and the levels of anthropogenic impact and of industrial development in the region.

Obviously, the problem of studying and determining the anthropogenically-altered natural background is particularly relevant in terms of a regional monitoring of pollution of the natural environment. That are regional geological and geology-hydrological characteristics of the region that define the formation of a new natural background with the anthropogenic factor. Herewith, a new anthropogenically-altered natural background determined by a complex of rapidly changing external impact can become a base point for the evaluation of the new ecological status of water bodies of the European North of Russia.

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