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REPORT
ON THE RESEARCH IN THE AMUR BASIN, AMUR LIMAN AND SAKHALIN BAY IN 2008

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Introduction

The research was carried out in the frame of the Implementation Agreement on the Joint Research of the Amur River, its Estuary and the Sea of Okhotsk between the Institute of Water and Ecology Problems (IWEP FEB RAS) (Russia) and the Research Institute of Humanity and Nature (RIHN) (Japan), signed on April 19, 2005 and based on the Agreement on Cooperation between the Far Eastern Branch of the Russian Academy of Sciences and the Research Institute of Humanity and Nature, signed on March 4, 2004.

Since its beginning in 2005, the research is based on the contracts, annually developed and signed between IWEP FEB RAS and RIHN and includes expeditions, field and laboratory works.

In 2008 all the works consisted basically of two parts:

- studies in the Amur lower reaches, the Amur Liman and the Sakhalin Bay;
- studies in the Kiya River basin.

The main Project tasks in the Amur lower reaches, the Amur Liman and the Sakhalin Bay include the following:

1. Assessment of water runoff and terrigenous and chemical material discharge in the Amur, viewed in seasonal and multiyear aspect and based on filed observations.
2. Investigation of the main sources of the origin of different iron forms in the Amur River considering the specifics of landscapes most common for the region of interest.
3. Clarification of the role of forest fires and water run-off from the floodplain lakes in the formation of Amur water chemical composition.

The research objects include:

1. The Amur River from Khabarovsk to Nickolaevsk on Amur.
2. The Amur Liman and the Sakhalin Bay (southern part).
3. Observation stations of monthly water sampling (Khabarovsk, Bogorodskoe)
4. An observation station for regular water sampling in the Amur estuary (since 2007).

Intensive hydrological and geochemical studies in the Kiya basin were carried throughout the 2008 summer-autumn period from July to October. The Project task was to identify the migration mechanisms of iron and other chemical substances in natural and agricultural landscapes of the Amur Basin. Regular Kiya and Birushka river monitoring included water discharge measurements twice a month, river and ground water sampling and analyses, soil sampling in two landscape-geochemical profiles.

The report data on 2008 field studies in the Amur Liman and the Sakhalin Bay south, and the results of analyses of sediment and water samples collected at the observation station in the Amur Basin are presented in chapters 1, 2, and 3. The Kiya basin research results are described in chapter 4.

Studies in the Amur Basin, the Amur Liman and the Sakhalin Bay

1. Research Methods

Following the terms of the contract between The Research Institute of Humanity and Nature (Japan) and Institute of Water and Ecology Problems FEB RAS (Russia) the research in 2008 included expedition works in the Amur Liman and the Sakhalin Bay, the Amur River monitoring with participation of Roshydromet at Khabarovsk and Bogorodskoe and with participation of Dr. A.B. Kozlovsky at Nickolaevsk-on-Amur.

Amur monitoring at Khabarovsk and Bogorodskoe consisted of monthly sampling from May to January. Only during the period of ice-freezing (November) and in June at Khabarovsk (due to technical impossibilities of Roshydromet) no samples were collected. At Nickolaevsk-on-Amur the works were carried out from June to October. Sea-water samples were treated right on the research vessel during the expedition, whereas other samples were treated in laboratories in Khabarovsk (21 sample) and Nickolaevsk-on-Amur (20 samples) and at the hydrostation in Bogorodskoe (24 samples). Chemical analyses of water, particles on filters and bottom sediments were carried out at the Interregional Center for Ecological Monitoring of Hydropower complexes (№ ROCC RU 0001.515988), affiliated with IWEP FEB RAS. Totally 83 water samples and 9 bottom sediment samples were collected and analyzed.

Assessment of water quality in the Amur Liman and the Sakhalin Bay were conducted from 4 to 7 of August, 2008. All the works were implemented following the tasks set in the contact between RIHN and IWEP FEB RAS for 2008.

Field observations were carried out from the board of a hydrographic vessel. During the expedition water and bottom sediment samples were collected at 9 stations. For bottom sediment sampling a bottom-grab sampler, designed and made in IWEP was used. It is in the form of a metal cylinder with a shifted gravity center. Water was sampled with a bathometer (Fig. 1.1.) and with an electric vacuum pump at 9 stations at surface and bottom water layers. Totally 18 water samples and 9 bottom sediment samples were collected.

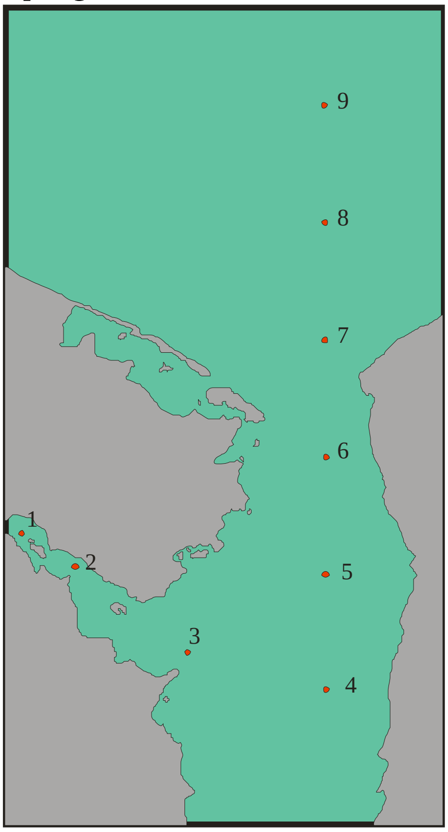
The depths were measured with the Humminbird Matrix 67 eco-sounder. The locations were identified with the GPS-navigator Etrex Vista.

Expedition works in 2008 were mainly focused on getting additional data on the composition of water and bottom sediments in the Amur River estuary, the Amur Liman and the Sakhalin Bay of the Okhotsk Sea.

Expedition works were carried out by IWEP senior researchers Dr. Vladimir I. Kim and Dr. Vladimir P. Shesterkin and the chief of the Ecology Department of Nickolaevsk-on-Amur Regional Administration Dr. Valentin B. Kozlovsky.

The scheme of sampling stations in given in Fig. 1.2. and Table. 1.1.

Fig. 1.1. Water Sampling with a Bathometer from the board of a hydrographic vessel



• - точки отбора проб воды и донных отложений

Fig. 1.2. Scheme of Water and Bottom Sediment Sampling Stations.

Table 1.1. Stations, where Water and Bottom Sediment Samples were Collected in 2008.

№	date	Sampling area/ Station	Water samples (water layers)	Bottom sediment samples
1.	4.08	Estuary – Lower Nickolaevsk-on-Amur St.1	Surface and bottom	1 sample
2.	4.08	Estuary – Vospri Island - St. 2	Surface and bottom	1 sample
3.	4.08	Estuary – opposite cape Pronge – St.3	Surface and bottom	1 sample
4.	5.08	Amur Liman – St. 4	Surface and bottom	1 sample
5.	5.08	Amur Liman - St. 5	Surface and bottom	1 sample
6.	5.08	Amur Liman - St. 6	Surface and bottom	1 sample
7.	5.08	Amur Liman - St. 7	Surface and bottom	1 sample
8.	5.08	Amur Liman - St. 8	Surface and bottom	1 sample
9.	5.08	Amur Liman - St. 9	Surface and bottom	1 sample

The following measurements were performed on board of a hydrographic vessel: water temperature, pH, salinity, electroconductivity, dissolved oxygen concentration and suspended matter concentration with the Water Quality Meter WQC-24 (Fig. 1.3.). Water turbidity was also measured with the turbidimeter HI93703.

Immediately after the samples were collected they were filtered and treated as required on board of a hydrographic vessel. After treatment all samples were stored in the refrigerator and freezer. When the field works were completed all the samples were transported to Khabarovsk to be analyzed in the IWEP FEB RAS laboratories.

Fig. 1.3. Measurements of water physical parameters.

2. Hydrologic Characteristics of the Amur River

2.1. Water Regime of the Amur River in 2005-2008

The Amur River is ranked among 10 biggest rivers of the world (Appolov, 1951; Ginko, 1965; Hydrological Study…, 1966; World…, 1974; Estimation…, 1989). Among the Russian rivers the Amur holds the third place by length and the fourth place by the water content and drainage area after the Yenisei, Ob and Lena (Resources…1966, 1970).

The Amur basin is a big natural system, composed of numerous rivers basins, situated in different natural and climatic zones. Such natural factors as specifics of natural conditions and geographic situation of the Amur basin create a special regime of it run-off and chemical element flux formation. Significant changes of river run-off within the year, extremely low water levels in some years, big floods, well-marked multiyear changes of Amur run-off and intensive riverbed deformations greatly influence water and floodplain ecosystems of the river basin.

The main part of the river run-off is formed in the Middle Amur. This river passage of 1000 km accumulates nearly 65% of the total run-off owing to the biggest tributaries Zeya, Bureya, Sungari and Ussuri. Moreover, this parameter sharply changes within the year. In winter the share of three regulated rivers (Zeya, Bureya and Sungari) in Amur run-off reaches 90%. Thus, in the Amur lower reaches water content and quality much depend on water discharge from hydropower water reservoirs.

One of the Amur water regime peculiarities is an evident repetition of 8 to 15-year periods of low water and high water content. Extremely low water levels in overall low water content period of 1900-ies - early 2000 occurred in the summers of 2000, 2001 and 2002 and were the lowest in the observation time. It caused the sand bard, river channels, lakes overgrowing with vegetation and due to this a significant input of organic material into the river in summer and autumn.

Another important factor that influences the Amur water ecosystem is the Amur capacity to form numerous channels in the floodplain, which have their own water and bed specifics. The river mainstream and the biggest channels have peculiar morphometric characteristics. They are usually extremely wide compared to their depth. The width-depth ratio is usually 400:1 – 500:1. Such situation of a vast water spreading results in a high water warming in summer and a quick cooling in autumn, as well as the formation of a thick ice cover, even when winter precipitation is rather low.

In recent years the impact of anthropogenic factors has increased substantially due to global climate changes and agricultural and industrial development of the basin and hydropower system construction in particular (dams and bank-protection constructions on the Sungari, Zeya and Bureya rivers). River pollution with industrial and sewage waters also increases.

Never the less there still are possibilities to efficiently manage water resource content and quality in the Amur basin, especially to mitigate the consequences of emergency situations. One of them is releasing water from water reservoirs, which are situated in difference distances from the mainstream. The other is the redistribution of run-off between various river channels. For example such measures were implemented and proved to be very efficient during a significant Amur River pollution after the accident on the Sungari in November 2005.

A vast area of the Amur drainage system, its form peculiarities and big tributaries in various parts of the basin, coupled with precipitation specifics (locality and high intensiveness) cause the appearance of several areas of run-off formation. Each of such areas is made up by big river basins with noticeably different hydrologic regimes. Specifics of flood wave formation and behaviour within a particular area depend on water regime of its territory. Besides, the time and duration of flood are also of great importance. The most catastrophic floods on the Amur were observed in those years, when floods of low water content happened at the same time in all the areas of run-off formation (Kim, 1999).

In the last decades significant global climate changes have been observed throughout the whole our planet causing the increase of surface air temperature (Budyko at al., 1991; Izrael at al., 2001; Hardy, 2003; IPCC, Climate Change 1995; IPCC, Climate Change 2001). Many authors provide data, confirming 0.6-0.7 ^{o}C annual average increase of global temperature in the instrumental observation period (from 1850-ies up to 2000) (Global…, 2004, Climate…, 2001).

Global warming in the XX century was uneven in time. Three periods are usually identified: warming in 1910-1945, light cooling in 1945-1975 and the most intensive warming beginning from 1976. 1990-ies were the warmest decade and 1998 happened to be the warmest year. On the Russian territory the intensity of warming in the 1901-2000 period was estimated 0.9 ^{o}C. Maximum warming was registered in 1995 (1.9 ^{o}C deviation of temperature from the norm) (Izrael et al., 2001). Global warming was expressed differently in different regions of Russia. In the second half of the XX century (1951-2000) the highest warming trend was observed in Pribaikalje (3.5 ^{o}C/100 years) and Middle Siberia. Warming in Russia is more evident in winter and spring (the trend is 4.7 and 2.9 ^{o}C/100 years respectively).

Climate warming tendencies in the Amur basin are synchronous with the global ones. Warning gradually continues till the present time.

In 1980-2005 period the trend of Amur water content decrease with rate 12 %/100 years is observed. Amur run-off decreasing tendencies, especially in recent decade, are caused not only be climatic but also by anthropogenic factors, primarily associated with hydropower system constructions in the Amur basin (Novorotsky, 2006, 2007 a, 2007 в). In the last 4 years water content in the Amur decreases (Fig. 2.1.) In 2005 a maximal water level was registered during a spring flood (371 cm above «0» of the Khabarovsk water measuring station graph). In August a moderate flood (235 cm) was observed.

In 2006 the Amur had moderate water content. After winter low water (-180 cm) during spring floods in the first decade of June water levels rose up to 370 cm. Then summer low water followed. A rain-caused summer flood in August was characterized with 2 moderate peaks (235 cm). After that Amur water level gradually decreased and reached its minimum before the river freezing (-180 cm).

In 2007 the Amur water regime was also characterized with low water content. After winter low water (-170 см) a moderate spring flood followed and by the end of May water levels rose up to 220 cm. Then the water level decrease was observed, which is usual for summer low water. Minimal water levels were registered from 19 to 22 July (-47 cm). Then a summer-autumn rain flood followed and in August-September it was characterized with relatively moderate water content and practically 2 peaks (174cm – 3-4 August and 172cm – 5 September). After that Amur water level gradually decreased and reached its minimum before the river freezing (-105 cm).

In 2008 the Amur River was characterized with particularly low water content. After winter low water (-150 см) during a spring flood water levels rose up to + 4 cm at the beginning of June (6 June). Then a very low summer low water was observed. The minimal water level dropped down -130 cm (10 July). A summer-autumn rain flood that followed has moderate peaks: in July + 54 cm, in August + 65 cm and at the beginning of October + 50 (above «0» of the Khabarovsk water measuring station graph). Water content in the Amur in 2008 was extremely low (Fig. 2.2.)

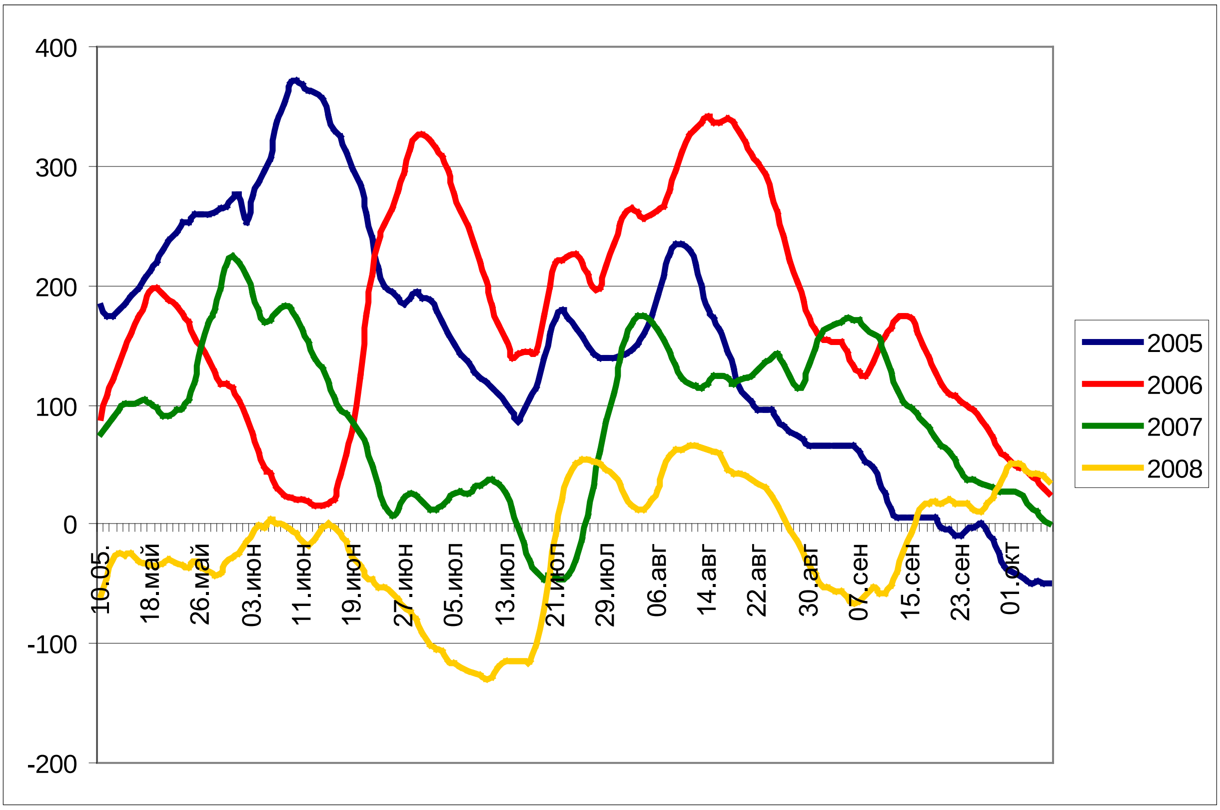


Fig. 2.1. Graph of Water Level Fluctuations in the Non-Freezing Period in 2005-2008.

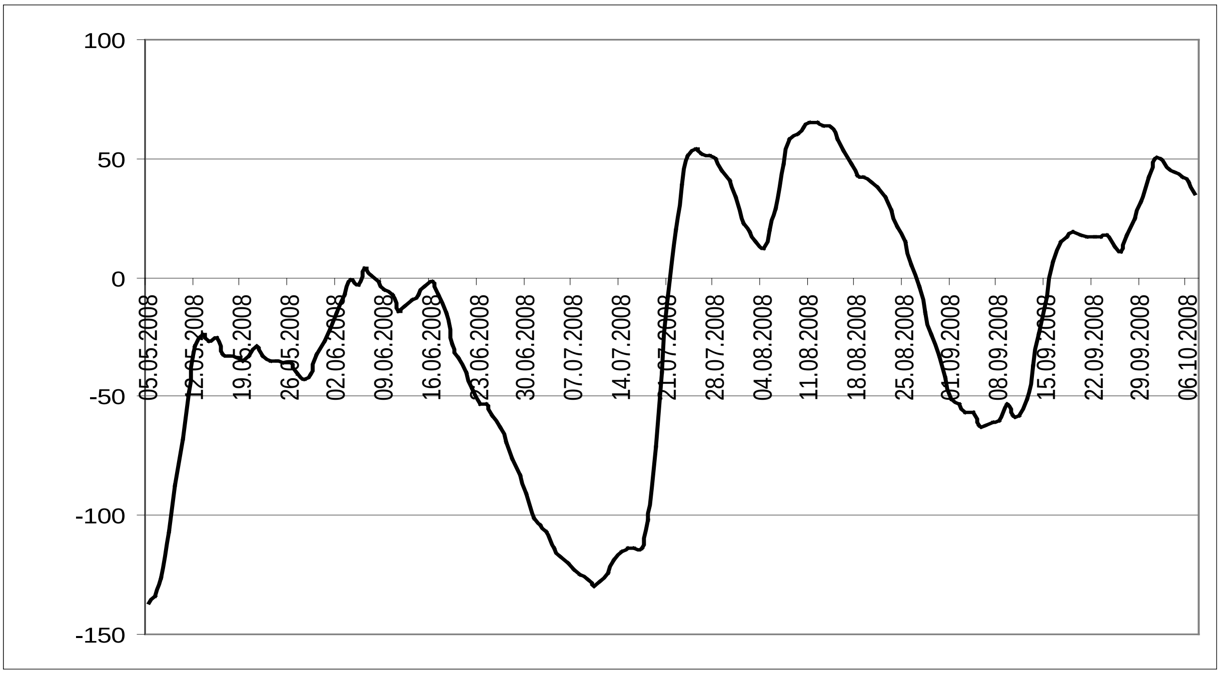


Fig. 2.2. Graph of Water Level Fluctuations in the Amur at Khabarovsk in May-October 2008.

2.2.Suspended Matter Content

Suspended matter flow is not only determined by the river hydrologic regime but is also much influenced by the relief structure, climate, soil and supporting rock specifics, degree of swamping, vegetation peculiarities and anthropogenic load in the basin area.

Systematic observations of the terrigenous material flow in the Amur are conducted at three stations: namely at Khabarovsk, at Komsomolsk-on-Amur and at Bogorodskoe. Observations at Khabarovsk began in 1950 and are being continued up to the present time.

Annual average suspended matter content at Khabarovsk is 24 million tons (average suspended matter discharge is 760 kg/sec). The biggest amount of suspended matter (47 million tons) was registered in 1956 and 1960 and the minimal amount (6.3 million tons) was observed in 1979 (Multiyear…, 1986).

The analysis of suspended matter flow dynamics shows that it changes significantly with time. During floods, which cause a high rise of the water level, fragile particles of floodplain sediments are washed out. And, quite opposite, in the years of low water content in the Amur, suspended matter content in the river is not high. This can be explained with the fact that in periods of low water content and low flow velocity the bank washing-out is insignificant.

Suspended matter flow within the year is noticeably uneven. The biggest amount of sediments is transported in the non-freezing period. In the summer-autumn period (April – September) the solid substance flow makes 87% of the annual amount and in some years this portion reaches 91%.

The average Amur water turbidity at Khabarovsk is 94 g/m^3, whereas the maximal turbidity at Khabarovsk reaches 400 g/m^3, at Komsomolsk-on-Amur the average is 66 g/m^3 and the maximal is 220 g/m^3 (Hydrological Yearbook, 1932-1987). In winter low water suspended matter content in water is minimal and does not exceed 5-15 g/m^3.

It is found that there is a 30-35% decrease of suspended matter content along the river from Khabarovsk towards the Amur lower reaches. It happens due to directed sediment accumulation process in the Middle Amur valley.

The studies in the Amur Liman and the Sakhalin Bay were implemented at the time of low water. As Amur water content was low suspended matter concentrations in waters of the Amur Liman and the Sakhalin Bay were also not high (Table 2.1.)

Table 2.1. Suspended Matter Content (August 2008).

№	Date	depth, m	Sampling area/ Station	Suspended matter content, g/m^3	
				Surface	Bottom
1.	4.08	9.2	Estuary – Lower Nickolaevsk-on-Amur St.1	8.4	6.0
2.	4.08	15.1	Estuary – Vospri Island - St. 2	6.8	4.0
3.	4.08	18.3	Estuary – opposite cape Pronge – St.3	3.1	3.4
4.	5.08	7.7	Amur Liman – St. 4	5.0	1.6
5.	5.08	16.3	Amur Liman - St. 5	3.7	9.8
6.	5.08	10.3	Amur Liman - St. 6	5.8	11.3
7.	5.08	10.4	Amur Liman - St. 7	3.6	5.6
8.	5.08	21.1	Amur Liman - St. 8	0	0
9.	5.08	45.0	Amur Liman - St. 9	0	0

The highest values of turbidity were registered in the river estuary. In the Amur Liman suspended matter concentrations are observed to decrease. In water samples from the last observations stations suspended matter was not found.

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3. Hydrochemical Studies of the Amur River, its Estuary, the Amur Liman and the Sakhalin Bay

3.1. Characteristics of Water Chemical Composition in the Amur River in 2008

Chemical composition of Amur water in the non-freezing period was formed in the conditions of low water content in the river. The Amur run-off at Khabarovsk mostly depended on the run-offs of the Upper Amur and Zeya and less on the Sungari run-off.

Main Ions

Maximal concentrations of main ions in Amur water at Khabarovsk are registered at the beginning of the freezing period. It happens so because of the predominance of the Sungari River and the Upper Amur waters, which have a higher mineralization value (> 150 mg/l) in the Amur run-off compared to the rest of major Amur tributaries. At the freezing period the dominance of the Upper Amur and Sungari in the Amur run-off gradually decreases, whereas the share of the regulated Zeya and Bureya Rivers increases. Water in Zeya and Bureya Rivers is characterized with low concentrations of mineral substances (mineralization value does not exceed 50 mg/l). Such specifics of a hydrologic regime cause a gradual decrease of main ion concentrations in Amur waster up to the end of the freezing period. If in December 2000 the maximum calcium ion concentrations in Amur water at Khabarovsk was 19.2 mg/l, in December 2006 it was already 15.2 mg/l and in December 2007 it reached 13.4 mg/l.

Quite a different dynamics of main ion concentrations is observed at Bogorodskoe. Bogorodskoe is very far from Khabarovsk and water velocity at this Amur passage is rather low. Because of these conditions ion concentrations reach their maximum values much later, i.e. in January-February (Fig. 3.1.)

Main ion distribution in the Amur cross-sections at Khabarovsk and at Bogorodskoe also differs. At Bogorodskoe ion concentrations are distributed rather even, whereas upper Khabarovsk the highest concentrations are usually registered at the right part of the river. Such heterogeneity of main ion distribution in the Amur cross-section is caused by Sungari water, which is more mineralized, compared to Amur water at the Amur-Sungari junction [1]. The heterogeneity of main ion distribution becomes more evident in winter low water.

The predominance of the Bureya and Zeya run-off (up to 55%) in the Middle-Amur run-off continued in the flood-time. The 2008 flood was characterized with low water content (water levels were 2.0 m lower the norm). This caused the decrease of concentrations of natrium, potassium and calcium ions and the increase of sulphate ions. Magnesium and chloride ion concentrations remain unchanged. Similar changes of ion concentration levels, excluding the last two, mentioned above, ware observed at Bogorodskoe (Fig. 3.1).

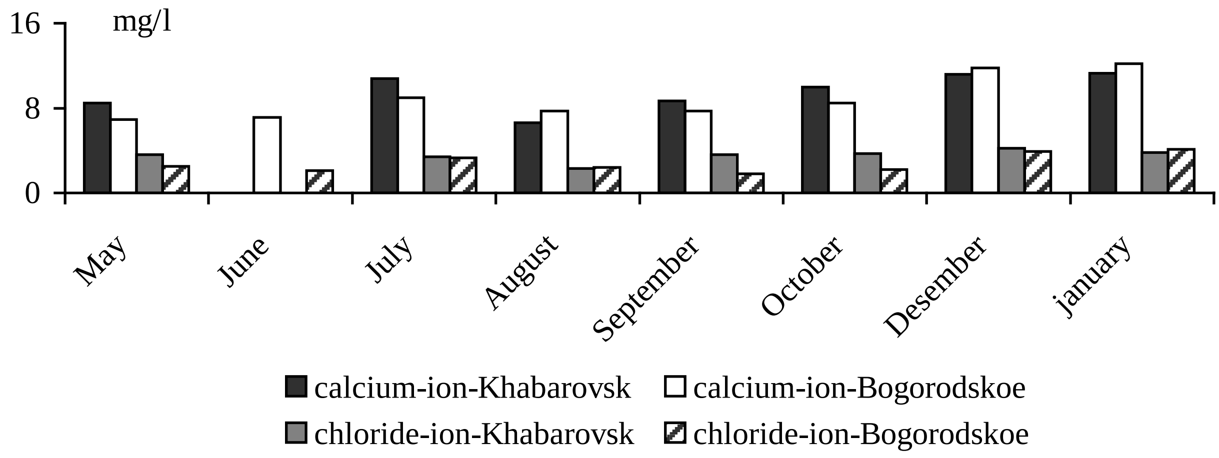

Fig. 3.1. Dynamics of Main Ion Concentrations (mg/l) in Amur Water at Khabarovsk and Bogorodskoe in 2008-2009.

Similar main ion dynamics was also observed in 2007, when water content was low. In 2006, when water content was high (water level was above 100 cm), such situation was not registered at Khabarovsk but uneven distribution of chemical components in water across the river was distinctly observed. Sulphate ion concentration at that time was nearly three times lower. (Fig. 3.2.)

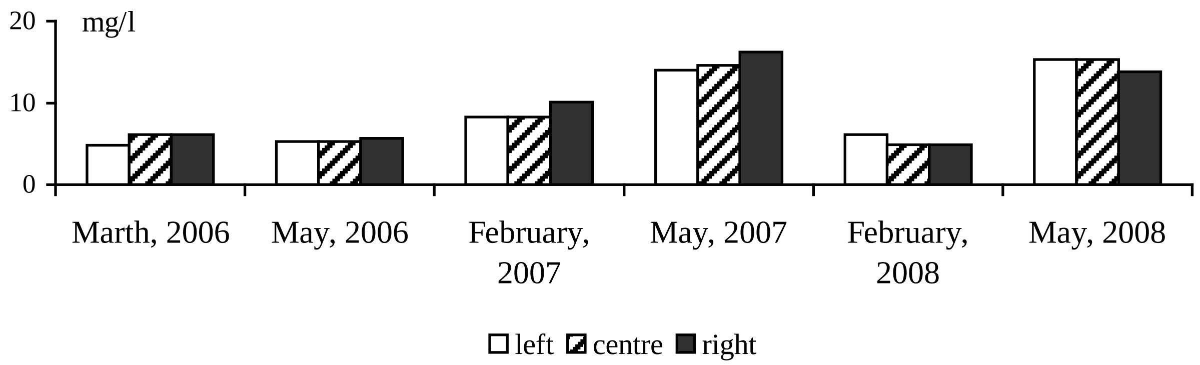

Fig. 3.2. Distribution of SO_4^{2-} in Amur Water at Khabarovsk in Winter Low Water and in Flood-time in 2006-2008.

Summer low water lasted rather long. The lowest water level at Khabarovsk was registered 130 cm. At the end of June the Zeya and Bureya water levels were 1.5 m lower than usual, and the Middle Amur water level was even 2.0-2.8 m lower. Due to low water content in Amur and not a big share of the Sungari in the Amur run-off, calcium and sulphate ion concentrations increased in all parts of the river. Their concentration differences across the river smoothed. Natrium ion concentrations increased but much less. Significant changes in concentrations of other ions were not observed.

Even distribution of main ion concentrations across the Amur in all parts of the river remained also in August (Table 3.1.). The Amur water levels at that time in the passage between Blagoveshchensk City and the Bureya juncture were 1.5-2.5 m lower the norm, and further down the river the water level was even 2.5-4.0 m lower the norm. The smallest concentrations of main ions in Amur water at Khabarovsk were observed at this particular time (Fig. 3.1.) due to the impact of a medium-size flood, which was formed in the Zeya River basin. At Bogorodskoe and especially at Nickolaevsk-on-Amur the impact of this flood on ion concentrations was much less due to flood water spreading into numerous channels and floodplain lakes, but this impact was longer in time. The Ussuri, Anui, Amgun and other rivers, which waters contain less salts than Amur water, also produced a certain impact on ion concentrations in the Amur. For example, if at Khabarovsk the differences between July and August concentrations of natrium and calcium were 2.4 and 4.2 mg/l respectively, at Bogorodskoe they were 1.8 and 1.3 mg/l respectively.

In September, when a big flood wave originated in the Upper Amur (the Upper Amur share in the Middle-Amur run-off was 45%, the Sungari share was 15% and the Bureya share was 10%), main ion concentrations in Amur water at Khabarovsk started to grow (Fig. 3.1.). After this flood water levels sharply decreased and reached their minimal values before the river-freezing. It caused gradual increase of calcium and sulphate ion concentrations in water. At Bogorodskoe just before the river freezing only a little increase of calcium ion concentrations was registered. Quite a different picture was observed at Nickolaevsk-on-Amur, where low concentrations of main ions remained till the beginning of river freezing. Low water content in the Amur and, probably, tidal specifics eased a sea water inflow into the area of Station 3. Thus main ion concentrations there appeared to be much higher. Natrium, magnesium, sulphate and chloride ion concentrations were even one order higher compared to the values registered at Station 1, situated upper the stream (Table 3.1.). Big differences were also noticed in the distribution of main ion concentrations along the vertical profile. Surface waters were less mineralized than the bottom water horizons.

Maximal concentrations of main ion in Amur water in all studied areas were the highest in the first months of the river freezing.

Biogenic Substances

Dynamics of biogenic substances in Amur water significantly differs from that of main ions. Maximal concentrations of iron and ammonium and nitrite nitrogen, increased concentrations of nitrogen and phosphates are mostly registered in winter low water. Upper Khabarovsk the highest concentrations of these substances were observed in the right part of the river, as it was last year. Near Bogorodskoe, also like in last year, differences in biogenic substance distribution across the Amur were not significant. Compared to 2007 concentrations of biogenic substances, excluding ammonium nitrogen, were lower. Phosphate and suspended nitrogen concentrations were especially much lower. That is why a mineral form of nitrogen prevailed over its suspended form. Total nitrogen content in water in February 2008 was 0.99 mg/l at average and compared to 2007 was nearly 1.5 lower.

In spring melting snow water flows into the river net and usually causes the decrease of concentrations of nitrogen mineral forms and smoothing of differences of their distribution across the Amur River. The ratio between nitrogen forms is also changing at this time. The portion of suspended and ammonium nitrogen increases. A similar situation was clearly observed at Khabarovsk and Bogorodskoe in 2008. The prevalence of Zeya and Bureya water in the Middle-Amur run-off at Khabarovsk at that time caused nitrate nitrogen (Fig. 3.3.) and silicon concentrations, which were extremely low for this period of time.

In summer low water a water temperature was high (at the end of July at Komsomolsk-on-Amur a water temperature was 26.4 C^{o}) and phosphorus and iron concentrations in Amur water at Khabarovsk reached the lowest values for in whole non-freezing period. Compared to flood time, nitrate nitrogen concentrations increased, ammonium nitrogen concentrations decreased and suspended forms of nitrogen significantly prevailed over its mineral forms. Similar concentrations of nitrogen compounds, conditioned with their consumption by hydrobionts, were also registered in summer low water in 2007. Even lower concentrations of nitrogen mineral forms (ammonium nitrogen concentrations were below the detection limit) were observed later in time (at the end of July) in Amur water at Bogorodskoe (Fig. 3.3.) and at Nickolaevsk-on-Amur (Table 3.1.).

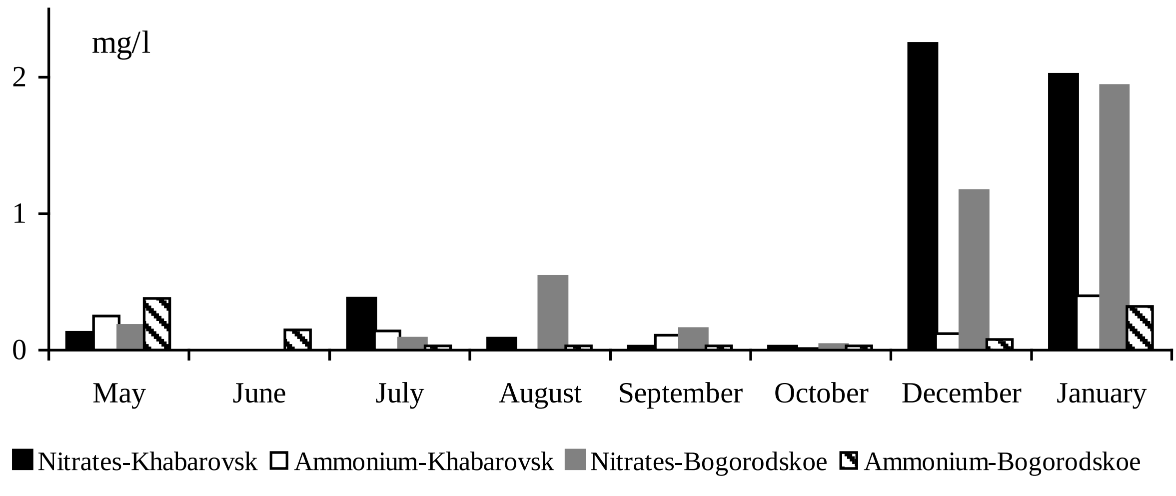

Fig. 3.3. Dynamics of Nitrate and Ammonium Ion Concentrations at Khabarovsk and Bogorodskoe in 2008-2009.

At the end of August during the recession of the Zeya-formed flood wave biogenic substance concentrations in Amur water, as well as main ion concentrations, sharply changed. At the end of August at Khabarovsk phosphate, silicon and ion concentrations were found to increase (Fig. 3.4.). Concentrations of all minerals forms of nitrogen sharply decreased (those of ammonium nitrogen even below the detection level) and thus the dominance of its suspended form became more evident.

Similar concentrations of these substances, excluding silicon, were observed in Amur water at Bogorodskoe and at Nickolaevsk-on-Amur.

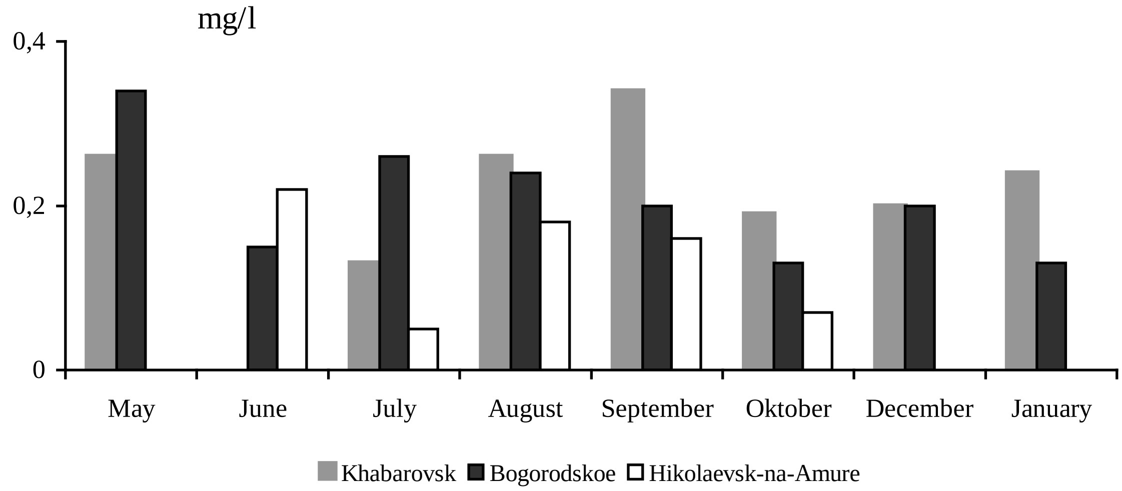

Fig. 3.4. Seasonal Dynamics of Iron Concentrations in Amur Water and Khabarovsk and Bogorodskoe.

At the end of September, when the Upper-Amur-formed flood wave was passing Khabarovsk, the highest increase of ammonium nitrogen was registered in Amur water, whereas nitrate nitrogen and phosphate concentrations were extremely low and below the detection level. Maximal concentrations of a suspended form of nitrogen (up to 0.47 mg/l at average) were also registered at this time. Further down the river the impact of this medium-size flood on biogenic substance concentrations was practically insignificant and not noticeable. Both at Bogorodskoe and at Nickolaevsk-on-Amur concentrations of nitrogen mineral forms and, also phosphates at several observation stations, before river-freezing were either insignificant or below the detection level. That is why, as well as in summer a suspended form of nitrogen was dominating.

Iron concentrations also underwent significant changes at this time. Iron concentrations at all observation stations reached minimal values (Fig. 3.4.) probably due to the decrease of run-off from the bogs.

At the beginning and first months of river-freezing biogenic substance concentrations in Amur water sharply increased, especially those of nitrogen and phosphates. Suspended nitrogen concentrations decreased. Similar changes in water composition happened at Bogorodskoe. These specifics indicate the decrease of photosynthetic activity of phytoplankton. That is why at this time of the year a mineral form of nitrogen starts to dominate over its other dissolved forms.

Thus compared to 2006, low water content in Amur in 2008 caused higher concentrations of main ions and lower concentrations of biogenic substances in the passage from Khabarovsk to Nickolaevsk-on-Amur. Concentrations of a suspended form of nitrogen were the lowest among all mineral forms of nitrogen although this form dominated in water composition during the non-freezing period.

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3.2. Hydrochemical Characteristics of the Amur Liman and the Sakhalin Bay

The Amur Liman is an integral part of the Amur estuary area and serves as a division between Asia and the northern Sakhalin Island. In the south the very narrow Nevelskoy Channel and the Tatar Strait connect the Sea of Japan with the Sakhalin Bay of the Okhotsk Sea. The Amur Liman is 185 km long, 40 km wide and 3-4.5 km deep. Its western coast is indented and mountainous, whereas its eastern coast is flat and sandy. The maximum width of the Sakhalin Bay is 160 km. From November till May the Amur Liman is covered with ice. The Sakhalin Bay is covered with ice till June. Daily tides are uneven and exceed 2 m.

In the estuary the main stream of the Amur, except the water that spreads between shoals and sandbars, splits into three almost equal waterways: Nevelskoi, Vostochny (Eastern) and Yuzhny (Southern). The Nevelskoi waterway with depth between 3.5-22 m goes to the north, the Vostochny waterway with depth between 1.5-15 m goes to the east and the Yuzhny with depth between 3.0-11 m goes along the continent to the south and then to the south-east. Shallow areas are overgrown with water vegetation. In the eastern part of the Amur Liman there is the Sakhalinsky waterway that goes along the Sakhalin coast. It is divided into its northern and southern parts, which actually are two furrows: Eastern and Western. In its northern part the Sakhalinsky waterway is over 8.5 m deep [2].

Chemical analyses of water samples, collected in the Amur Liman and Sakhalin Bay during the expedition in August 2008, were made in the Interregional Center for Hydrosystem Monitoring (№ROCC RU 0001.515988) at IWEP FEB RAS. Concentrations of main ions (natrium, potassium, calcium, magnesium, sulphate and chloride ions) biogenic substances (nitrite, nitrate, phosphate, ammonium and silicon ions) and heavy metals (Al, Mn, Co, Ni, Cu, Fe) were analyzed (Tables 3.2., 3.3., 3.4.)

In the Amur estuary (stations 1-3) waters are well warmed, weakly acid and suspended substances are distributed there unevenly. The highest concentrations were found in the bottom water layers and the maximum concentration was registered at the deepest Station 3. Suspended matter concentration here was 2.5 higher than in the surface water.

Main ions and biogenic substances are unevenly spread in the estuary. Main ion concentrations are low, although higher compared to 2006. Sulphate and chloride ion concentrations are 2 times lower. Such differences can be explained with different water content in the Amur in the observation period. Thus in 2006 observations were conducted during the flood and in 2008 during the summer very low water.

Low water content in the Amur in 2008 also significantly influenced concentrations of biogenic substances, primarily those of nitrate and ammonia nitrogen. Compared to 2006 observations concentrations of these nitrogen forms were much lower, especially of nitrate nitrogen. Low concentrations of these substances in the Amur water are caused by the photosynthetic activity of algae. They were also observed during field studies in year 2000 in the Lower Amur in summer low-water period. Low silicon concentrations (2.5 times lower than in 2006) may be also explained with the photosynthetic activity of algae. Contrary to nitrogen and silicon compounds, concentrations of phosphates did not differ much: in 2006 the average was 0.079 mg/dm^3 and in 2009 – 0.062 mg/dm^3.

Heavy metals also revealed a noticeable heterogeneity. Fe and Ni had the highest concentrations. At Station 5 the concentration of Al was also high. Concentrations of Cu, Cd and Co were below the level of detection (0.001 mkg/l). In the vertical profile the highest Fe and Ni concentrations are found mostly in the bottom water layers and the highest Mn concentrations are found in the surface layers.

The Amur Liman peculiarity is its complex currents [2]. Uneven daily tides in the Sakhalin Bay and semi-diurnal tides in the Sea of Japan coupled with fluctuating water discharge from the Amur River create a significant heterogeneity of distribution of suspended and dissolved substances throughout the liman and its profile. The biggest differences in suspended substance distribution along the profile due to rough sea conditions were registered in the shallow areas (St. 6). Mixing of ultra-fresh Amur waters with sea waters cause the formation of saltish and weakly alkaline waters. Low water content in the Amur in 2008 resulted in a weak dilution of sea waters and thus main ion concentrations in 2008 were higher than in 2006. For example, natrium and chloride ion concentrations at Station 3 in 2008 exceeded 2006 concentrations 2.3 and 2.58 times respectively.

The lowest concentrations of main ions were observed in the surface water in the central part of the Amur Liman. In shallow waters no big difference between vertical distribution of ions was observed. In deep areas (St. 5) main ion concentrations in surface water were 2-3 times lower compared to bottom water layers.

Big changes of concentrations of silicon and mineral forms of nitrogen were revealed. Concentrations of these substances decrease due to their consumption by phytoplankton. Nitrate nitrogen decrease was found to be the highest. Minimal concentrations of nitrogen and phosphorus compounds were observed in surface waters. Contrary to silicon and mineral forms of nitrogen phosphate concentrations in water remained increased. In 2008 nitrate nitrogen and phosphate concentrations in sea water were lower than in 2006 due to low discharge of these substances from the Amur River.

Concentrations of heavy metals differed in the Amur estuary and the Amur Liman. Some of them (Ni, Co and Cu) sharply increased, others (Al, Mn) fluctuated and the third (Fe) decreased. Only Cd concentration did not differ and was, as observed before, below the detection level. In the water profile maximal concentrations only of Ni, Co and Cu were found in bottom water layers, whereas maximal concentrations of other metals were observed in different water layers. Compared to 2006, concentrations of Ni, Cu, Co and Al in sea water at Stations 4-6 in 2008 were higher and those of Mn were lower. Differences in metal concentrations can be explained with low water content in the Amur River.

In the Sakhalin Bay (Stations 7-9) suspended substance concentrations and water temperature gradually decreased and pH value and water salinity (and, thus, main ion concentrations) increased. Differences in main ion concentrations along the water profile gradually decrease with the increasing depth and distance from the Amur Liman. Compared to ion behaviour, biogenic substance concentrations in salt water sharply decreases and silicon and nitrate and ammonium nitrogen concentrations were below the level of detection. Phosphate concentrations also become minimal.

Cu concentrations underwent the most noticeable changes. They gradually increased with water salinity increase and became evenly distributed along the profile. Fe, Co and Ni concentrations also evened out along the profile. Al and Mn behaviour differ much from the behaviour of other metals. Al concentration in surface water with salinity 24-27 $^{0}/_{00}$ was below the detection level, whereas in bottom layers with temperature below 0^{0} C it reached its maximum. Cadmium appeared in sea water. Mn concentrations were distributed in a mosaic pattern. Compared to 2006, observation data of 2008 revealed higher concentrations of Cu, little different from Co and Ni concentrations

Thus, dissolved substance concentrations in waters of the Amur Liman and the Sakhalin Bay in 2008 were significantly influenced by low water content in the Amur River this year. Compared to 2006, main ion and heavy metal concentrations were higher and biogenic substance concentrations were lower.

References

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Table 3.1. Amur Water Chemical Composition at Khabarovsk, mg/l

Date	Station	Na	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	NH_4^+	NO_2^-	NO_3^-	N_{tot}	N_{sus}	HPO_4^{2-}	Fe_{tot}	Si	Turbidity*
14.02.08	left	7.2	1.4	10.8	2.8	6.1	9.5	0.88	0.015	1.11	0.93	<0.05	0.022	0.40	4.6	3.1
	centre	7.2	1.8	10.0	3.3	4.9	9.1	0.93	0.013	1.49	1.09	0.09	0.014	0.43	4.3	1.6
	right	7.1	1.8	10.4	2.8	4.9	9.1	0.91	0.011	1.11	0.96	<0.05	<0.01	0.40	3.8	3.8
28.05.08	left	5.9	1.5	9.2	3.5	3.6	15.3	0.27	0.002	<0.03	0.23	0.19	0.014	0.22	1.1	1.8
	centre	6.2	1.5	9.6	3.3	4.4	15.3	0.34	0.002	<0.03	0.30	0.19	0.033	0.23	1.0	2.5
	right	4.5	1.3	6.6	3.0	2.9	13.1	0.14	0.009	0.36	0.42	0.19	0.037	0.33	2.9	1.9
17.07.08	left	6.4	1.5	10.8	3.5	3.6	13.8	0.17	0.012	0.33	0.28	0.19	<0.01	0.15	2.1	1.0
	centre	6.4	1.5	10.8	3.0	3.5	15.3	0.12	0.012	0.47	0.44	0.19	<0.01	0.11	2.2	2.0
	right	6.4	1.5	10.8	3.5	3.1	15.3	0.12	0.011	0.30	0.42	0.28	<0.01	0.13	2.2	1.5
30.08.08	left	4.1	1.0	6.6	2.7	2.9	9.4	< 0.03	<0.002	0.13	0.35	0.19	0.037	0.28	3.4	1.3
	centre	3.8	1.1	6.6	2.7	1.9	9.6	< 0.03	0.010	0.05	0.32	0.28	0.041	0.23	2.6	1.3
	right	4.2	1.1	6.6	2.5	2.2	8.6	< 0.03	0.010	0.07	0.20	0.19	0.044	0.28	2.8	1.6
25.09.08	left	5.5	1.1	8.3	3.3	3.5	10.1	0.13	0.006	<0.03	0.20	0.56	< 0.01	0.62	2.6	1.7
	centre	5.5	1.1	9.5	2.9	3.5	11.6	0.11	0.004	<0.03	0.30	0.37	< 0.01	0.20	2.6	2.4
	right	5.6	1.0	8.3	3.0	3.5	13.6	0.09	0.003	<0.03	0.42	0.47	< 0.01	0.19	2.7	12.8
23.10.08	left	5.6	1.0	10.0	3.2	3.0	11.4	< 0.03	0.013	<0.03	0.20	0.19	< 0.01	0.18	3.0	5.4
	centre	5.2	1.1	10.0	2.9	3.0	10.6	0.04	0.014	<0.03	0.30	0.19	< 0.01	0.22	2.5	2.1
	right	5.7	1.1	10.0	2.9	3.0	14.1	< 0.03	0.013	<0.03	0.40	0.19	< 0.01	0.16	3.0	2.2
25.12.08	left	5.6	1.5	9.8	4.5	2.6	13.6	< 0.03	0.005	1.80	0.43	0.09	0.041	0.20	5.3	1.5
	centre	5.1	1.8	10.7	5.0	4.1	15.1	0.13	0.005	1.89	1.00	0.09	0.037	0.20	4.1	1.7
	right	9.1	2.1	13.1	2.4	5.9	19.0	0.22	0.006	3.04	1.00	0.76	0.052	0.20	4.1	1.4
21.01.09	left	5.3	1.3	9.4	2.7	2.4	10.1	0.20	0.010	1.38	0.56	0.09	0.029	0.28	1.3	1.2
	centre	6.8	1.5	11.5	3.5	3.9	11.1	0.44	0.010	2.26	0.96	0.19	0.037	0.23	0.9	1.6
	right	8.6	1.8	13.1	4.0	5.0	16.1	0.55	0.016	2.39	1.09	0.19	0.029	0.22	2.2	2.2

*water turbidity units in formazine

Table 3.1. continued. Amur Water Chemical Composition at Bogorodskoe, mg/l

Date	Station	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	NH_4^+	NO_2^-	NO_3^-	N_{tot}
26.02.08	left	7.1	1.8	10.4	2.8	4.9	7.5	0.62	<0.002	1.55	0.86
	centre	7.0	1.8	10.0	3.0	4.2	7.9	0.51	<0.002	1.23	0.76
	right	6.6	1.7	11.2	2.6	5.8	7.9	0.79	0.002	1.49	0.96
19.03.08	left	6.4	1.6	10.4	2.8	5.9	8.3	0.82	0.002	1.23	0.93
	centre	6.6	1.7	10.0	2.8	4.5	7.9	0.84	0.003	1.36	0.99
	right	6.4	1.6	10.0	2.8	3.9	7.9	0.64	<0.002	0.98	0.82
29.05.08	left	3.9	1.1	6.6	2.6	2.9	12.6	0.36	0.012	0.16	0.58
	centre	4.1	1.1	7.4	2.1	2.1	12.6	0.45	0.007	0.25	0.65
	right	4.1	1.1	6.6	2.6	2.6	10.6	0.32	0.006	0.11	0.56
28.06.08	left	4.4	1.1	6.6	2.6	2.0	9.6	0.05	0.002	< 0.03	0.38
	centre	4.1	1.1	7.4	2.6	2.2	10.1	0.18	0.002	< 0.03	0.38
	right	4.4	1.1	7.4	3.0	2.1	10.6	0.22	0.002	< 0.03	1.36
29.07.08	left	6.1	1.4	9.0	2.5	3.2	12.4	< 0.03	0.006	0.06	0.23
	centre	6.1	1.4	9.0	2.5	3.2	12.9	< 0.03	0.006	0.06	0.40
	right	6.3	1.4	9.0	2.5	3.4	12.1	< 0.03	0.006	< 0.03	0.27
28.08.08	left	4.4	1.2	7.4	2.5	2.3	9.1	< 0.03	0.005	0.51	0.40
	centre	4.4	1.3	7.8	2.5	2.3	11.1	< 0.03	0.005	0.67	0.30
	right	4.4	1.2	7.8	2.5	2.5	9.1	< 0.03	0.003	0.42	0.38
28.09.08	left	4.9	1.2	7.4	2.7	1.8	9.1	< 0.03	0.005	0.14	0.30
	centre	4.9	1.2	7.8	2.5	1.8	10.1	< 0.03	0.005	0.12	0.27
	right	5.0	1.0	7.8	2.5	1.8	8.6	0.04	0.005	0.19	0.35
30.10.08	left	4.6	1.0	8.6	2.7	2.2	8.1	< 0.03	0.002	0.03	0.32
	centre	4.9	1.0	8.6	2.7	2.1	9.1	< 0.03	0.002	< 0.03	0.32
	right	4.2	1.0	8.2	2.7	2.2	8.6	0.04	<0.002	< 0.03	0.51
30.12.08	left	7.9	1.5	11.9	3.7	3.8	12.1	0.16	0.006	0.98	0.55
	centre	7.0	1.3	11.9	4.0	4.6	13.1	< 0.03	0.003	1.25	0.53
	right	5.8	1.5	11.5	3.5	3.3	12.1	0.07	0.005	1.25	0.48
26.01.09	left	7.0	1.5	12.3	4.0	4.0	12.6	0.34	0.010	1.80	1.30
	centre	6.8	1.8	12.3	3.7	3.5	16.6	0.31	0.006	1.93	1.23
	right	7.7	1.6	11.9	3.7	4.8	13.1	0.29	0.010	2.07	1.88

Table 3.1. continued. Amur Water Chemical Composition at Nickolaevsk-on-Amur, mg/l

Date	Station	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	NH_4^+	NO_2^-	NO_3^-	HPO_4^2
22.06.08	St.1. surface	3.8	1.0	6.6	1.6	3.7	10.1	0.25	0.004	< 0.03	0.014
	St.1. bottom	3.5	0.9	6.6	2.6	5.3	10.6	0.22	0.004	0.07	0.037
	St.2. surface	3.7	0.9	5.8	2.6	4.4	9.6	0.25	0.006	0.04	0.022
	St.2. bottom	3.5	1.0	5.8	2.3	3.4	10.1	0.27	0.007	0.15	0.037
20.07.08	St.1. surface	4.4	1.1	5.8	2.8	3.7	8.1	0.18	0.006	0.08	< 0.01
	St.1. bottom	4.6	1.1	5.8	2.6	3.6	7.2	0.25	0.006	0.08	0.014
	St.3. surface	4.4	1.1	5.8	3.0	4.4	8.3	0.25	0.007	0.10	0.014
	St.3. bottom	4.3	1.2	5.8	2.6	2.8	8.3	0.25	0.009	0.11	< 0.01
28.08.08	St.1. surface	4.8	1.3	7.4	2.5	2.7	11.6	0.14	0.010	0.28	0.056
	St.1. bottom	4.8	1.3	7.4	2.5	2.7	11.6	0.02	0.010	0.34	0.052
	St.3. surface	5.3	1.3	7.4	2.5	3.2	11.6	0.08	0.010	0.33	0.033
	St.3. bottom	5.2	1.3	7.4	2.5	3.0	12.1	0.08	0.010	0.34	0.048

28.09.08	St.1. surface	5.5	1.4	7.8	2.7	2.9	10.1	<0.3	0.006	0.07	0.044
	St.1. bottom	5.6	1.2	7.8	2.7	2.9	10.1	<0.3	0.006	0.05	0.044
	St.3. surface	119	7.2	9.8	15.9	216	32.4	<0.3	0.008	0.05	0.044
	St.3. bottom	58.6	4.5	9.4	9.9	107	23.0	<0.3	0.009	0.05	0.052
18.10.08	St.1. surface	5.1	1.1	9.1	2.7	2.8	12.6	<0.3	0.005	0.11	0.018
	St.1. bottom	5.2	1.1	7.5	2.8	2.1	10.1	0.06	0.006	0.08	0.018
	St.3. surface	3.5	0.7	5.8	2.1	2.0	9.1	<0.3	0.003	0.04	<0.003
	St.3. bottom	3.0	0.6	5.0	1.9	1.9	9.6	<0.3	0.002	0.04	0.010

Table 3.2. Characteristics and Chemical Composition of Water in the Amur Liman and the Sakhalin Bay

H	T	pH	Turbidity	S	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}
m	°C	unit	g/m^3	$^0/_{00}$	mg/l					
St 1, 4.08.08.										
0.0	22.8	7.66	11.3	0.0	5.6	1.4	8.2	2.7	4.7	11.6
9.2	23.1	7.43	30.5	0.0	5.7	1.4	8.2	2.7	3.9	12.6
St 2. 4.08.08.										
0.0	22.9	7.35	9.5	0.0	6.0	1.4	8.2	2.7	4.3	12.6
15.1	23.1	7.10	9.4	0.0	5.9	1.4	8.2	2.5	4.6	11.9
St 3. 4.08.08.										
0.0	22.6	7.27	13.6	0.0	5.7	1.3	8.2	2.7	4.5	11.6
18.3	22.6	7.06	30.5	0.0	5.7	1.3	8.2	2.2	4.0	10.9
St 4. 5.08.08.										
0.0	18.8	7.92	9.8	14.6	4939	209	173	566	8230	1854
7.7	18.3	7.91	16.0	26.0	4576	209	181	571	8469	1756
St 5. 5.08.08.										
0.0	18.4	7.98	7.6	7.0	3485	131	100.7	315	4572	1013
16.3	18.4	7.45	61.3	25.6	7121	341	308	1005	14400	2845
St 6. 5.08.08.										
0.0	18.4	7.90	9.4	20.8	6394	287	259	830	12197	2350
10.3	18.4	7.85	70	23.0	6758	310	275	915	13299	2448
St 7. 5.08.08.										
0.0	16.4	7.92	24.4	22.3	7697	355	275	881	12705	2448
10.4	7.7	7.94	100	23.5	9879	402	329	1070	15417	3092
St 8. 5.08.08.										
0.0	14.1	8.00	5.9	24.1	8424	324	112	987	14230	2966
21.1	0.4	8.00	3.2	31.1	9515	386	319	1221	17620	3709
St 9. 5.08.08.										
0.0	10.7	8.04	3.5	26.9	9515	418	337	1112	16264	3263
19.5	-1.0	7.95	3.4	32.3	9879	355	355	1112	16264	3758

Table 3.2. continued

NH_4^+	NO_2^-	NO_3^-	HPO_4^{2-}	Si	Fe.$_{tot}$	Al	Mn	Co	Ni	Cu	Cd
	mg/l					mkg/l					
St 1. 4.08.08											
0.17	0.010	0.19	0.060	1.4	0.30	5.04	3.50	35.04	0.38	< 0.001	< 0.001
0.08	0.010	0.19	0.063	1.4	0.34	2.83	3.05	2.34	0.56	< 0.001	< 0.001
St 2. 4.08.08.											
0.14	0.020	0.08	0.063	1.4	0.26	< 0.001	0.19	< 0.001	0.60	< 0.001	< 0.001
0.16	0.010	0.12	0.063	1.4	0.59	0.31	0.08	< 0.001	1.02	< 0.001	< 0.001
St 3. 4.08.08.											
0.11	0.010	0.08	0.060	1.2	0.18	< 0.001	0.45	< 0.001	0.35	< 0.001	< 0.001
0.11	0.010	0.09	0.060	1.6	0.30	< 0.001	< 0.001	< 0.001	0.35	< 0.001	< 0.001
St 4. 5.08.08.											
< 0.05	0.002	< 0.03	0.018	1.0	0.13	11.33	12.18	0.35	4.79	50.02	< 0.001
< 0.05	0.002	< 0.03	0.025	1.0	0.13	11.57	0.03	0.90	9.34	147.98	0.00
St 5. 5.08.08.											
< 0.05	0.004	< 0.03	0.033	1.3	0.18	< 0.001	0.46	0.11	3.09	17.48	< 0.001
0.12	0.002	< 0.03	0.048	0.3	0.13	4.48	< 0.001	0.72	8.58	199.00	< 0.001
St 6. 5.08.08.											
< 0.05	0.005	< 0.03	0.056	0.8	0.18	3.18	0.70	0.57	7.56	257.03	< 0.001
0.16	0.002	< 0.03	0.063	0.7	0.18	10.13	1.27	0.68	8.73	361.99	< 0.001
St 7. 05.08.08											
< 0.05	0.004	< 0.03	0.071	0.6	0.13	4.86	1.63	0.62	8.11	371.82	< 0.001
< 0.05	0.002	< 0.03	0.037	0.1	0.13	0.85	0.16	0.62	8.68	412.52	< 0.001
St 8. 5.08.08.											
< 0.05	0.002	< 0.03	0.033	0.3	0.30	< 0.001	0.34	0.67	8.40	415.17	< 0.001
0.07	0.002	< 0.03	0.041	<0.05	0.09	0.08	0.92	0.79	8.41	426.96	0.07
St 9. 5.08.08.											
< 0.05	0.001	< 0.03	<0.01	<0.05	0.13	< 0.001	2.16	0.75	8.05	437.30	0.05
< 0.05	<но	< 0.03	0.014	<0.05	0.13	29.31	0.90	0.73	7.63	434.68	0.07

Table 3.3. Chemical Composition of Bottom Sediments (metals, mg/kg N - %)

Station	Al	Mn	Fe	Co	Ni	Cu	N
St. 1	15000.00	486.00	17100.00	7.57	10.00	9.08	0.04
St. 2	18600.00	733.00	22800.00	9.22	12.10	9.23	0.16
St. 3	2510.00	103.00	7120.00	2.63	1.50	1.63	0.01
St. 4	13600.00	654.00	18300.00	6.82	9.26	6.51	0.07
St. 5	16700.00	332.00	20500.00	7.58	10.80	8.51	0.08
St.6	1680.00	91.50	7480.00	2.29	0.42	1.92	0.01
St. 7	4480.00	261.00	14700.00	3.92	2.66	2.70	0.02
St.8	4170.00	90.90	6790.00	2.66	2.12	1.44	0.02
St. 9	4680.00	145.00	8210.00	3.16	2.24	2.73	0.03

Table 3.4. Chemical Composition of particle of the filters, mg/l

Station	Al	Mn	Fe	Co	Ni	Cu	N
St.1. surface	1174.7	56.0	352. 0	< 0,001	< 0,001	< 0,001	0.14
St.1. bottom	426.7	32.1	< 0,001	< 0,001	< 0,001	< 0,001	0.14
St.2. surface	523.4	41.0	24.4	< 0,001	< 0,001	< 0,001	0.08
St.2. bottom	299.4	32.2	< 0,001	< 0,001	< 0,001	< 0,001	0.14
St.3. surface	1197.2	65.6	358.6	< 0,001	< 0,001	< 0,001	0.14
St.3. bottom	1627.5	79.1	714.5	< 0,001	< 0,001	< 0,001	0.17
St.4. surface	147.1	7.8	< 0,001	< 0,001	< 0,001	< 0,001	0.07
St.4. bottom	1909.7	48.1	383.8	< 0,001	< 0,001	< 0,001	0.06
St.5. surface	26.4	31.0	61.9	< 0,001	< 0,001	< 0,001	0.07
St.5. bottom	737.4	24,7	379,2	< 0,001	0,53	< 0,001	0.04
St.6. surface	364.6	24.3	< 0,001	< 0,001	< 0,001	< 0,001	0.07
St.6. bottom	1185.4	33.7	312.3	< 0,001	< 0,001	< 0,001	0.06
St.7. surface	452.0	19.4	< 0,001	< 0,001	< 0,001	< 0,001	0.06
St.7. bottom	3023.8	55.2	1848.3	0.20	< 0,001	< 0,001	0.04
St.8. surface	398.1	25.8	< 0,001	< 0,001	< 0,001	< 0,001	0.07
St.8. bottom	< 0,001	0,40	< 0,001	< 0,001	< 0,001	< 0,001	0.04
St.9. surface	< 0,001	2,2	< 0,001	< 0,001	< 0,001	< 0,001	0.06
St.9. bottom	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	0.06

Table 3.5. Heavy Metal and N Concentrations in Amur Water, mkg/dm^3 (Roshydromet samples)

№	Observation date and specifics	Al	Mn	Co	Ni	Cu
1	28.05.08-Khabarovsk. left.	42.74	3.55	0.07	0.66	< 0.001
2	-«-«-«-centre	23.92	2.96	0.07	0.52	< 0.001
3	-«-«-«-right	142.08	4.61	0.08	0.61	< 0.001
4	17.07.08-Khabarovsk. left	11.83	2.75	0.04	0.74	< 0.001
5	-«-«-«-centre	10.07	2.44	0.04	0.77	< 0.001
6	-«-«-«-right	8.50	2.54	0.05	0.82	< 0.001
7	30.08.08-Khabarovsk. left.	26.07	4.10	0.04	0.66	< 0.001
8	-«-«-«-centre	30.45	2.68	0.03	0.47	< 0.001
9	-«-«-«-right	20.47	3.03	0.03	0.72	< 0.001
10	25.09.08-Khabarovsk. left	47.12	3.06	0.05	0.64	1.01
11	-«-«-«-centre	75.43	3.88	0.06	0.73	5.19
12	-«-«-«-right	233.04	39.15	0.28	0.96	3.07
13	23.10.08-Khabarovsk. left	30.50	4.61	0.05	0.54	9.46
14	-«-«-«-centre	25.06	5.89	0.06	0.56	2.91
15	-«-«-«-right	31.42	3.04	0.16	0.65	6.73
16	25.12.08-Khabarovsk. left					
17	-«-«-«-centre					
18	-«-«-«-right					
19	25.01.09-Khabarovsk. left					
20	-«-«-«-centre					
21	-«-«-«-right					
22	29.05.08-Bogorodskoe. left	56.54	5.54	0.04	0.50	< 0.001
23	-«-«-«-centre	32.96	7.34	0.04	0.46	< 0.001
24	-«-«-«-right	33.15	5.48	0.04	0.49	< 0.001
25	28.06.08-Bogorodskoe. left	6.89	2.09	0.01	0.39	< 0.001
26	-«-«-«-centre	8.23	1.43	0.01	0.41	< 0.001
27	-«-«-«-right	11.46	1.94	0.01	0.50	< 0.001
28	29.07.08-Bogorodskoe. left	6.79	1.37	0.01	0.43	< 0.001
29	-«-«-«-centre	5.04	11.47	0.01	0.38	< 0.001
30	-«-«-«-right	9.14	33.31	0.02	0.71	< 0.001
31	29.08.08-Bogorodskoe. left					
32	-«-«-«-centre					
33	-«-«-«-right					
34	25.09.08-Bogorodskoe. left					
35	-«-«-«-centre					
36	-«-«-«-right					
37	25.10.08-Bogorodskoe. left					
38	-«-«-«-centre					
39	-«-«-«-right					
40	30.12.08-Bogorodskoe. left					
41	-«-«-«-centre					
42	-«-«-«-right					
43	26.01.09-Bogorodskoe. left					
44	-«-«-«-centre					
45	-«-«-«-right					
46	22.06.08-Nickolaevsk-on-Amur. St.1. surface	23.00	8.99	0.02	0.30	< 0.001
47	-«-«-«- bottom	19.94	8.90	0.01	0.44	< 0.001

48	-«-«-«-«. St.2. surface	21.74	8.57	0.01	0.30	< 0.001
49	-«-«-«- bottom	19.36	7.91	0.01	0.29	< 0.001
50	20.07.08-Nickolaevsk-on-Amur. St.1. surface	16.98	9.28	0.01	0.43	< 0.001
51	-«-«-«- bottom	10.82	8.64	0.01	0.28	< 0.001
52	-«-«-«-«. St.2. surface	12.43	8.51	0.01	0.43	< 0.001
53	-«-«-«- bottom	12.04	9.26	0.01	0.26	< 0.001
54	28.08.08-Nickolaevsk-on-Amur. St.1. surface	36.18	11.10	0.03	0.40	< 0.001
55	-«-«-«- bottom	35.12	11.38	0.02	0.46	< 0.001
56	-«-«-«-«. St.2. surface	33.03	10.30	0.02	0.50	< 0.001
57	-«-«-«- bottom	34.60	14.96	0.03	0.50	< 0.001
58	28.09.08-Nickolaevsk-on-Amur. St.1. surface	17.47	11.79	0.02	0.43	< 0.001
59	-«-«-«- bottom	15.72	11.49	0.02	0.21	< 0.001
60	-«-«-«-«. St.2. surface	15.32	11.69	0.02	2.13	< 0.001
61	-«-«-«- bottom	16.04	11.80	0.02	0.33	5.71
62	18.10.08- Nickolaevsk-on-Amur. St.1. surface	17.49	13.55	0.03	0.50	2.46
63	-«-«-«- bottom	3.91	9.18	0.02	0.37	4.12
64	-«-«-«-«. St.2. surface	9.90	12.61	0.01	0.85	4.54
65	-«-«-«- bottom	40.40	13.87	0.03	4.05	5.82

Table 3.6. Heavy Metal Concentrations on filters of Amur Water, mkg/kg (Roshydromet samples)

№	Observation date and specifics	Al	Mn	Fe	Co	Ni	Cu
1	28.05.08-Khabarovsk, left	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
2	-«-«-«-centre	< 0.001	917.3	< 0.001	< 0.001	< 0.001	< 0.001
3	-«-«-«-right	< 0.001	83.3	< 0.001	< 0.001	< 0.001	< 0.001
4	17.07.08-Khabarovsk, left	< 0.001	760.5	< 0.001	< 0.001	< 0.001	< 0.001
5	-«-«-«-centre	< 0.001	205.4	< 0.001	< 0.001	< 0.001	< 0.001
6	-«-«-«-right	< 0.001	1153.2	< 0.001	< 0.001	< 0.001	< 0.001
7	30.08.08-Khabarovsk, left	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
8	-«-«-«-centre	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
9	-«-«-«-right	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
10	25.09.08-Khabarovsk, left	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
11	-«-«-«-centre	< 0.001	434.6	< 0.001	< 0.001	< 0.001	< 0.001
12	-«-«-«-right	< 0.001	1184.9	< 0.001	< 0.001	< 0.001	< 0.001
13	23.10.08-Khabarovsk, left	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
14	-«-«-«-centre	< 0.001	28934.6	< 0.001	< 0.001	< 0.001	< 0.001
15	-«-«-«-right	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
16	25.12.08-Khabarovsk, left						
17	-«-«-«-centre						
18	-«-«-«-right						
19	25.01.09-Khabarovsk, left						
20	-«-«-«-centre						
21	-«-«-«-right						
22	29.05.08-Bogorodskoe, left	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
23	-«-«-«-centre	5397.7	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
24	-«-«-«-right	1212.5	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
25	28.06.08-Bogorodskoe, left	< 0.001	4514.8	< 0.001	< 0.001	750.29	< 0.001
26	-«-«-«-centre	< 0.001	1733.6	< 0.001	< 0.001	558.06	< 0.001
27	-«-«-«-right	< 0.001	1991.1	< 0.001	< 0.001	< 0.001	< 0.001
28	29.07.08-Bogorodskoe,left						
29	-«-«-«-centre						
30	-«-«-«-right						
31	29.08.08-Bogorodskoe, left						
32	-«-«-«-centre						
33	-«-«-«-right						
34	25.09.08-Bogorodskoe, left						
35	-«-«-«-centre						
36	-«-«-«-right						
37	25.10.08-Bogorodskoe, left						
38	-«-«-«-centre						
39	-«-«-«-right						
40	30.12.08-Bogorodskoe, left						
41	-«-«-«-centre						
42	-«-«-«-right						
43	26.01.09-Bogorodskoe, left						
44	-«-«-«-centre						
45	-«-«-«-right						
46	22.06.08-Nickolaevsk. St. 1. surface	15737.3	680.1	1842.0	< 0.001	< 0.001	< 0.001
47	-«-«-«-bottom	21610.2	1056.0	833.5	< 0.001	45.51	< 0.001

48	-«-«-«-«. St.2 surface	20191.6	976.1	3079.7	< 0.001	< 0.001	< 0.001
49	-«-«-«-bottom	30121.1	1264.5	1869.4	< 0.001	54.13	< 0.001
50	20.07.08- Nickolaevsk. St. 1. surface	27944.8	1438.3	6132.7	< 0.001	38.56	< 0.001
51	-«-«-«-bottom	7328.6	391.3	521.9	< 0.001	33.70	< 0.001
52	-«-«-«-«. St.2 surface	42896.4	2192.1	6985.9	< 0.001	11.50	< 0.001
53	-«-«-«-bottom	38975.9	2099.5	5121.0	< 0.001	< 0.001	< 0.001
54	28.08.08-Nickolaevsk. St. 1. surface	37421.7	1382.5	4479.9	< 0.001	13.48	< 0.001
55	-«-«-«-bottom	50198.7	2326.4	4140.7	< 0.001	< 0.001	< 0.001
56	-«-«-«-«. St.2 surface	1851.8	71.9	423.0	0.13	< 0.001	< 0.001
57	-«-«-«-bottom	53967.0	1588.4	13152.0	2.67	22.21	< 0.001
58	28.09.08- Nickolaevsk. St. 1. surface	542.3	31.4	< 0.001	< 0.001	< 0.001	< 0.001
59	-«-«-«-bottom	453.0	17.3	< 0.001	< 0.001	< 0.001	< 0.001
60	-«-«-«-«. St.2 surface	5027.9	218.7	< 0.001	< 0.001	< 0.001	< 0.001
61	-«-«-«-bottom	268.8	11.5	< 0.001	< 0.001	< 0.001	< 0.001
62	18.10.08- Nickolaevsk. St.1. surface	26929.3	650.1	< 0.001	< 0.001	< 0.001	< 0.001
63	-«-«-«-bottom	19658.7	320.0	2875.4	< 0.001	< 0.001	< 0.001
64	-«-«-«-«. St.2 surface	36198.7	1119.8	< 0.001	< 0.001	< 0.001	< 0.001
65	-«-«-«-bottom	23470.2	653.1	1731.1	< 0.001	< 0.001	< 0.001

3.3. Organic Matter Concentrations in Amur Water

Concentrations of dissolved organic carbon (DOC) in Amur water in the hydrological section near Khabarovsk (Telegino village) fluctuated in the period of observations at average in the range 3.7 - 8.4 mgC·l^{-1} (Table 3.7.). Such concentrations are quite common for Amur water, but they were lower than those, observed in 2007. The maximal concentrations were registered at the right bank and in the middle of the river. February 2008 happened to be an exception as maximal DOC values were registered at the left river bank.

Table 3.7. DOC in Amur water at Khabarovsk (February 2008 – January 2009), mgC·l^{-1}

Sampling date	Sampling location		
	Left bank	River middle	Left bank
14.02.08	7.0	6.8	6.5
28.05.08	7.5	7.5	9.0
17.07.08	5.5	6.1	6.9
30.08.08	6.0	6.7	6.7
25.09.08	7.5	9.1	8.3
23.10.08	7.1	9.0	9.0
25.12.08	3.8	3.8	4.5
21.01.09	4.5	7.5	5.0

Concentrations of suspended organic matter (SOM) in Amur water in the hydrological section near Khabarovsk (Telegino village) fluctuated in the period of observations at average in the range 0.04 - 0.65 mgC·l^{-1} (Table 3.8.). Maximal concentrations were observed in spring 2008 due to floods and minimal concentrations were observed in winter. The highest SOM values are registered at the right bank and in the middle of the river and can be explained with Sungari water flow impact, which was also observed in previous years (Levshina, 2008). SOM values across the river differ 1.5-4 times. As a whole, SOM values at Khabarovsk were one order lower than in the previous years due to low water content in the Amur in 2008.

Table 3.8. SOM in Amur water at Khabarovsk (February 2008 – January 2009), mgC·l^{-1}

Sampling date	Sampling location		
	Left bank	River middle	Left bank
14.02.08	0.02	0.02	0.08
28.05.08	0.96	0.34	0.65
17.07.08	0.27	0.96	0.15
30.08.08	0.25	0.40	0.32
25.09.08	0.35	0.97	0.37
23.10.08	0.26	0.21	0.35
25.12.08	0.02	0.16	0.23
21.01.09	0.18	0.49	0.34

Concentrations of dissolved organic carbon in Amur water in the hydrological section at Bogorodskoe ranged between 3.6 and 7.5 mgC·l^{-1} (Table 3.9.). The maximal DOC concentration 8.4 mgC·l^{-1} was registered at the left bank of the river in May and the minimal 3.0 mgC·l^{-1} – in the river middle in December. Concentrations of suspended organic matter in Amur at Bogorodskoe ranged between 0.23 and 0.66 mgC·l^{-1} (Table 3.10.). The maximal SOM concentration 0.80 mgC·l^{-1} was registered at the left bank of the river in spring (March) and the minimal 0.14 mgC·l^{-1} – at the right river bank in winter (February). No marked tendencies in the distribution of dissolved and suspended organic matter across the Amur were observed. On the whole, organic matter concentrations in 2008 in Amur water at Bogorodskoe were lower than those observed in 2006-2007. This situation can probably be explained with low water content in Amur in 2008 and a relatively smaller input of technogeneous wastes into the water organic component.

Table 3.9. DOC in Amur water at Bogorodskoe (February 2008 – January 2009), mgC·l^{-1}

Sampling date	Sampling location		
	Left bank	River middle	Left bank
26.02.08	7.3	7.8	6.5
19.03.08	4.5	5.3	4.1
29.05.08	8.4	7.7	6.5
28.06.08	6.9	6.8	6.4
29.07.08	5.3	5.4	6.0
28.08.08	6.0	4.5	4.5
28.09.08	6.2	4.5	4.2
30.10.08	3.9	4.5	4.5
30.12.08	4.2	3.0	3.5
26.01.09	4.1	4.9	4.1

Table 3.10. SOM in Amur water at Bogorodskoe (February 2008 – January 2009), mgC·l^{-1}

Sampling date	Sampling location		
	Left bank	River middle	Right bank
26.02.08	0.59	0.63	0.14
19.03.08	0.80	0.50	0.69
29.05.08	0.53	0.46	0.61
28.06.08	0.48	0.46	0.46
29.07.08	0.22	0.15	0.15
28.08.08	0.50	0.51	0.52
28.09.09	0.52	0.35	0.18
30.10.08	0.31	0.27	0.19
30.12.08	0.25	0.29	0.26
26.01.09	0.24	0.21	0.23

Closer to the Amur estuary (Nickolaevsk-on-Amur) DOC values did not significantly differ in water layers and fluctuated at the surface between 4.6 and 7.3 and at the river bottom between 4.4 до 7.3 mgC·l^{-1} (Table 3.11.). The maximal DOC value (8.3 mgC·l^{-1}) was registered in the surface water layer in August and the minimal DOC values (3.8 mgC·l^{-1}) were found in both surface and bottom water layers in September.

Table 3.11. DOC in Amur Water at Nickolaevsk-on-Amur, mgC·l^{-1}

№	Sampling layer	Sampling date				
		22.06.08	20.07.08	28.08.08	28.09.08	18.10.08
1-2	surface	6.8	6.0	8.3	5.3	5.6
2-2	bottom	7.6	6.8	7.5	4.5	5.3
3-2	surface	7.6	6.8	6.6	3.8	4.5
4-2	bottom	7.2	7.5	6.8	3.8	4.5

Table 3.12. SOM in Amur water at Bogorodskoe (February 2008 – January 2009), mgC·l^{-1}

№	Sampling layer	Sampling date				
		02.06.08	20.07.08	28.08.08	28.09.08	18.10.08
1-2	surface	2.99	2.99	0.13	0.19	0.30
2-2	bottom	1.46	1.84	0.08	0.17	0.46
3-2	surface	1.15	1.23	0.21	0.08	0.42
4-2	bottom	1.38	2.07	0.13	0.17	0.37

Concentrations of suspended organic matter in Amur surface and bottom water layers ranged from 0.23 to 2.11 and from 0.10 to 2.00 mgC·l^{-1} respectively (Table 3.12.). The maximal SOM value (2.99 mgC·l^{-1}) was registered in the surface water layer in June and July and the minimal values were found in the bottom layer in August and in the surface layer in September.

It does not seem possible to identify any particular tendency in suspended matter distribution along the vertical, but it is already evident that there is a big difference in SOM concentrations between the river surface and bottom water layers (in dozens of times).

3.4. Organic Matter Concentrations in Water and Bottom Sediments in the Amur Estuary, Amur Liman and Sakhalin Bay

Suspended organic matter concentrations in surface and bottom waters of the Amur estuary, Liman and Sakhalin Bay fluctuated at average from 0.22 to 0.52 $mgC \cdot l^{-1}$ (Table 3.13.) and revealed a complex distribution pattern. The maximal SOM values were found in samples of Stations 5 and 7 and the minimal value was observed at Station 9, where water has 26-32‰ salinity (sea water). Suspended organic matter concentrations in 2008 were found higher than in the previous observation years and may be probably explained with phytoplankton activity in the warm period (August).

Table 3.13. Organic Carbon in Suspended Matter (C_{sus}) in Waters of the Amur estuary, Liman and Sakhalin Bay, $mgC \cdot l^{-1}$

№	Station	Water layer	C_{sus}
1.	St 1	surface	0.34
2.		bottom	0.41
3.	St 2	surface	0.21
4.		bottom	0.35
5.	St 3	surface	0.45
6.		bottom	0.28
7.	St 4	surface	0.26
8.		bottom	0.21
9.	St 5	surface	0.55
10.		bottom	0.47
11.	St 6	surface	0.52
12.		bottom	0.31
13.	St 7	surface	0.50
14.		bottom	0.54
15.	St 8	surface	0.30
16.		bottom	0.27
17.	St 9	surface	0.20
18.		bottom	0.25

Organic carbon concentrations in bottom sediments fluctuated between 0.79 and 11.0 $mgC \cdot l^{-1}$ (Table 3.14.). The maximal values were found in samples of Station 2 and the minimal values were observed at Station 3.

Table 3.14. Total Organic Carbon Concentrations (C_{org}) in bottom sediments, $mgC \cdot l^{-1}$ (dry weight) in summer 2008.

Station	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9
C_{org}	6.52	11.0	0.79	6.11	7.47	1.19	3.14	2.28	2.56

References

1. Levshina S.I. Dissolved and Suspended Organic Matter in the Amur and Songhua Water // Water Resources. 2008. Vol. 35. № 6, pp. 716-724.

4. Studies in the Kiya River Basin

4.1. Landscape and Hydrologic Characteristics of the Studied Area

Landscape and hydrological studies were undertaken in the Kiya River basin (mainly in its middle passage) (Fig. 4.1.). The Kiya River drainage area is 1290 km^2, its length is 173 км and the total river fall (the elevation of the river-head point over the estuary point)) – 463 m, the average gradient of the river is 2.7 ‰.

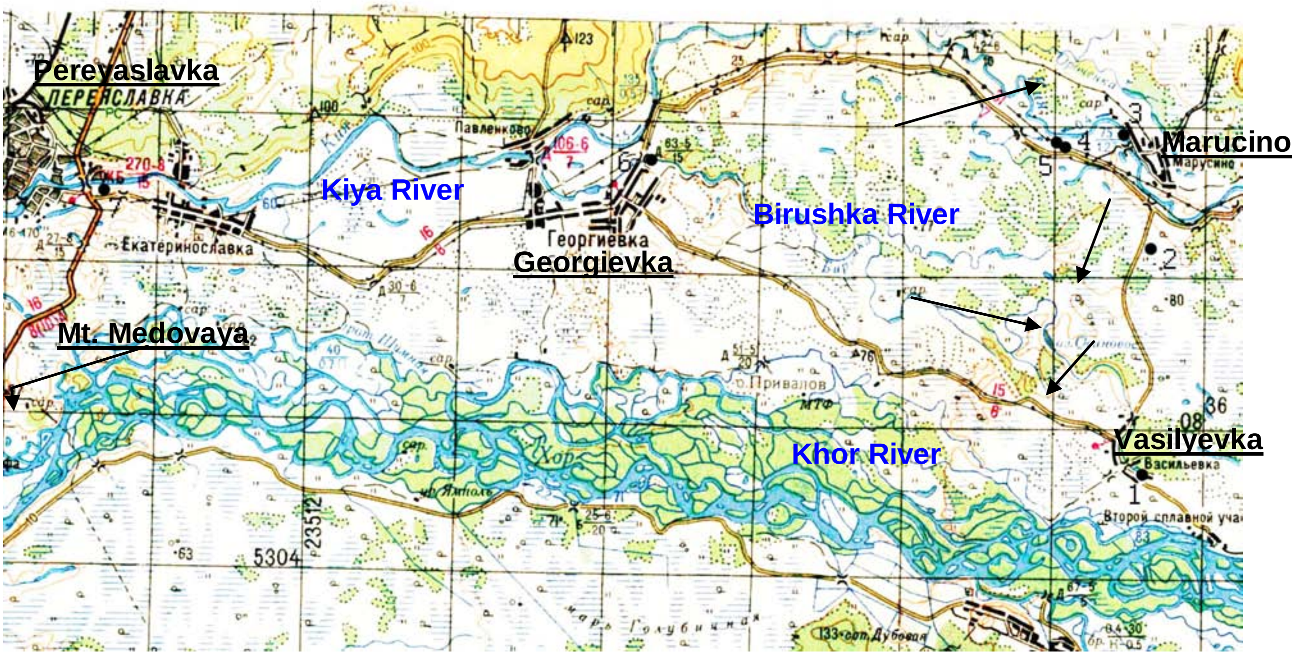

Fig. 4.1. The Area of Field Studies in 2008 – the Middle Passage of the Kiya River. Black dots and figures indicate regular sampling stations.

The rivers Khor and Kiya in the studied area flow through the terraced plain. Its boundaries and adjacent mountain slopes are characterized with the abundance of forest podbel soils under the small-leaved forests including larch. Podbel soils are formed on the loam-clay weakly permeable deposits. In mountain divide areas brown mountain-forest soils are formed under coniferous-broad-leaved forests. Residual and talus deposits of basement rocks of different composition serve as a soils-forming base here. Due to their highly-rubble composition these soils have a high permeability. Vast terraces are covered with wet meadows (reedgrass and sedge meadows), low and intermediate bogs with meadow-gley, peat and peat-gley soils.

The Khor River has a well-developed floodplain with well-drained alluvial soddy and floodplain stratified soils under forests abundant in ash, elm, nut-trees and similar tree-species. Most part of the studied area underwent significant transformations due to agriculture development in the last century. There are several settlements on the banks of these rivers, including big ones Pereyaslavka and Khor.

The Kiya River begins its flow from the western slopes of the southern spurs of the Bolshoi Amban Upland (995 m above the sea level) and further runs through the Sikhote-Alin foothills and the West-Primorskaya Plain. Near Chernyaevo village it joins from the right the Ussuri River, 32 km upper its mouth.

Due to its orographic specifics the Kiya basin is divided into three parts: mountainous, hilly and plain ones. The spurs of the Bolshoi Amban Upland form the highest and biggest part of the basin. The divide heights range here from 400-500 to 600-700 meters above the sea level. The middle part of the basin (approximately lower the Fartovy Stream mouth) has a hilly relief with divide heights 100-200 meters above the sea level. The rest part of the basin is a nearly flat plain with lots of low bars, covered with forests, which create a wavy pattern. Forests cover the mountainous and hilly parts of the basin, whereas wet meadows and bogs prevail in the pain, where drier areas have been ploughed and/or used as pastures. The hydrographic net is only developed in the mountainous part of the basin and its mean density coefficient is 0.44 km/km^2 [Resources…, 1972; Mordovin, 1996].

According to the plain and riverbed composition and river-flow conditions, the Kiya River can also be divided into three parts or reaches:

1) the reach from the Kiya head to the mouth of the Fartovy Stream (35 km long),
2) the reach from the mouth of the Fartovy Stream up to Pereyaslavka (78 km long),
3) the reach from Pereyaslavka to the Kiya mouth (60 km long).

The reach from the Kiya head to the mouth of the Fartovy Stream is mountainous and hilly and the river runs at the bottom of a box-like valley with few curves. The valley is 0.5-1 km wide. Steep forest-covered slopes of this valley are cut with dry notches and valleys of smaller tributaries of the Kiya River. The left slope of the Kiya River is terraced. The floodplain is two-sided, covered with forests and 100-120 km wide (even 300 km in some areas). The floodplain surface is covered with hummocks and is moderately cut with streambeds and oxbows. The riverbed is meandering, medium-channeled and comparatively stable. Predominant river widths are 10-15 km and depths are 0.6-0.7 m. From the Kiya head to the Kontorsky Stream the riverbed is rocky and characterized with a significant gradient and flow velocity up to 2 m/sec. Further down the river there are rifts and stretches, where flow velocity prevails within the range of 0.5 – 0.7 m/sec. The river bottom is uneven, pebbled and sandy and in summers overgrows with water vegetation.

From the Fartovy juncture up to Pereyaslavka the Kiya River flows through a wavy plain (Fig. 4.2.)

Fig. 4.2. The Middle Passage of the Kiya River.

The valley has an asymmetric structure: only its right side is well-marked and in some places is relatively steep towards the river. A gently sloping left side of the valley smoothly merges with the adjacent plain. The floodplain is two-sided and mostly boggy. Its hummock surface is mostly covered with sedge and other bog vegetation and spotted with shrubs. Oxbow-lakes in different stages of overgrowing can be found here. The floodplain is composed of sabulous and clayish-sandy soils. Dry areas and areas dried with trenches are used as agricultural grounds. The riverbed is slightly meandering and almost not channeled. The river bottom is pebbled or pebble-sandy. The width of this river passage fluctuates between 25 and 40 meters lower the Tazovka and Birushki junctures and in some places reaches 120-150 meters. Flow velocity is not high, 0.4 – 1 m/sec in particular. In summers the riverbed is overgrown with water vegetation.

The reach of the Kiya valley from Pereyaslavka to the Kiya mouth is a wide plain, covered with hummock pigweed. The valley sides smoothly merge with the adjacent plain landscape. The floodplain is two-sided, covered with meadows and bogs and spotted with shrubs. Elevated areas are used as plough-land. Soils are similar to those of the previous passage, described above. The riverbed is slightly meandering and almost not channeled. There is only one big island, called Razboi, 10 km long and up to 4 km wide. Two thirds of the island is covered with forest and the rest is ploughed. This island is high and is covered with water only during floods that rarely happen. The river is 40-60 km wide here. The rifts occur every 3-4 meters. They are usually 50-200 m long and up to 0.6 m deep. The flow velocity here is usually 0.1-0.3 m/sec, sometimes even less than 0.1 m/sec. In many places of the modern mainstream old riverbeds can be found. They are 10-40 m wide and 0.5-1.5 m deep. Their length ranges from 30-60 to 100-600 meters. In the Kiya lower reaches some dead riverbeds reach 3-4 km. Pebble-sandy bars and beaches are abundant here. The river bottom is pebble-sandy and in deep spots is clay-sandy. In summers the riverbed is often overgrown with water vegetation. [Resources…, 1970].

Table 4.1. Information on Dalhydromet Hydrometric Stations on the Kiya River

Hydrometric station	Observed drainage area, km^2	Observation period	
		open	closed
Marusino	505	23 Sep 1948	in action
Pereyaslavka	629	19 Apr 1924	31 Dec 1943
Pereyaslavka	629	1 Aug 1965	in action
Mogilevka	889	1 Nov 1943	7 Sep 1964

According to its water regime the Kiya River is ranked as a far eastern type of rivers, which specific feature is well-marked prevalence of summer-autumn rainfall run-off. The share of precipitation in the total annual water run-off is 60-85 %. In the warm time of the year (April – November) 96 % of the annual water run-off is formed. In spite of increased water content due to heavy rainfalls, the river run-off fluctuates significantly that gives a hydrograph a ridged pattern. Kiya average perennial run-off in the river mouth is 11.2 m^3/sec, or 8.68 l/sec·km^2 [Resources…, 1972; Mordovin, 1996]. Spring floods begin in March or the beginning of April and last till the end of April – the beginning of March. Water rise is usually less than in summer-autumn floods, but sometimes, especially after extremely snowy winters and early beginning of monsoon rains, which create snow-rain floods, water rise in spring can exceed the summer rise.

A food season begins in May and usually lasts till the end of November. Three to five floods happen during this period, and in particular years even nine. Water rises at average for 05.-1.2 m above the before-flood water level. The maximal rise of 1.7 m is observed at Marusino village. During high floods in the Khor River water flows over the wage divide into the Kiya River, thus increasing the Kiya water level by 2-2.5 m. Water rise intensity is 0.3-0.5 meters per day, sometimes reaching maximum of 0.5 meters per day. The flood recession is slower and its intensity is 0.2-0.3 meters per day. The highest water rise keeps for 5-6, or even up to 2 days.

The flood recession in the river upper reaches lasts at average 8-10 days and in the river valley passage it lasts 15-20 days. Quite often the flood wave recession is accompanied with new floods, thus prolonging the overall recessing to 25-30 days. As a rule there are short periods of low run-off between particular floods. Totally the process takes 38-48 days.

After the formation of the ice cover the river bed is constrained and the river is partially frozen. Due to these processes the water level gradually rises during the whole winter. Winter low water lasts for 135-150 days.

Autumn ice flow is absent as a rule. The river becomes frozen over before the first decade of November and stays frozen for 165-170 days. In winter icings up to 0.2-0.6 m are formed in the mainstream. The Kiya River is completely frozen only in its valley passage, whereas in its upper reaches in shallow places it is rarely frozen only in severe winters. The river ice break starts in the second half of April [Resources…, 1972].

The Birushka River, the biggest Kiya tributary, is 30 km long. It drains mostly from a plain area abundant in bogs and wet meadows, which are partially used for agriculture. The riverbed is heavily overgrown with water and bog vegetation. The river is less than 5 m wide and 0.5-1 m deep. Water velocity is rather slow and is 0.1 m/sec as average.

4.2. Research Objects and Methods

In 2008 water discharge was measured at the Kiya and Birushka Rivers (stations 3, 6 and 7 as indicated in Fig. 4.1) from the bridge and on foot with a hydrometric velocity-meter GR-21M (factory serial number 1041). River water was sampled form middle water horizons. In the Kiya River sampling was done 5 m from the left bank and in the Birushka River sampling was done in the middle of the stream upper the automobile bridge. Such physical and chemical characteristics of water mass as turbidity, temperature (t ºC) and water pH were measured. Oxygen concentrations and water temperature were measured in situ with a "Toledo" thermooximeter. Water turbidity was measured with thermostatic-gravimetric technique.

To describe different water components the following methods were applied:

- ionometry for pH
- a complex method for water hardness (Ca^{2+}+Mg^{2+});
- titration for Ca^{+2};
- photometry for Si in the yellow form of molibdic silicic acid;
- titration with mercury salt for chlorides (Cl^-);
- titration with photometry to follow for sulfates (SO_4^{2-});
- a flame photometry for Na^++K^+;
- titration for hydrocarbonates (HCO_3^-)
- photometry with Nessler's reagent for ammonium (NH_4^+);
- photometry sodium salicylate for nitrates (NO_3^-);
- photometry with Griss reagent for nitrites (NO_2^-);
- photometry for (PO_4^{3-}) in the form of molybdenum blue;
- a bio-chromatic method for dissolved organic carbon (DOC);
- inductively coupled plasma mass spectrometry (ICP-MS) for total iron, manganese, cadmium, zinc, copper and aluminum.
- photometry with α,α'-dipyridyl for Fe^{2+}, Fe^{3+} .

4.3. Research Results

4.3.1. **Hydrological Characteristics of the Studied Area in 2008 Summer-Autumn Period**

Background conditions of the 2008 warm period in the area of study were dry (Tables 4.2., 4.3.). From the beginning of June monthly precipitation sums were lower than the norm. Thus the sum of precipitation in Marusino area from May to October was only 63.5% of the norm. Table 4.2. shows monthly precipitation sums for the 2008 warm period at Marusino

Meteostation, calculated based on observation data of Bichevaya Meteostation [www.rp5.ru] and using the relation of average monthly sums of the two stations (Fig. 4.3.).

Table 4.2. Characteristics of Atmospheric Moistening in the Kiya River Basin at Marusino Meteostation. Summer and Autumn Period of 2008.

Months	2008	Average of the whole observation period [data from www.gismeteo.ru]
	Sum of precipitation, mm	
May	68.3	59
June	7.9	91
July	87.7	119
August	86.2	125
September	48.6	88
October	38.4	49
Total	337	531

Table 4.3. Daily Precipitation Sums at Bichevaya Meteostation. May - October 2008 [initial data from www.rp5.ru].

Date	May	June	July	August	September	October
1	0.5					
2	0.0			25.0	0	
3	8.0		0.7	13.0	11.0	
4	6.0		8.4			0.1
5	35.0		14.0	36.0		
6		0.0		0.8		
7	2.0		3.0			
8	6.0	0.4				
9	0.0	7.0				1.0
10		0.4				
11				0.0	5.0	13.0
12		0.6		0.6	8.0	0.2
13		0.0		0.0	10.0	
14			1.0	9.0		
15		0.0		3.4		
16	1.0		11.0		6.0	
17			16.0	12.0		
18	0.0			1.2	6.0	
19	11.0		0.0			7.1
20	3.0	2.0				
21					0.6	
22					0.3	
23			0.4	2.0	6.0	
24	2.0		6.0			8.0
25	7.0					
26	0.7				6.3	14
27		0.0				3.8
28	0.6			0.4	0.3	
29	0.4			1.3		
30			31.0	0.0		
31			15.0			
Monthly Sum	**83.2**	**10.4**	**106.5**	**104.7**	**59.5**	**47.2**
Average Monthly Sum	**72**	**109**	**145**	**152**	**106**	**59**

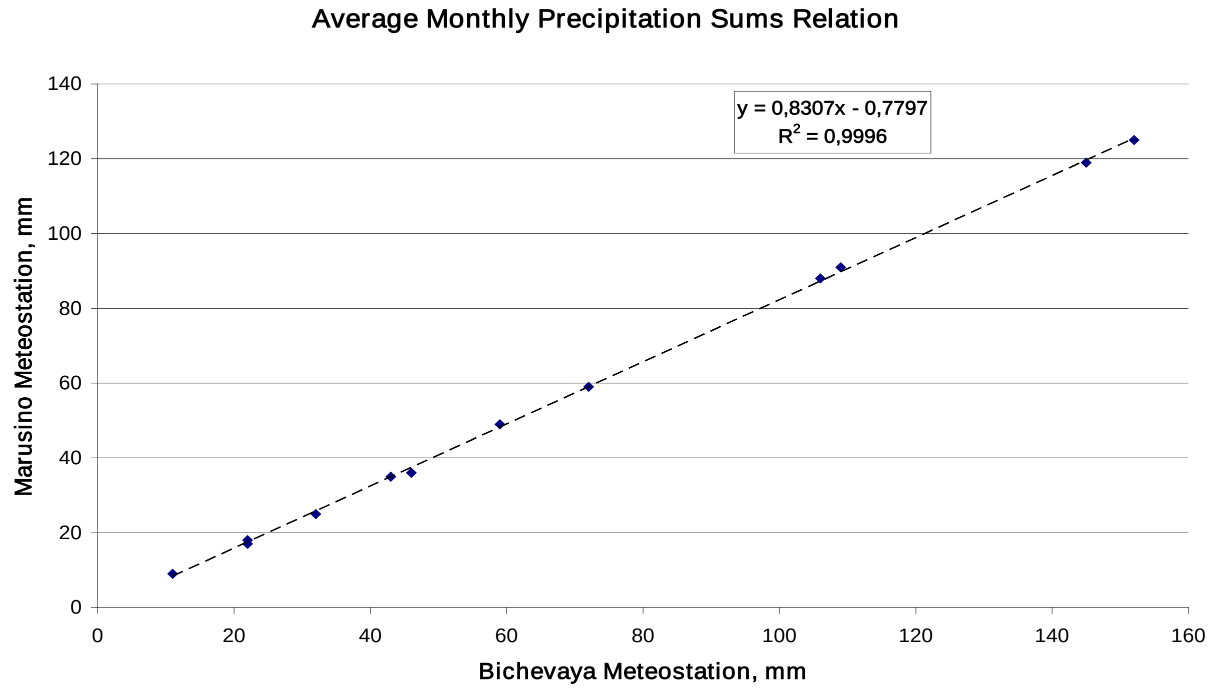

Fig. 4.3. Relation of the Average Monthly Precipitation Sums at Bichevaya and Marusino Meteostations [data from www.gismeteo.ru]

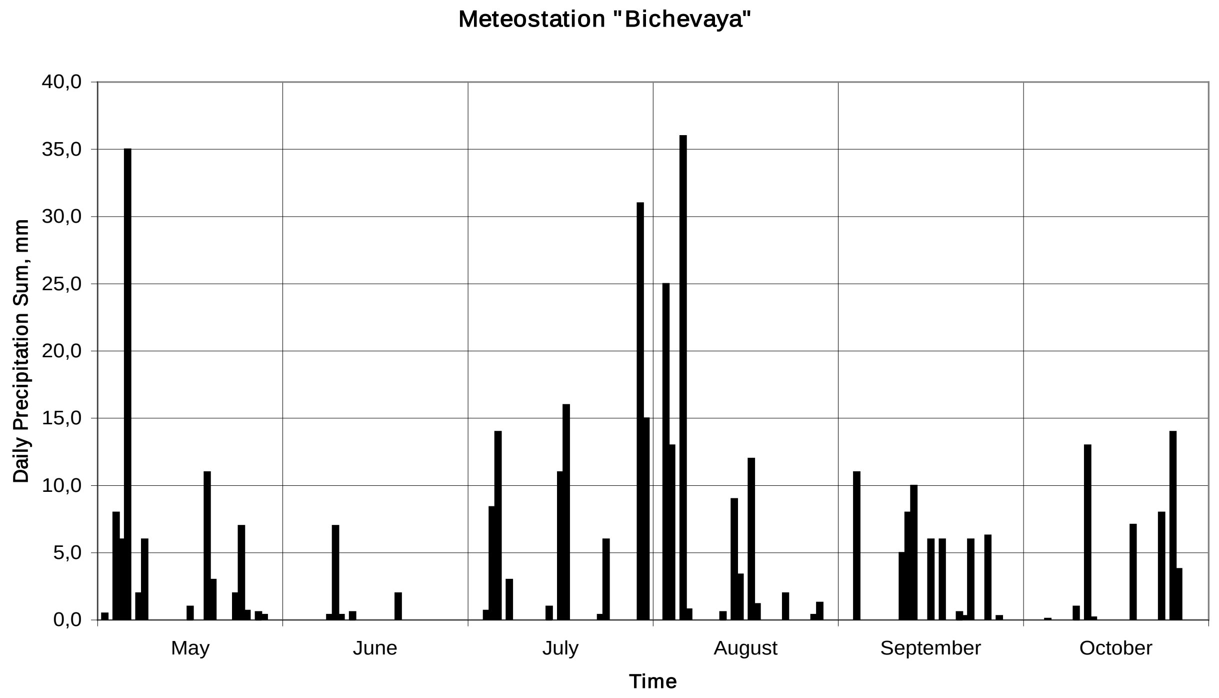

Fig. 4.4. Interseasonal Distribution of Daily Precipitation Sums at Bichevaya Meteostation in 2008 [initial data from www.rp5.ru].

Water discharge measurement data are given in Table 4.4. and the graphs (Fig. 4.5.-4.7.) below.

Water sampling and hydrometric observations at the Kiya River, carried out August, 9 2008, coincided with the recession of a medium-size flood, which appeared due to heavy rains from July, 30 to August, 6. The precipitation sum reached 100 mm. Thus, Kiya run-off sharply increased 3 times compared to the previous observations, dated July, 31 (Fig. 4.5.). It is remarkable that in the Birushka River water discharge, measured July, 31, showed 3.5 times increase after a previous rain with precipitation depth of 30 mm, whereas the following rains at the beginning of August of the precipitation sum about 70 mm did not cause the increase of the run-off depth (Fig. 4.7.)

Table 4.4. Measured Water Discharge (m^3/sec)

№	Measuring date	River – measuring site		
		Kiya – Marusino village	Kiya – Pereyaslavka village	Birushka – Georgievka village
1	10-11.VII	0.77	1.88	0.014
2	31.VII-1.VIII	0.77	2.08	0.048
3	9.VIII	2.61	4.37	0.028
4	14.VIII	1.72	3.00	No measurements
5	25-26.VIII	1.21	2.20	0.015
6	9.IX	0.57	1.85	0.013
7	26-27.IX	1.48	2.14	0.006
8	14.X	1.29	2.12	0.013

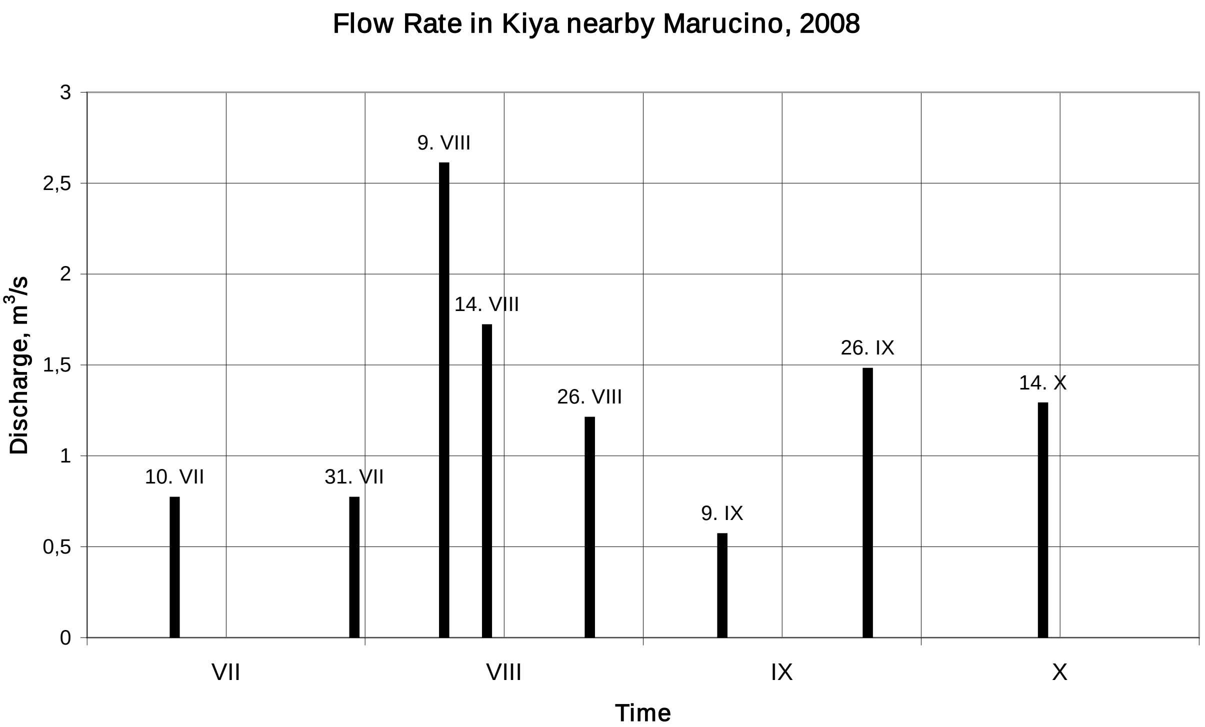

Рис. 4.5. Interseasonal Distribution of Kiya Flow Rate at Marusino Based on Measured Data (m^3/sec) for July – October 2008.

As a whole, atmospheric moistening conditions in the summer-autumn period in 2008 caused the decrease of moisture content in the Kiya Basin, which became particularly evident in a gradual decrease of ground water level in the area of study. Data of hydrogeological profiles, made September 25 and 26 at the high floodplain of the Kiya River near Marusino village, revealed the decrease of ground water level with the increase of distance from the river edge (Fig. 4.8., 4.9.)

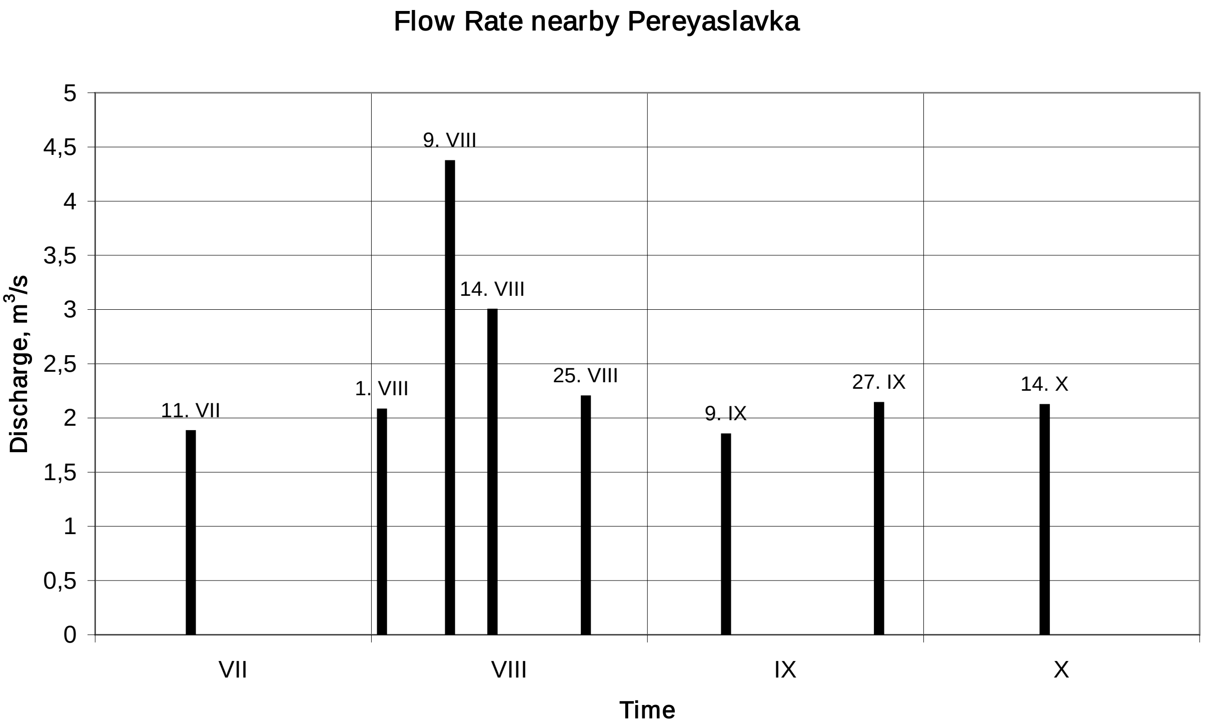

Рис. 4.6. Interseasonal Distribution of Kiya Flow Rate at Pereyaslavka Based on Measured Data (m^3/sec) for July – October 2008.

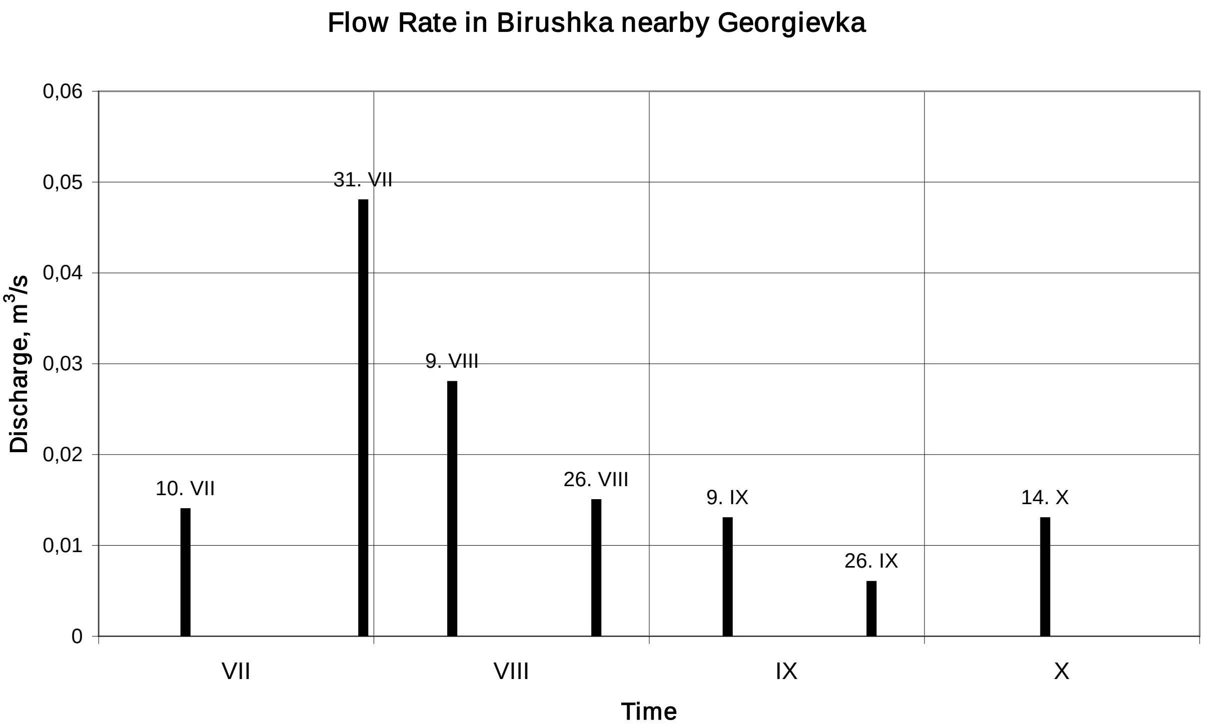

Рис.4.7. Interseasonal Distribution of Birushka Flow Rate at Georgievka Based on Measured Data (m^3/sec) for July – October 2008.

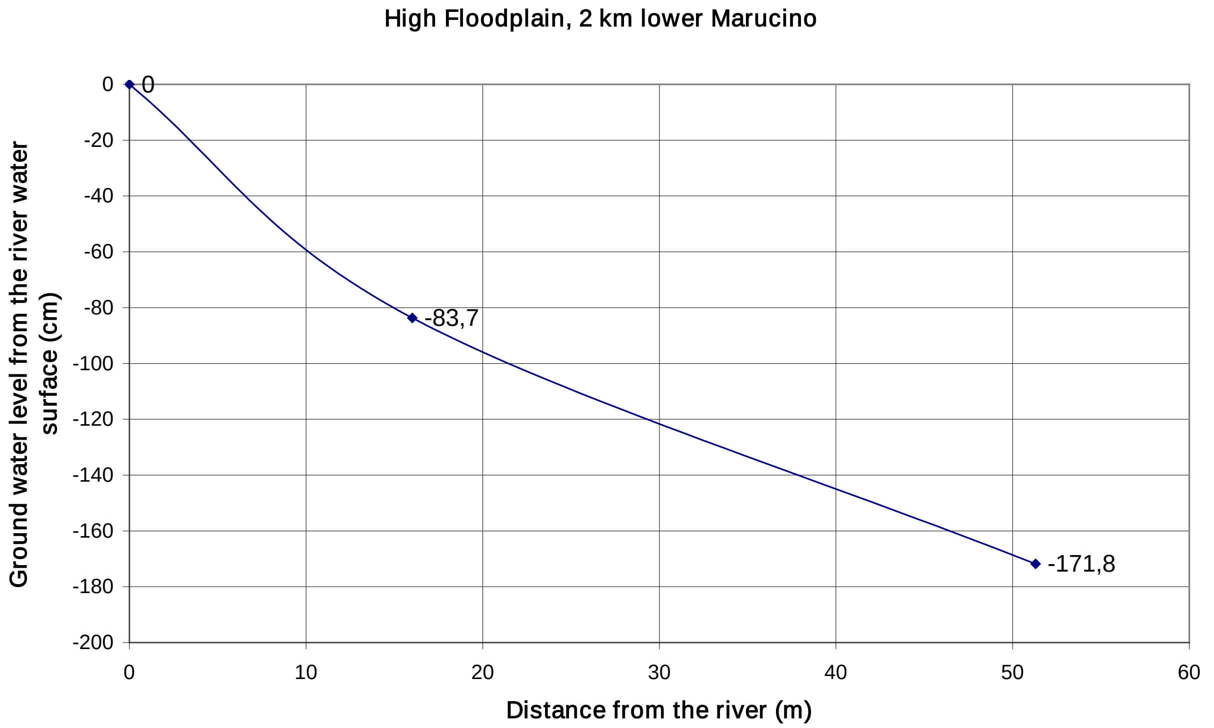

Fig. 4.8. Decrease of Ground Water Level on High Floodplain Depending on the Distance from the Kiya River (the right bank 2 km downstream Marusino). Observation Date 26.09.2008.

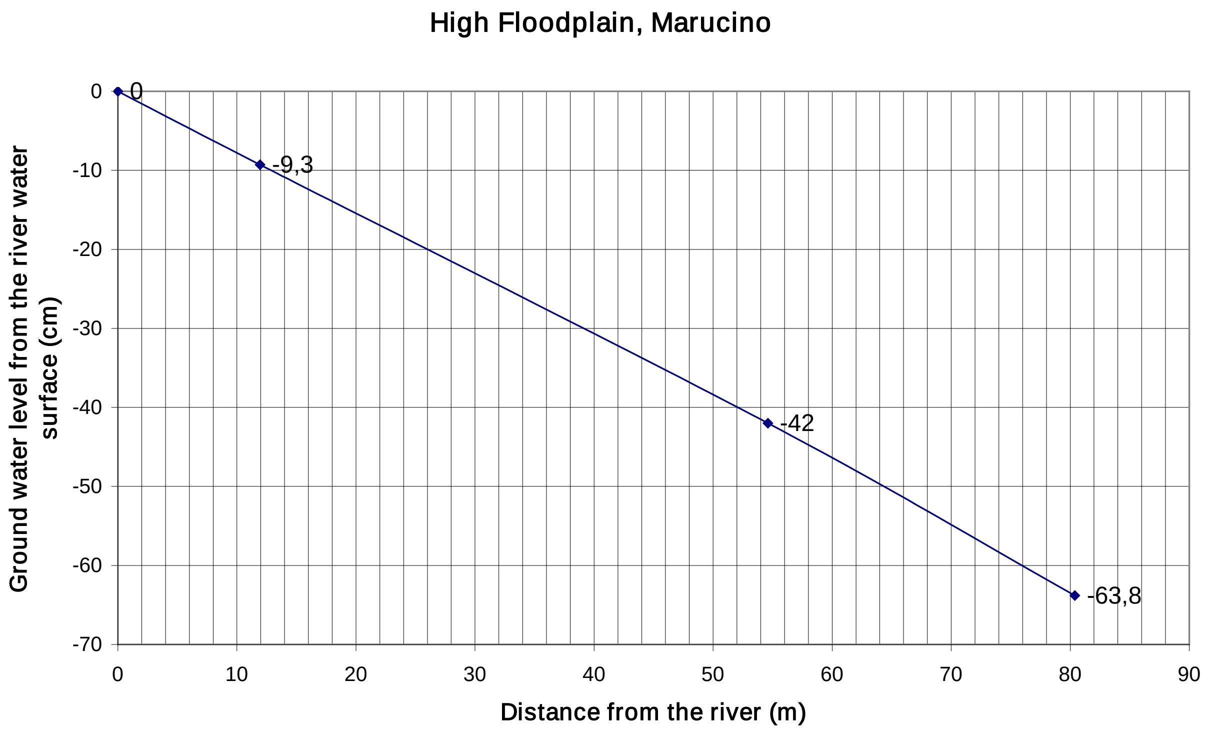

Fig. 4.9. Decrease of Ground Water Level on a High Floodplain Depending on the Distance from the Kiya River (the left bank of the river at Marusino village). Observation Date 25.09.2008.

References

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4.3.2. Organic Matter in the Kiya River Basin

Organic matter (OM) concentrations in waters in the studied area in 2008 fluctuated in a big range between 2.0 and 9.9 mgC·l^{-1} (Table 4.5.), but the values were not very high and did not exceed the values, registered in the previous year. The lowest concentrations were observed at the beginning of autumn at Stations 3 and 4. Maximal concentrations at the same period were found in Kiya river water at Station 7, which may be explained with intensive agricultural activities in Pereyaslavka area. River water pH values in the observation period were 6.16–8.07 (Table 4.6.), which is quite common for the studied area in summer-autumn period (Water Resources….,1990).

Table 4.5. Total Organic Carbon Concentrations in Waters of the Studied Area (July-October 2008), mgC·l^{-1}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	5.6	–	4.1	8.3	4.1	6.8	9
2	Bog, Birok riv. upper reaches	20	24	25.2	20	46.4	17.2	21.2
3	Kiya river, Marusino vil.	4.9	7.5	12.4	6.8	2.3	5.6	5.6
4	Kiya river, Marusino (wetland)	–	–	–	–	9.5	16	12.4
5	Transition zone, catena near Marusino	–	–	–	–	8.4	20	42
6	Birushka river, Georgievka vil.	8.3	4.5	9.6	7.5	2	6	3.8
7	Kiya river, Pereyaslavka	8.5	8.3	4.7	7.5	9.9	4.2	4.1
8	Underground waters	–	–	–	–	16	2.3	–

Note: here and in other tables "–" was not analyzed as samples were not collected due to low water content in the studied object.

Table 4.6. Hydrogen Ion Concentrations (pH) in Kiya, Birushka and Bog Waters (summer, autumn 2008)

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	6.80	–	6.41	6.55	6.16	6.76	6.70
2	Bog, Birok riv. upper reaches	5.76	5.61	5.63	5.32	6.02	5.50	5.36
3	Kiya river, Marusino vil.	7.47	6.82	7.06	7.65	6.93	7.29	6.80
4	Kiya river, Marusino(wetland)	–	–	–	–	5.43	6.70	5.74
5	Transition zone, catena near Marusino	–	–	–	–	5.86	6.07	6.06
6	Birushka river, Georgievka vil.	7.05	7.10	7.18	7.60	6.50	6.55	6.82
7	Kiya river, Pereyaslavka	8.07	7.56	7.80	7.34	6.96	7.56	6.64
8	Underground	–	–	–	–	4.75	6.70	–

	waters							

Bog waters (Station 2) contained organic matter in much higher concentrations that river waters. Total organic carbon concentrations fluctuated from 17.2 to 46.4 mgC·l^{-1}. Such values are considered to be not high for bog waters. Bog water colority was not high and was between 120 and 450 degrees in the Co-Pt scale. The comparison of TOC values in samples from Stations 2 and 4 revealed that Station 4 samples (in certain observation dates) contained less organic matter. Their colority did not exceed 120 degrees. Nitrogen ion concentrations in bog water (Stations 2, 4) were low and ranged 5.32-6.02 (Table 4.6.). Water sampled at Station 4 in the end of September with pH 6.7 was an exception. No well-evident "input – output" from the transition zone (Station 5) into the bog (Station 4) was observed probably due to dry autumn and absence of a soil-leaching regime.

Iron concentrations in the Kiya and Birushka rivers fluctuated in a small range (Table 4.7.) Such iron concentrations are common for Priamurje waters (Trufanov, Korobii, 1973; Chudaeva, 2002; Matushkina at all., 2006. The values, increasing the iron permissible level in water (100 mcg·l^{-1}) (Sanitary Norms…, 2000), were registered in Kiya water at Marusino (1.6 of the permissible level) in autumn. The presence of Fe(III) is common for these rivers. For bogs higher iron concentrations are common (from 220 to 880 mg·l^{-1}), predominantly in Fe(II) form. Fe(II) concentrations in water increase with the increase of pH. For example, in bog water at Station 4 with low pH (<5.5) Fe(II) values reached 868 mg· l^{-1}. The presence of Fe(II) is also common for underground waters, although iron concentration in water is not high (20.9 mg l^{-1}).

Table 4.7. Iron Concentrations (Fe_{tot}, Fe^{+2} and Fe^{+3}) in Kiya, Birushka and Bog Waters (summer, autumn 2008), mcg·l^{-1}

1	Birushka river, Vasiljevka vil.	Fe_{tot}	100.20	–	100.35	143.22	159.71	84.61	89.60
		Fe^{+2}	45.0	–	47.0	60.0	68.0	36.0	20.0
		Fe^{+3}	65.0	–	53.0	83.0	91.0	48.0	69.0
2	Bog, Birok river upper reaches	Fe_{tot}	654.0	665.0	378.42	500.00	881.24	563.9	225.56
		Fe^{+2}	420.0	466.0	268.0	362.0	473.0	527.0	155.0
		Fe^{+3}	234.0	199.0	110.0	138.0	408.0	37.0	70.0
3	Kiya river, Marusino vil.	Fe_{tot}	89.40	71.40	105.74	134.60	145.02	160.29	96.3
		Fe^{+2}	48.0	27.0	48.0	49.0	56.0	40.0	25.0
		Fe^{+3}	41.0	41.0	58.0	85.0	99.0	120.0	71.0
4	Kiya river, Marusino vil. (wetland)	Fe_{tot}	–	–	–	–	868.82	746.44	280.47
		Fe^{+2}	–	–	–	–	868.0	640.0	280.0
		Fe^{+3}	–	–	–	–	not found	106	not found
5	Transition zone, catena near Marusino	Fe_{tot}	–	–	–	–	485.32	548.73	225.4
		Fe^{+2}	–	–	–	–	464.0	502.0	202.0
		Fe^{+3}	–	–	–	–	25.0	46.0	22.9
6	Birushka river, Georgievka vil.	Fe_{tot}	82.00	98.65	122.00	95.00	86.2	75.77	66.66
		Fe^{+2}	30.0	23.0	36.0	23.0	40.2	18.0	20.0
		Fe^{+3}	56.0	76.0	86.0	72.0	46.0	57.0	46.0
7	Kiya river, Pereyaslavka	Fe_{tot}	133.40	127.42	100.65	115.10	143.11	93.42	78.1
		Fe^{+2}	25.0	47.0	32.0	27.0	41.0	23.0	35.0
		Fe^{+3}	108.0	80.0	68.0	88.0	102.0	70.0	43.0
8	Underground waters	Fe_{tot}	–	–	–	–	20.9	not found	–
		Fe^{+2}	–	–	–	–	20.9	not found	–
		Fe^{+3}	–	–	–	–	not found	not found	–

Dissolved manganese concentrations in studied waters were not high ranging from 0 (i.e. below the detection limit) to several dozens of microgram per litre (Table 4.8.). Low values were found in he Birushka at Station 1. The Maximal manganese concentrations were found in water at Station 7 in the beginning of summer, which reached 1.6 of the permissible level (10 mcg·l^{-1})

(Sanitary Norms…, 2000). In bog water manganese concentrations were much higher (166.3 mcg·l^{-1}). In underground waters no manganese was found.

Table 4.8. Manganese Concentrations (mcg/l) in Kiya, Birushka and Bog Waters, mcg·l^{-1}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	2.602	–	9.990	4.320	0.630	< 0.001	< 0.001
2	Bog, Birok river upper reaches	50.126	68.290	162.57	125.300	54.010	80.921	61.000
3	Kiya river, Marusino vil.	0.760	12.501	7.780	3.680	1.913	< 0.001	1.9020
4	Kiya river, Marusino(wetland)	–	–	–	–	153.301	92.545	64.256
5	Transition zone, catena near Marusino	–	–	–	–	84.401	386.980	231.130
6	Birushka river, Georgievka vil.	12.083	9.071	1.990	4.210	0.980	< 0.001	< 0.001
7	Kiya river, Pereyaslavka	15.956	11.301	2.651	3.542	1.211	7.570	4.510
8	Underground waters	–	–	–	–	< 0.001	< 0.001	–

Cobalt concentrations in river and bog waters were not high, ranging mostly 0 – 0.52 mcg·l^{-1} (Table 4.9.) High concentrations up to 1.60 mcg·l^{-1} were found in the transition zone (Station 5), which may be coming from mountain rock leaching as well as from soils due to plant and organism decomposition.

Table 4.9. Cobalt Concentrations (mcg/l) in Kiya, Birushka and Bog Waters, mcg·l^{-1}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	0.040	–	0.49	0.160	0.040	< 0.001	< 0.001
2	Bog, Birok river upper reaches	0.060	0.569	0.520	0.320	0.430	0.270	0.200
3	Kiya river, Marusino vil.	0.052	0.163	0.520	0.470	< 0.001	< 0.001	< 0.001
4	Kiya river, Marusino vil. (wetland)	–	–	–	–	0.390	0.150	0.100
5	Transition zone, catena near Marusino	–	–	–	–	0.810	1.600	0.530
6	Birushka river, Georgievka vil.	0.060	0.024	0.480	0.210	< 0.001	< 0.001	< 0.001
7	Kiya river, Pereyaslavka	0.300	0.428	0.040	0.120	< 0.001	< 0.001	< 0.001
8	Underground waters	–	–	–	–	< 0.001	< 0.001	–

Nickel concentrations in river and bog waters were not high, ranging mostly from 0 to 0.980 and 7.420 mcg·l^{-1}, respectively (Table 4.10.). Nickel compounds in studied waters did not exceed the permissible level = 10 mcg·l^{-1} (Sanitary Norms…, 2000). In underground waters no manganese was found.

Copper concentrations in river waters were not high (< 0.001–0.130 mcg·l^{-1}) and in bog water did not exceed mcg·l^{-1} (Table 4.11.). On the whole cooper concentrations in studied waters did not exceed the permissible level = 1 mcg·l^{-1} (Sanitary Norms…, 2000). In underground waters no manganese was found.

Table 4.10. Nickel Concentrations in Kiya, Birushka and Bog Waters (summer, autumn 2008), mcg·l^{-1}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	< 0.001	–	< 0.001	0.250	0.680	0.600	< 0.001
2	Bog, Birok river upper reaches	0.069	0.516	1.080	0.910	7.420	0.490	< 0.001
3	Kiya river, Marusino vil.	0.342	< 0.001	0.880	0.450	0.790	0.406	0.203
4	Kiya river, Marusino(wetland)	–	–	–	–	0.900	0.500	0.280
5	Transition zone, catena near Marusino	–	–	–	–	1.210	1.490	0.420
6	Birushka river, Georgievka vil.	0.132	< 0.001	0.840	0.580	0.370	0.580	0.220
7	Kiya river, Pereyaslavka	0.107	0.617	0.980	0.640	0.610	0.520	< 0.001
8	Underground waters	–	–	–	–	< 0.001	< 0.001	–

Table 4.11. Copper Concentrations in Kiya, Birushka and Bog Waters (summer, autumn 2008), mcg·l^{-1}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	< 0.001	–	< 0.001	< 0.001	< 0.001	0.090	< 0.001
2	Bog, Birok river upper reaches	< 0.001	0.380	< 0.001	< 0.001	< 0.001	0.330	< 0.001
3	Kiya river, Marusino vil.	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.050	< 0.001
4	Kiya river, Marusino vil. (wetland)	–	–	–	–	< 0.001	< 0.001	< 0.001
5	Transition zone, catena near Marusino	–	–	–	–	< 0.001	< 0.001	< 0.001
6	Birushka river, Georgievka vil.	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.130	< 0.001
7	Kiya river, Pereyaslavka	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
8	Underground waters	–	–	–	–	< 0.001	< 0.001	–

Aluminum concentrations in river waters fluctuated in a big range (Table 4.12.). Low concentrations of aluminum were found in water of the river upper reaches. Down the river towards its mouth they highly increased even 1.5-3 times exceeding the permissible level (40 mcg·l^{-1}) (Sanitary Norms…, 2000). In bog waters dissolved aluminum concentrations were much higher due to low pH and higher concentrations of dissolved organic matter. Aluminum concentrations in the transition zone waters (Station 5) did not noticeable differ from those of bog waters (Station 4).

Table 4.12. Aluminum Concentrations in Kiya, Birushka and Bog Waters (summer, autumn 2008) $mcg \cdot l^{-1}$

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	6.504	–	6.710	6.320	1.380	5.090	2.710
2	Bog, Birok river upper reaches	< 0.001	11.350	48.230	57.100	122.710	40.820	15.760
3	Kiya river, Marusino vil.	< 0.001	< 0.001	11.350	11.350	8.290	12.080	10.200
4	Kiya river, Marusino vil. (wetland)	–	–	–	–	72.780	89.010	61.200
5	Transition zone, catena near Marusino	–	–	–	–	70.100	85.750	56.340
6	Birushka river, Georgievka vil.	23.273	2.113	10.424	70.600	1.360	8.230	5.600
7	Kiya river, Pereyaslavka	75.676	42.960	40.090	12.370	13.860	12.740	4.370
8	Underground waters	–	–	–	–	4.090	3.170	–

Moderate concentrations of organic matter in Kiya and Birushka waters in the studied area can be explained with natural specifics of this area, soil and humus formation specifics in particular, i.e. relatively moderate humus acid concentrations, their fixation in the soil profile with calcium and ferric oxides and their reduced migrations out of the profile (Ivanov, 1076). Iron and manganese distribution pattern is quite common for Priamurje waters. Manganese accumulates in bog waters mostly due to their low pH.

On the whole metal concentrations in the studied waters depended on soil-formation specifics in the studied area and a low atmospheric moistening in July-October 2008.

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4.3.3. Hydrochemical Studies of the Kiya River Basin

Hydrochemical characteristics of surface, bog and ground waters are based on the analyses of main ions (Na^+, K^+, Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^-, SO_4^{2-}) and biogenic substances (NO_3^-, NO_2^-, NH_4^+, PO_4^{3-}, Si).

Main Ions

All water objects belong to a hydrocarbonate class. Calcium mainly prevails among cations with exception of samples from stations 6 (25.08.08), 5-7 (26-27.09.08), 5, 6 (14.10.08), where magnesium prevails. Cations in water usually form a series Ca^{2+}> Mg^{2+}>Na^+>K^+ or Ca^{2+}>Na+>Mg^{2+}>K^+, rarely Mg^{2+}>Ca^{2+}>Na^+>K^+ or Mg^{2+}>Na+>Ca^{2+}>K^+.

Natrium ion concentrations in water fluctuated in the range 3.13 - 7.59 mg·dm^{-3} (Table 4.13.) and were much higher than in the previous year. The minimal concentrations were found at station 2 and the maximal concentrations were observed at station 7. In ground water natrium ion concentrations were higher than in surface and bog waters.

Table 4.13. Natrium Ion Concentrations in the Studies Area (July-October 2008), mg·dm^{-3}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	3.13	-	4.02	3.35	4.02	3.35	4.69
2	Bog, Birok riv. upper reaches	1.73	1.56	2.57	1.79	1.90	1.79	1.79
3	Kiya river, Marusino vil.	4.02	4.02	3.46	4.02	4.02	4.02	3.57
4	Bog, catena near Marusino (wetland)	-	-	-	-	3.80	3.80	2.68
5	Transition zone, catena near Marusino	-	-	-	-	4.46	4.46	4.91
6	Birushka river, Georgievka vil.	3.80	3.13	3.80	4.24	3.35	4.24	5.02
7	Kiya river, Pereyaslavka	4.02	4.46	4.13	4.69	7.59	6.47	4.91
8	Underground waters near Marusino	-	-	-	-	6.47	6.92	-

Note: here and in other tables "–" was not analyzed as samples were not collected due to low water content in the studied object.

Potassium ion concentrations fluctuated in a big range (Table 4.14.) possibly due to surface water run-off from agricultural lands.

Table 4.14. Potassium Ion Concentrations in the Studies Area (July-October 2008), mg·dm^{-3}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	0.28	-	0.48	1.51	1.24	1.51	2.20
2	Bog, Birok riv. upper reaches	1.07	1.51	0.14	2.06	1.10	2.06	0.48
3	Kiya river, Marusino vil.	0.62	0.62	0.48	0.90	1.03	0.90	1.24
4	Bog, catena near Marusino (wetland)	-	-	-	-	0.34	0.69	0.28
5	Transition zone, catena near Marusino	-	-	-	-	1.93	1.31	3.85

6	Birushka river, Georgievka vil.	0.55	0.34	0.21	1.03	0.76	1.03	0.14
7	Kiya river, Pereyaslavka	0.41	0.62	0.48	0.69	4.68	0.96	1.24
8	Underground waters near Marusino	-	-	-	-	4.00	3.23	-

Water hardness (Ca^{2+}+Mg^{2+}) in the Birushka and Kiya rivers ranged 0.280 - 0.599 mmole·dm^{-3} of equivalent. Water in these rivers is characterized as soft. The maximal values were registered in autumn and the minimal values were observed in July (Table 4.15.).

Table 4.15. Water Hardness (Ca^{2+}+Mg^{2+}) (July-October 2008), mmole·dm^{-3} of equivalent

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	0.371	-	0.496	0.406	0.571	0.571	0.599
2	Bog, Birok riv. upper reaches	0.338	0.277	0.307	0.252	0.323	0.351	0.331
3	Kiya river, Marusino vil.	0.359	0.363	0.457	0.422	0.595	0.489	0.559
4	Bog, catena near Marusino (wetland)	-	-	-	-	0.638	0.426	0.406
5	Transition zone, catena near Marusino	-	-	-	-	0.552	0.559	0.559
6	Birushka river, Georgievka vil.	0.280	0.298	0.406	0.382	0.394	0.406	0.481
7	Kiya river, Pereyaslavka	0.344	0.372	0.433	0.453	0.563	0.599	0.587
8	Underground waters near Marusino	-	-	-	-	0.863	0.871	-

Calcium ion concentrations were in the range 3.2 – 6.7 mg·dm^{-3}. The minimal concentrations were found at station 2 (Table 4.16.). In bog water calcium ion concentrations are lower probably due to their bond with humus acids.

Table 4.16. Calcium Ion Concentrations in the Studies Area (July-October 2008), mg·dm^{-3}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	4.8	-	6.0	4.9	6.2	6.5	6.7
2	Bog, Birok riv. upper reaches	4.3	3.2	3.2	3.2	5.7	4.3	3.9
3	Kiya river, Marusino vil.	4.4	4.6	6.0	5.4	6.0	6.1	6.6
4	Bog, catena near Marusino (wetland)	-	-	-	-	6.5	6.2	4.3
5	Transition zone, catena near Marusino	-	-	-	-	6.2	5.5	6.2
6	Birushka river, Georgievka vil.	3.3	3.6	4.5	3.2	4.3	4.0	3.9
7	Kiya river, Pereyaslavka	4.1	3.9	5.1	5.2	6.6	3.9	6.5
8	Underground waters near Marusino	-	-	-	-	9.9	10.0	-

Magnesium ion concentrations were in the range 1.4 – 3.4 mg·dm^{-3} (Table 4.17.). In surface water magnesium concentrations significantly fluctuate and as a rule are maximal in low water periods and minimal in flood-time.

Table 4.17. Magnesium Ion Concentrations in the Studies Area (July-October 2008), mg·dm^{-3}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	1.6	-	2.4	2.0	3.2	3.0	3.2
2	Bog, Birok riv. upper reaches	1.5	1.4	1.8	1.1	0.5	1.6	1.6
3	Kiya river, Marusino vil.	1.7	1.6	1.9	1.9	3.6	2.3	2.8
4	Bog, catena near Marusino (wetland)	-	-	-	-	3.8	1.4	2.3
5	Transition zone, catena near Marusino	-	-	-	-	3.0	3.4	3.0
6	Birushka river, Georgievka vil.	1.4	1.4	2.2	2.7	2.2	2.5	3.4
7	Kiya river, Pereyaslavka	1.7	2.1	2.2	2.3	2.9	4.9	3.2
8	Underground waters near Marusino	-	-	-	-	4.5	4.5	-

Hydrocarbonate ion concentrations in surface water ranged 18.0 – 41.3 mg·dm^{-3}. The maximal HCO_3^- concentrations were found in river water samples, collected 27.09.08, and the minimal in a sample from station 3 (9.08.08), which probably can be explained with river hydrologic regime specifics at that time (Table 4.18.).

Table 4.18. Hydrocarbonate Ion Concentrations in the Studies Area (July-October 2008), mg·dm^{-3}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	28.9	-	29.6	28.4	39.6	41.3	37.9
2	Bog, Birok riv. upper reaches	20.5	17.2	13.2	13.6	11.0	15.5	8.5
3	Kiya river, Marusino vil.	26.5	29.3	18.0	21.6	29.7	32.9	28.6
4	Bog, catena near Marusino (wetland)	-	-	-	-	40.9	20.1	14.4
5	Transition zone, catena near Marusino	-	-	-	-	38.4	41.3	32.1
6	Birushka river, Georgievka vil.	22.9	31.7	25.0	25.3	27.2	32.9	32.0
7	Kiya river, Pereyaslavka	27.7	32.8	24.4	27.2	33.4	38.1	35.6
8	Underground waters near Marusino	-	-	-	-	50.8	41.9	-

Chloride ion concentrations in surface water ranged 0.3 – 2.9 mg·dm^{-3}. The minimal Cl^- concentrations were observed in the Birushka River and the maximal concentrations were observed in the Kiya River (Table 4.19.). In ground waters chloride and hydrocarbonate ion concentrations were higher than in surface and bog waters due to the specifics of the formation their chemical composition.

Table 4.19. 7 Chloride Ion Concentrations in the Studies Area (July-October 2008), mg·dm^{-3}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	3.0	-	1.1	1.0	1.1	1.1	1.8
2	Bog, Birok riv. upper reaches	0.6	0.7	0.8	1.7	0.8	1.2	2.9
3	Kiya river, Marusino vil.	1.7	1.5	1.3	1.7	2.2	1.6	1.6
4	Bog, catena near Marusino (wetland)	-	-	-	-	0.7	1.7	2.2
5	Transition zone, catena near Marusino	-	-	-	-	1.3	1.8	1.7
6	Birushka river, Georgievka vil.	0.3	0.3	0.5	0.6	0.7	1.0	1.7
7	Kiya river, Pereyaslavka	2.0	1.6	2.1	1.7	2.5	2.3	2.9
8	Underground waters near Marusino	-	-	-	-	5.5	4.9	-

Sulfate ion concentrations in surface waters were 1.6 – 6.8 mg·dm^{-3} (Table 4.20.). Such concentrations are quite common for Amur water. The maximal SO_4^{2-} concentrations were observed in samples collected 27.09.08. Sulfate concentrations in surface waters reveal noticeable seasonal fluctuations. The SO_4^{2-} regime depends much on the ratio between surface and ground water run-offs. Redox processes, biological specifics of water objects and human activities influence SO_4^{2-} concentrations in water objects.

Table 4.20. Sulfate Ion Concentrations in the Studies Area (July-October 2008), mg·dm^{-3}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	1.9	-	4.0	3.2	3.6	5.1	4.7
2	Bog, Birok riv. upper reaches	2.8	3.2	4.7	5.2	4.4	4.3	3.6
3	Kiya river, Marusino vil.	1.6	1.4	4.3	4.8	3.8	6.1	5.7
4	Bog, catena near Marusino (wetland)	-	-	-	-	4.5	5.9	4.9
5	Transition zone, catena near Marusino	-	-	-	-	3.9	4.1	2.9
6	Birushka river, Georgievka vil.	1.9	1.6	3.9	2.7	3.7	6.8	5.7
7	Kiya river, Pereyaslavka	2.6	2.5	4.9	4.7	3.6	6.0	6.9
8	Underground waters near Marusino	-	-	-	-	4.2	6.8	-

Biogenic substances

Biogenic substances include compounds of mineral nitrogen (nitrate, nitrite and ammonium ions), phosphorus and silicon.

Nitrate ion concentrations in surface waters were 0.14 – 0.78 mg·dm^{-3}. The maximal concentrations were found in samples from station 1, collected in summer, and the minimal were in samples from stations 3 and 7, collected in autumn (Table 4.21.). In bog waters nitrate ion concentrations ranged 0.11 – 0.27 mg·dm^{-3}. High NO_3^- concentrations were found in ground water. NO_3^- concentrations in natural waters depend on nitrifying bacteria activities in water, i.e. ammonium ion nitrification in the presence of oxygen, and water run-off from the fields, where nitrogen fertilizers are used.

Table 4.21. Nitrate Ion Concentrations in the Studies Area (July-October 2008), mg·dm^{-3}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	0.78	-	0.28	0.67	0.14	0.13	0.25
2	Bog, Birok riv. upper reaches	0.28	0.20	0.15	0.11	0.11	0.18	0.15
3	Kiya river, Marusino vil.	0.33	0.10	0.14	0.14	0.22	0.81	0.18
4	Bog, catena near Marusino (wetland)	-	-	-	-	0.27	0.25	0.19
5	Transition zone, catena near Marusino	-	-	-	-	0.23	0.25	0.37
6	Birushka river, Georgievka vil.	0.17	0.10	0.14	0.14	0.07	0.11	0.18
7	Kiya river, Pereyaslavka	0.23	0.20	0.14	0.14	0.14	0.53	0.46
8	Underground waters near Marusino	-	-	-	-	15.94	14.54	-

Nitrite ion concentrations in river waters were 0.001 – 0.020 mg·dm^{-3}. Higher concentrations were observed in the Kiya compared to the Birushka (excluding the sample from station 6, collected 25.08.08) (Table 4.22).

Table 4.22. Nitrite Ion Concentrations in the Studies Area (July-October 2008), mg·dm^{-3}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	0.001	-	0.007	0.003	0.007	0.003	0.010
2	Bog, Birok riv. upper reaches	0.005	0.007	0.007	0.007	0.010	0.003	0.013
3	Kiya river, Marusino vil.	0.003	0.002	0.010	0.003	0.010	0.013	0.020
4	Bog, catena near Marusino (wetland)	-	-	-	-	0.014	0.003	0.013
5	Transition zone, catena near Marusino	-	-	-	-	0.014	0.007	0.007
6	Birushka river, Georgievka vil.	0.002	0.002	0.007	0.050	0.007	0.003	0.007
7	Kiya river, Pereyaslavka	0.008	0.010	0.003	0.010	0.010	0.003	0.020
8	Underground waters near Marusino	-	-	-	-	0.016	0.030	-

Nitrite concentrations in water objects serve an important sanitary indicator of water quality. Increased concentrations of nitrites of water indicate intensive processes of organic matter decomposition under a slow oxidation of NO_2^- в NO_3^-, and thus indicate the pollution of a water object.

Ammonium ion concentrations (Table 4.23.) in surface waters fluctuated in the range 0.02 – 0.24 mg·dm^{-3}, in bog waters they reached 0.46 mg·dm^{-3}and in ground waters they reached 1.10 mg·dm^{-3}. Following the water quality classification based on ammonium ion concentrations, waters in the Kiya (stations 3 and 7) and the Birushka (station 6) may be characterized as very clean and clean; Birushka water at Vasiljevka village (station 1) and bog water (station 2) are clean and moderate polluted, and underground water in the sample, dated 9.09.08 is polluted (Table 4.24.). The inflow – outflow of nitrite and ammonium ions from the transition zone into the bog is observed. Increased ammonium ion concentrations also serve an indicator of a deterioration of the sanitary state of a water object and its pollution with sewage and agricultural waste water.

Table 4.23. Ammonium Ion Concentrations in the Studies Area (July-October 2008), mg·dm^{-3}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	0.06	-	0.18	0.23	0.19	0.18	0.19
2	Bog, Birok riv. upper reaches	0.15	0.20	0.35	0.37	0.39	0.39	0.42
3	Kiya river, Marusino vil.	0.10	0.02	0.24	0.04	0.12	0.13	0.14
4	Bog, catena near Marusino (wetland)	-	-	-	-	0.46	0.30	0.28
5	Transition zone, catena near Marusino	-	-	-	-	0.08	0.15	0.15
6	Birushka river, Georgievka vil.	0.05	0.03	0.07	0.02	0.05	0.14	0.05
7	Kiya river, Pereyaslavka	0.05	0.02	0.08	0.05	0.05	0.22	0.11
8	Underground waters near Marusino	-	-	-	-	1.10	0.08	-

Table 4.24. Ammonium Concentrations in Water Objects with Different Degree of Pollution

Pollution degree (classes of water object)	Ammonia nitrogen, mg/dm^3
Very clean	0.05
Clean	0.1
Moderate polluted	0.2-0.3
Polluted	0.4-1.0
Dirty	1.1-3.0
Very dirty	>3.0

Phosphate ion concentrations fluctuated in a wide range (Table 4.25.). In river waters it was 0.068 – 0.216 mg·dm^{-3} and in bog waters it was 0.088 – 0.370 mg·dm^{-3}. The maximal PO_4^{3-} concentrations were found in ground waters. Increased phosphate concentrations in water, especially ground water may be caused by fertilizers, sewage and decomposing biomass.

The range of silicon concentrations in surface waters was 2.84 – 6.66 mg·dm^{-3}. In Kiya water they were higher that in Birushka water (Table 4.26.). In Amur water silicon concentrations fluctuate from 0.1 to 7.0 mg·dm^{-3}and an average is 5.3 mg·dm^{-3}. Most silicon in natural waters results from land and water plant decomposition and partially comes with precipitation. Silicon concentrations in surface water gradually decrease towards autumn. The maximal concentrations were found in bog water (station 5). Silicon regime in surface water is similar to those of nitrogen and phosphorus compounds, but silicon never limits the growth of vegetation.

Table 4.25. Phosphate Ion Concentrations in the Studies Area (July-October 2008), mg·dm^{-3}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	0.071	-	0.095	0.170	0.184	0.062	0.042
2	Bog, Birok riv. upper reaches	0.088	0.112	0.167	0.251	0.370	0.250	0.193
3	Kiya river, Marusino vil.	0.127	0.189	0.193	0.24	0.208	0.072	0.104
4	Bog, catena near Marusino (wetland)	-	-	-	-	0.346	0.120	0.145
5	Transition zone, catena near Marusino	-	-	-	-	1.310	0.360	0.563
6	Birushka river, Georgievka vil.	0.081	0.15	0.049	0.122	0.103	0.057	0.046
7	Kiya river, Pereyaslavka	0.147	0.216	0.072	0.144	0.178	0.068	0.039
8	Underground waters near Marusino	-	-	-	-	0.517	0.075	-

Table 4.26. Silicon Ion Concentrations in the Studies Area (July-October 2008), mg·dm^{-3}

№	Sampling site	Sampling date						
		10-11.07.08	31.07.08	09.08.08	25-26.08.08	09.09.08	27.09.08	14.10.08
1	Birushka river, Vasiljevka vil.	6.12	-	2.84	4.92	5.17	4.42	1.79
2	Bog, Birok riv. upper reaches	0.98	4.78	0.24	1.54	2.57	1.25	2.39
3	Kiya river, Marusino vil.	5.07	4.62	4.03	6.66	5.17	6.42	6.57
4	Bog, catena near Marusino (wetland)	-	-	-	-	7.05	3.67	2.69
5	Transition zone, catena near Marusino	-	-	-	-	18.35	9.55	11.19
6	Birushka river, Georgievka vil.	6.03	-	3.43	4.57	4.12	2.98	3.07
7	Kiya river, Pereyaslavka	6.57	3.97	5.67	6.27	5.82	5.22	5.08
8	Underground waters near Marusino	-	-	-	-	8.21	8.51	-

Water chemical composition in the Kiya basin is influenced by natural and anthropogenic factors, such as climatic, soil and geologic conditions, river hydrologic regime phases, economic activities in the region. The revealed hydrochemical characteristics depended on soil formation specifics as well as a low atmospheric moistening in July-October 2008.

4.3.4. Characteristics of Soils in the South-Eastern Part of the Middle-Amur Plain

The studies were undertaken mostly in the Kiya River lower reaches. Special attention has been given to soil characteristics determined by different elements of relief and their geochemical conjugation in the catena.

The territory under study is situated in the zone of coniferous-broad-leaved forests in the Russian Far East south, where brown forest soils or cambisols (FAO/UNESCO classification) are quite common. Such type of soils has (O)-A1-Bm-BC profile. They are formed on fine-grain and rocky eluvium-deluvium sediments of basic rocks of different types and are common to a low mountain belt of the Sikhote-Alin macroslope. The Kiya upper reaches are situated in the mountain-forest landscapes of this belt.

Then the Kiya runs though an accumulative plain made of sand, gravel-pebble and in some rare places of clay deposits. Soddy brown soils are quite common here. They are formed on the alluvial deposits on the bars (positive relief forms of water and erosion origin).

Volcanic moderately high plateaus (about 100 m of absolute height) can be found on this accumulative plain near Pereyaslovka and Svyatogorje villages. These plateaus are formed with Quaternary effusive basic rocks (basalts, dolerites). Forest brown soils (cambisols) are formed on the well-drained elevated forms of the plateau relief. On the less elevated and flat weakly-drained plateau parts forest soils gleized at the surface (planosols) are formed and have a clay-differentiated (O)-A1-A2g-Bt-C profile.

Soddy alluvial soils are common to elevated wavy-plain parts of the Kiya – Khor interfluve. Such soils were formed under sparse forests and motley-grass meadows, which were ploughed later. Usually these soils have a light granulometric composition. They are sandy-sabulous or light loam soils with sand, gravel of pebble at the bottom. Such soils are well-drained.

The interfluve surface is cut with oxbow hollows, which accumulate water run-off from the higher areas (bars, terraces). Besides they are underflooded with Kiya water in flood-time. That is why stagnant water periods (element accumulation in reducing medium) are interchanged with running water periods (element transportation). Soils of meadow and bog type are formed in the hollows covered with reed-sedge-motley grass meadows. These soils are soddy gley, peat-humus-gley and clay-gley soils with sand, gravel, pebble or clayish sandy loam at the bottom.

The central part of the interfluve is flat and abundant in low and transition-type bogs. These bogs are predominantly sedge-sphagnum bogs with little bush. They are over wet constantly or most of the time due to stagnant atmospheric water. Geochemical processes take place in the reducing medium. The soils are peat-gley and peat soils. The peat is 0.4 – 0.7 meters thick.

There are also bogs with stagnant or slowly running water, for example near Marusino and Vasiljevka villages. These areas are mires with motley grass and sphagnum vegetation and peat-gley soils usually with loam or sandy loam with pebbles at the bottom, which lies 1 m deep.

Table 4.27. Some Characteristics of Soils in the Kiya River Valley

NN	Site	Element of valley	Landscape	Horizon, cm	OM, mg C/kg, (dry weight)	pH
1	Marusino	floodplain	wetland	Go 48-63	5,9	5,02
	Marusino	floodplain	wetland	Bg 33-48	19,1	5,63
	Marusino	floodplain	wetland	A 20-33	75,9	5,58
	Marusino	floodplain	wetland	H 0-20	92,4	5,35
2	Marusino	floodplain	transition zone	O 0-10	52,1	5,24
	Marusino	floodplain	transition zone	Bg 10-30	8,4	5,25
	Marusino	floodplain	transition zone	Cg 30-50	5,6	5,55
	Marusino	floodplain	transition zone	Gr >50	4,3	5,2

3	Marusino	terrace	grassland	Ap 0-5	26,8	7,22
	Marusino	terrace	grassland	BC 5-26	16,5	7,34
	Marusino	terrace	grassland	C1 26-49	9,6	7,27
	Marusino	terrace	grassland	$2C_2$ 49-61	7,4	6,43
4	nearby Marusino	ancient floodplain	wetland	H_1 0-30	278	5.0
	nearby Marusino	ancient floodplain	wetland	H_2 30-45	321,8	5,15
	nearby Marusino	ancient floodplain	wetland	H_3 45-68	321,8	5,1
5	nearby Marusino	ancient floodplain	transition zone	Go 20-30	4,0	5,34
	nearby Marusino	ancient floodplain	transition zone	H 0-20	21,1	5,35
6	nearby Marusino	terrace	forest	BC 40-66	1,5	6,21
	nearby Marusino	terrace	forest	Bw 8-40	2,8	5,84
	nearby Marusino	терраса terrace	forest	A 0-8	18,2	5,97
7	Medovaya hill	divide	forest	A 2-7	30,6	5,82
	Medovaya hill	divide	forest	Bw 7-20	9,9	5,08
	Medovaya hill	divide	forest	BC 20-33	5,6	5,16
	Medovaya hill	divide	forest	C 33-45	4,3	5,62

Soils in the interfluve Kiya – Khor form the following landscape-geochemical succession.

Point 7. Description made 21.08.2008. The Medovaya hill, a rise in the divide area, is a small basalt plateau in the Kiya – Khor interfluve. The hill is 10 km south of Pereyaslavka village close to the Khabarovsk – Vladivostok highway. The height above the sea level is 98 meters. The hill is covered with a secondary oak forest spotted here and there with single-standing aspen and birch trees. The underbush is composed of hazel and bush-clover and the surface cover is reed-sedge-motley grass. The soil profile was made in a well-drained spot close to the roundish hill top. The soil is brown forest soil on the basalt talus.

O 0 -2(3) cm. Weakly compressed sod.

A 2(3)-7 cm. Brownish-grey dust-like light loam, slightly moist, with a clumpy powdery structure and lots of small roots.

Bw (Bm) 7-20 cm. Light-brown, dust-like middle loam, wet, with a clumpy structure slightly schistosed (indication of talus), with lots of small gruss and big roots.

BC (Bmf) 20-33 cm. Middle (less dust-like) brown loam with a red-brown tint, wet, with fine nut-like particles covered with a fine clay wrapping, rock fragments are found.

C 33-45 cm. Brown loam here and there with reddish tint (spots of brown out basalt), clay, structured, with spots and films of black manganese efflorescence.

R 45-65 cm and deeper. Basalt fragments covered with brown and red-drown ferruginated erosion films.

This soil type is peculiar for the soil under the oak and broad-leaved forest of moderate and wet conditions of the Far East south. These soils are characterized with humus-clay soil formation, i.e. A horizon is close to the mull and indigenous claying and ironing in situ in metamorphic Bw (Bm and Bmf) horizons. The soil in point 7 is well drained and shows no evidence of gleying. Total organics carbon concentration in A horizon is characterized as moderate (30.6 mg C/kg) and sharply reduces with the profile depth. This indicates that humus substances are not transported down the profile. Medium reaction[1] in the humus horizon is close to neutral, in the profile middle it is weakly acid and in the bottom horizon it is close to neutral. Such pH changes along the profile indicate the absence or minimal role of aggressive humus acids. In Bw horizons iron hydroxides released due to intra-soil erosion are fixed in place (brown and reddish-brown tints)

[1] To describe the degree of soil acidity the following pH values were used: 3.0-4.5 – very acid; 4.6-5.0 – acid; 5,1-5,5 – weakly acid; 5.6-6.0 – close to neutral; 6.1-7.0 – neutral; 7.1-7.5 – weakly alkaline.

CATENA 1. Description made 14.08.2008.

Point 6. The bar on the first terrace above the Kiya floodplain (nearby Marusino village) 1-1.5 meters higher the surrounding depressions. The oak forest includes birch trees. The bush is composed of hazel, schizonotus and bush-clover. The grass cover is not thick. The soil is brown soddy soil on the alluvial deposits.

A 0-8 cm. Brownish - dark-grey sandy loam, slightly moist, with grain-clumpy structure Bw 8-40 cm. Yellow sandy loam of a slightly compressed structure, slightly moist.

BC 40-66 cm and deeper. Greyish-yellow fine-grained sand, sometimes with spots of ferrugination, slightly moist.

Soil peculiarity here is a poorly developed morphological profile. The soil is predominantly influenced by the atmospheric moistening and seems to be periodically underflooded by ground waters. Having a light granulometric composition this soil is well-drained, but at the profile bottom traces of light gleization are found. Medium reaction in the first 40 cm is close to neutral and further down is neutral. Organic matter concentrations in A horizon are low (18.2 mg C/kg). As a rule Fe^{3+} in such soils prevails over Fe^{2+}. Usually maximal concentrations of loose ion (Fe_o ac. to Tamm) are fund in the upper horizon.

Point 5. An oxbow depression (ancient floodplain). A transitional zone, surrounding the hollow bottom with a low bog. A reed-sedge-motley grass meadow with rare not high trees like willow, elm, maple. The soil is residual-floodplain primitive peat-gley soil on the gravel-sand deposits (supposedly fluvic reductive hystosol).

H1 0-20 cm. Brown nearly not decomposed grass peat with small mineral impurities, moist. The upper part is soddy.

Go 20-30 cm. Fine-grained sand of grey colour with small ochrish spots, with small roots, moist.

Gr 30-66 cm and deeper. Grey sand with gravel, wet.

The point 5 profile is characterized with slope and ground water moistening.

The soil in point 5 is highly wet due to slope and underground waters. Irregular moistening causes the appearance of redox horizons Gr and Go. Medium reaction in the entire profile is weakly acid. Organic matter concentrations in H1 horizon are rather low (21.1 mg C/kg). High concentrations (about 2%) of amorphous iron (Fe_o ac. to Tamm) are found in the upper horizon. Fe^{3+} prevails over Fe^{2+}. In Gr horizon Fe^{2+} may prevail.

Point 4. An oxbow depression (ancient floodplain). A low grass bog in the hollow bottom. Bog formation conditions are determined with regular over-moistening due to precipitation and slope, ground and river flood waters, as well as slowly melting seasonally frozen earth, which serves in the profile as a water confining bed. Vegetation is composed of sedge and reed grass with typical hygrophilous grasses like burnet, marsh marigold, lobelia and loosestrife. The soil is floodplain peat fulvic hystosol or even hystic cryosol.

H1 0-30 cm. Eutrophic read-sedge light-brown peat, nearly not decomposed, wet. Rusty spots of ion hydrate are found.

H2 30-45 cm. Dark brown peat, very weakly decomposed, wet.

H3 45-68 cm. Dark brown peat, weakly decomposed, wet.

About 70 cm deep – a mineral band with icy seasonally frozen earth (ice particles up to 6 cm).

Medium reaction in H1 surface peat horizon is acid, and in H2 and H3 horizons it is weakly acid. It may indicate a mesotrophic character of hystic horizons here. Total organic matter concentrations along the profile fluctuate from 278 to 321.8 mg C/kg. This may indicate a higher degree of a mesotrophic character of hystic horizons in point 4. Total organic carbon concentrations are within the range 278 - 321.8 mg C/kg. Biochemical process of organic mass decomposition takes place in reducing conditions.

CATENA II. Description made 21.08.2008 г.

Point 3. The first terrace above the Kiya floodplain. An agricultural field (after the harvest of grain-crops). The soil is weakly soddy alluvial (fluviosol).

AP 0-5 cm. Grey sandy loam weakly soddy with small roots, with gravel inclusions (1-3 cm in size), fresh, the transition to the underlying horizon is very gradual.

BC (AB ?) 5-26 cm. Light-grey (with a yellowish tint) light sandy loam (nearly loamy sand) with gravel inclusions, fresh.

C1 (*Al* I) 26-49 cm. Brown fine-sandy loam, weakly moist.

2C2 (*Al* II) 49-61 cm. Yellow light sandy loam, weakly moist.

The soil is well-drained, rarely underflooded (only during big floods). Medium reaction 49 cm deep is weakly acid (supposedly due to liming of the field) and neutral deeper. Organic matter concentrations are low, only 26.8 mg C/kg. Such soils quickly loose OM due to mineralization increase during filed ploughing. Biologic accumulation of chemical elements is limited with a weak development of a soddy horizon.

Point 2. The Kiya River floodplain. A reed-sedge-motley grass meadow changing into a low bog. The surface is hummock. The soil is a humus gley soil (perhaps fluvic redoxisol).

O 0-10 cm. Dark grey, nearly black, easily spreading, abundant in plant detritus, middle loamy, with a slightly granular structure, wet.

Bg1 10-30 cm. Grey-yellow with small blue-grey-ochre spots, loamy, rare roots, wet.

Cg1 30-50 cm. Yellow light loam with abundant peddle and gravel, moist, nearly wet.

As in point 5 the soil water regime here is determined with slope and ground waters, as well as periodical underflooding with river waters. Heavier granulometric composition and supposedly higher saturation with bases (due to harder soil and ground waters) determine the formation of humus horizon. Medium reaction in all horizons is weakly acid. Organic matter concentrations in O horizon is 52.1 mg C/kg, which correspond to humus (according to the Russian diagnostics of soil horizons). The second difference between points 2 and 5 is that there are redox horizons Bg and CG in the point 2 profile. These horizons are formed during temporary overwetting, when iron reduction processes alternate in time with oxidation (sedimentation) processes.

Point 1. The Kiya River floodplain. A low bog. Reed-sedge-grass is mixed with bog vegetation like burnet, marsh marigold and lousewort. The soil is a humus-peat-gley soil (perhaps fluvic hystosol).

H 0-20 cm. Grass peat of dark-brown-reddish colour in composed of weakly decomposed plant debris, wet, with clayish particles.

A 20-33 cm. Peat-mineral (humus-gley), blue-grey – dark-grey, with slightly ochre spots, easily spreading, wet.

Bg 33-48 cm. Brown with blue-grey and rusty spots, clay (loamy), with rare pebble and gravel inclusions, without structure, wet.

Go 48-63 cm. blue-grey – dark-grey, with rusty spots, without structure, wet.

The soil water regime here is formed under the influence of precipitation, ground and river flood waters and seems to have longer periods of drying compared to that of point 4. The second difference between these two points is that there is A horizon in the point 1 profile, which has a humus character, proved with organic matter concatenation of 92.4 mg C/kg. The third difference between these two points is that there are redox horizons Bg and Go in the point 1 profile. This fact indicates more contrasting oxidation-reduction conditions, which cause redistribution of chemical elements, primarily iron. Medium reaction changes along the profile from weakly acid in Y horizon to neutral in A and Bg horizons and acid in C horizon.

On the whole, a significantly decreased atmospheric moistening in the summer-autumn period of 2008 caused water reserve reduction in the Kiya basin, i.e. a stably low water content and a gradual decrease of ground water level in the studied area. Comparatively moderate (without water flooding the low floodplain) increase of water level and discharge in the Kiya and Birushka in the beginning of August resulted from intensive rains in the end of July – the beginning of August.

During the field works in August and September together with Japanese colleagues, soils common for the studied area were described, sampled and analyzed in the IWEP laboratories. Specifics of soils due to different relief elements and soil geochemical contingency in the catena were investigated. Ground water was sampled from August till October in one of the soil profiles (catena at Marusino). Besides, a snap sample of ground water from the upper stage near Marusino was collected and analyzed.

Moderate concentrations of organic matter in Kiya and Birushka waters can be explained with natural specifics of the studied area, soil and humus formation specifics in particular, i.e. relatively moderate humus acid concentrations, their fixation in the soil profile with calcium and ferric oxides and their reduced migrations out of the profile. Iron and manganese distribution pattern is quite common for Priamurje waters. Manganese accumulates in bog waters mostly due to their low pH. On the whole, relatively low metal concentrations in the studied waters depended on soil-formation specifics in the studied area and a low atmospheric moistening in July-October 2008.

Conclusion

The main results of the research implemented in the Amur Basin, Liman and the Sakhalin Bay are as follows.

1. The expedition to the Amur Liman and the southern part of the Sakhalin Bay was organized. Water and sediment samples ware collected at 9 stations and analyzed as stated in the agreed work program.

2. Significant amount of data on water regime, special and seasonal characteristics of terrigenous material and chemical substance flux in the Amur River was collected.

3. The analyses of collected data together with data, obtained in the previous years allowed clarifying the annual chemical substance flux and its seasonal variations in the Amur River.

4. Complex studies of chemical composition of surface, bog and underground waters in the Kiya basin revealed that concentrations of chemical substances in water there are typical for Priamurje and that they have seasonal fluctuations.

5. The correlation of Kiya water regime in the summer-autumn period 2008 and atmospheric moistening and ground water level was revealed.

6. The obtained results confirm the influence of the Amur River on the marine ecosystem in the Sea of Okhotsk and the importance of a sustainable economic development of the Amur Basin for preserving neighboring environment of international importance.

7. Further studies based on the data and materials obtained in 2005 - 2008 are viewed as perspective and important for Russia, Mongolia, China and Japan to be continued and developed as an international experience in addressing various environmental problems.