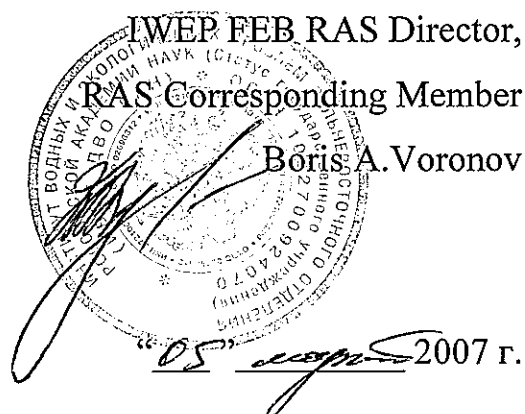


Russian Academy of Sciences
Far Eastern Branch
Institute of Water and Ecology Problems

“Approved “

IWER FEB RAS Director,
RAS Corresponding Member
Boris A. Voronov



05 июля 2007 г.

REPORT
On the Results of the Okhotsk-Amur Project Studies
In 2006

Project Director,

Dr. Geogr.



Alexei N. Makhinov

Khabarovsk – 2007

CONTENTS

1. Hydrological Characteristics of the Amur River in 2006	2
Water Regime	2
Sampling Period and Methods Used	3
Water Turbidity Characteristics in the Lower Amur, the Amur Estuary, the Amur Liman and the Sakhalin Bay	3
2. Amur River Water Chemical Composition in 2006	6
Result Analysis	9
Main Ions	9
Biogenic Substances	11
Organic Substances	12
3. Hydrochemical Characteristics of the Amur Liman and the Sakhalin Bay	14
Main Ions, Biogenic Substances and Trace Metals	14
Organic Substances	17
4. Hydrochemical Research in the Gassi Lake Basin in 2006	19
Research Object and Methods	19
Research Results	19
Soil Characteristics	19
Surface Water Characteristics	24
Organic Substances	26

1. Hydrological Characteristics of the Amur River in 2006.

Water Regime

In winter 2005-2006 the Amur River had a deep low water level. In December – March the water level fluctuated in the range -127 - -159 cm at the Khabarovsk water checking station. Maximal ice thickness was in February (105 cm).

In the ice-free period a spring flood was not big and in May 2006 the water level reached 197 cm above the 0 mark at the Khabarovsk water-checking station. Then a relatively moderate summer flood followed with two peaks of 327 cm (June 30) and 342 (August 14). Summer low water did not last long (7-10 days) and its minimal level was 15 cm (Fig.1).

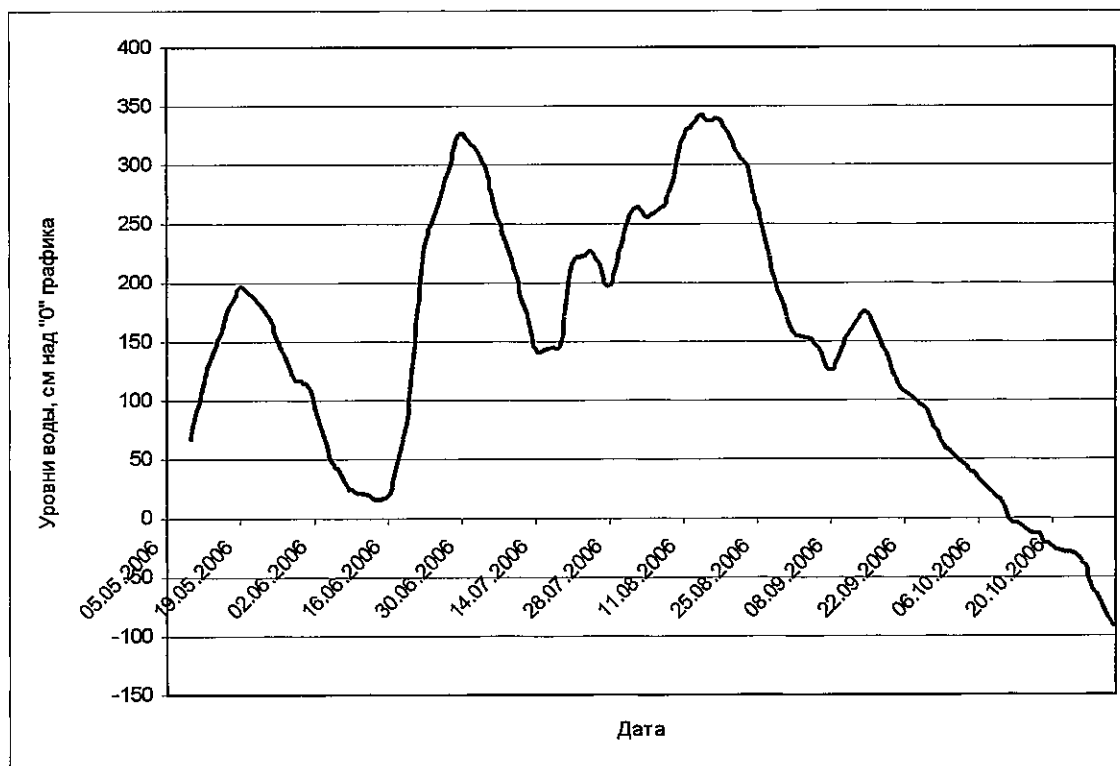


Fig 1. Amur Water Level Fluctuations at Khabarovsk in non-freezing period.

In the middle of June the water level in the Amur River between the two summer peaks dropped to 140 cm above the 0 mark at the Khabarovsk water-checking station. In autumn a gradual water level decrease was observed. It reached – 92 cm just before the river freezing. In general river water content in 2006 may be characterized as moderate. The most of the flood plain was covered with water (Makhinov, Kim, 1993). The summer and autumn flood lasted more than two months.

Sampling Period and Methods Used

Hydrological studies of the Amur River were carried out in summer (July and August). It was the time when a summer flood just started and water content was not high.

Studies in the Amur Estuary were undertaken from the “Amur” speedboat on August 10. Six water samples (3 of surface water and 3 of bottom water layers) and 3 bottom sediment samples were taken at 3 stations.

Studies in the Amur Liman and the Sakhalin Bay were undertaken from a special hydrological research ship on August 12-15. Water and bottom sediment samples were taken at 6 stations. Water sampling methods were the same as applied in the Amur Estuary. It turned out impossible to sample bottom sediments at station #9.

Sampling of water in the estuary was done with a water sampler (bathometer) and in the Amur Liman and the Sakhalin Bay an electric vacuum pump was used. A sediment sampler was used for sampling bottom sediments.

Sample preparations were carried out immediately after the sampling was completed. Samples were filtrated with a filtration unit following the procedure required and instructed by the Japanese side. Necessary sample conservation and storage in the refrigerator or a freezer were also provided as required.

Water and bottom sediment sampling was carried out by the scientists of the Institute of Water and Ecology Problems, FEB RAS (IWEP). The Japanese specialists stayed in Nikolaevsk-on-Amur at the expedition time and provided necessary technical and consultative assistance. Afterwards all the samples were delivered to Khabarovsk to be analyzed later on in the laboratories of IWEP and the Institute of Tectonics and Geophysics, FEB RAS (ITG).

Water Turbidity Characteristics in the Lower Amur, the Amur Estuary, the Amur Liman and the Sakhalin Bay

Water turbidity is an important indicator of water quality. Qualitative characteristics of suspended matter content in the Amur River significantly change along and across the river, as well as in time. Water turbidity changes most often are caused by river water content fluctuations within the year. The Amur hydrological regime peculiarities include deep winter low water, a comparatively moderate spring flood, high summer and autumn floods due to monsoon rains in the second half of summer.

During summer low water turbidity is minimal and it significantly increases with a water-level rise in warm time of the year. Heavy precipitation that increases surface runoff, soil and ground conditions, soil cultivation and other natural and anthropogenic factors contribute to water turbidity increase.

Observations of solid matter discharge in the Amur at Khabarovsk in recent 43 years revealed that annual solid matter amount is 22 million tons, annual average suspended matter discharge is 695 kg/sec, annual module of solid matter discharge is 13 tons/year km², average water turbidity for the 43-year observation period is 83 g/m³. The biggest amount of suspended matter (47 million tons) was discharged in

1956 and 1960 and the smallest amount of suspended matter (6.3 million tons) was discharged in 1979 (Water resources..., 1970).

The Amur tributaries Sungari and Ussuri significantly impact the distribution of water turbidity across and along the Amur mainstream. The Sungari River joins the Amur 270 km upper Khabarovsk. It is the main source of small-size suspended particle discharge. Suspended matter content in the Sungary is high and reaches 700 g/m³ at food time (Protasjev, 1942).

Table 1 shows suspended matter content in water sampled at various Lower Amur stations in July – August 2006.

Table 1

Mean Water Turbidity in the Amur River

Date	River - Station	Water turbidity, g/m ³
28.07	Amur – Sikhachi-Alyan village	177
28.07	Amur – Aktar island	204
30.07	Amur – Malmyzh village	115
31.07	Amur – Nizhnaya Tambovka village	94
01.08	Amur – Novoiljinovka village	95
02.08	Amur – Khabanda Lake	106
02.08	Amur – Sofiiskoe village	99
03.08	Sub-stream Mariinskaya – Ur. May	73
04.08	Amur – Savinskoe village	111
07.08	Amur – Susanino village	101
07.08	Amur – Tyr village	101

A well-marked regularity is observed. Suspended matter content in the Lower Amur gradually decreases towards the river mouth.

Water turbidity is much different across the river. It depends on morphological and hydrological characteristics of the riverbed, bank structure, sediment composition and number of sub-streams.

Near Sikachi-Alyan village twofold changes of the amplitude of water turbidity fluctuations across the river are observed, i.e. from 98 to 266 g/m³ (Fig.2). Water turbidity reaches its peaks in the middle of the section and significantly decreases towards the right and left banks of the river.

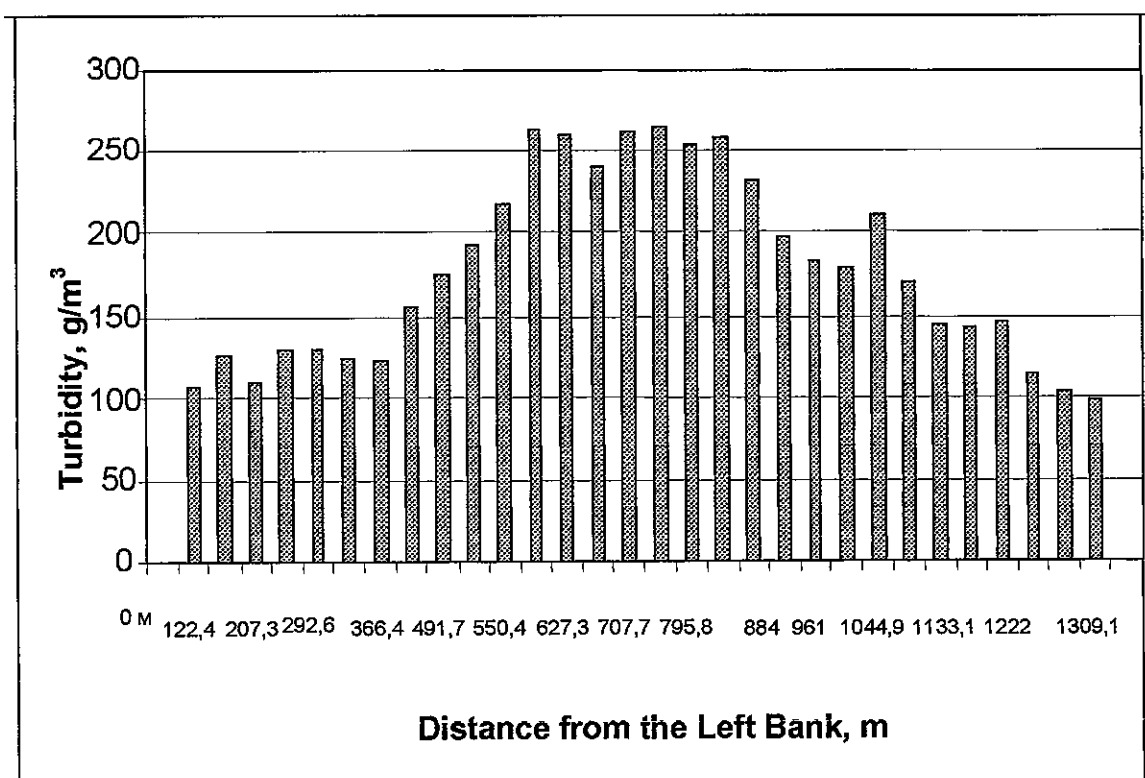


Fig. 2. Water Turbidity Changes across the River (Sikachi-Alyan).

In the very lower reaches of the Amur water turbidity distribution across the river is more even due to water mixing and absence of big tributaries that discharge suspended matter in big amounts. Near Susanino village water turbidity fluctuated within the range 85 – 150 g/m³ (Fig.3).

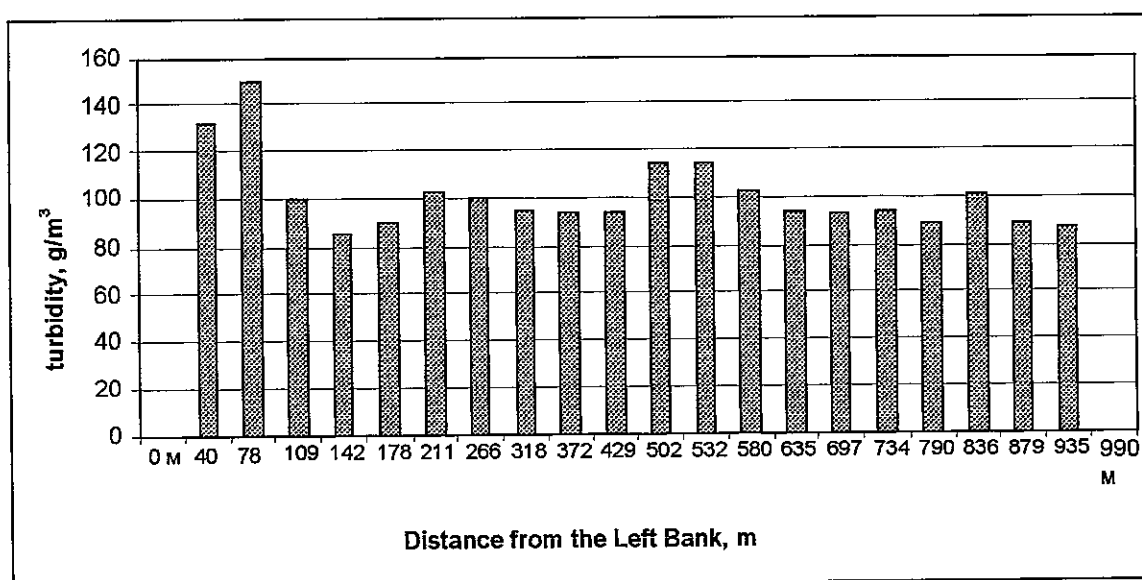


Fig. 3. Water Turbidity Changes across the river (Susanino).

In the river estuary and the Amur Liman suspended matter content decreased from the river mouth towards the open sea up to its minimal values. It can be explained with the decrease of mean velocity of the water currents in the sea area and Amur water dilution with sea waters of the Amur Liman and the Sakhalin Bay (Table 2).

Table 2

Water Turbidity in the Amur Liman (g/m³)

№	Surface Water Layers	Bottom Water Layers
1.	76	89
2.	83	90
3.	114	127
4.	49	53
5.	84	38
6.	37	37
7.	13	23
8.	12	5
9.	5	2

2. Amur River Water Chemical Composition in 2006

Chemical composition of water in the Lower Amur is mostly formed due to mixing of the Middle Amur and the Ussuri waters. The Amgun, Tunguska and other Amur tributaries have less influence as their total drainage area makes only 12.1% of the Amur drainage area.

Studies undertaken by the Institute of Water and Ecology Problems, Far Eastern Branch of the Russian Academy of Sciences (IWEP FEB RAS) showed significant changes of hydrological and hydrochemical regime of the Middle Amur water, caused by the construction of dams on the Amur tributaries Sungari, Zeya, Bureya and acceleration of economic activity in the Sungari basin. Such impact on the Amur hydrological regime also continued in 2006. In spring and the beginning of summer an active water resource accumulation in Zeya and Bureya water reservoirs caused low water level in the river in mid-June. Floods formed in the Sungary basin contributed to water level rise in July and August.

The Russian Hydrometeorological Agency (Roshydromet) conducted monthly monitoring of the Amur water chemical composition from March till October near Khabarovsk (3km upper the City) and near Bogorodskoe at three stations equally spread across the river. The Interregional Center for Monitoring Hydroenergy Facilities (Accreditation certificate # ROCC RU 0001.515988) at IWEP FEB RAS carried out water sample analysis. Main ions (Na⁺, K⁺, Ca²⁺, Mg²⁺, SO₄²⁻, Cl⁻) and biogenic substances (NO₃⁻, NO₂⁻ и NH₄⁺, HPO₄²⁻, Fe, Si) in water were analyzed.

Table 3

Amur Water Chemical Composition near Khabarovsk, mg/dm³

Date	Sampling site	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	Cl ⁻	SO ₄ ²⁻	NH ₄ ⁺	NO ₂ ⁻	NO ₃ ⁻	N _{odm}	HPO ₄ ²⁻	Fe _{odm}	Si
29.03.06.	Left bank	5,1	1,4	7,5	1,1	3,5	4,8	0,76	0,053	0,69	1,35	0,050	0,36	2,9
	Middle	5,2	1,2	8,3	1,4	5,8	6,1	0,89	0,065	0,99	1,20	0,038	0,31	3,1
	Right bank	6,0	1,3	8,8	1,4	4,3	6,1	1,08	0,074	0,79	1,09	0,038	0,26	4,2
31.05.06.	Left bank	4,3	1,6	7,4	5,1	2,6	5,3	0,45	0,006	0,36	0,69	0,031	0,26	2,8
	Middle	4,3	1,6	8,6	2,8	2,8	5,3	0,39	0,011	0,82	0,75	0,023	0,30	3,0
	Right bank	4,5	1,6	8,6	2,3	2,9	5,7	0,41	0,011	0,35	0,74	0,054	0,27	3,7
27.06.06.	Left bank	3,5	1,1	7,4	2,8	1,6	6,8	0,44	<0,005	0,94	0,74	0,046	0,31	3,1
	Middle	3,5	1,1	6,6	2,8	1,7	5,5	0,52	<0,005	1,10	0,84	0,069	0,28	3,1
	Right bank	3,5	1,1	6,6	2,8	1,7	5,5	0,65	<0,005	1,10	0,74	0,066	0,32	2,7
19.07.06.	Left bank	6,5	2,0	10,4	3,6	6,3	13,4	0,21	0,006	4,24	2,43	0,154	0,23	4,3
	Middle	6,4	2,0	10,4	3,4	6,6	14,5	0,24	0,008	3,83	2,93	0,158	0,21	4,8
	Right bank	3,6	1,5	10,4	3,9	3,4	13,6	0,21	0,008	3,93	2,43	0,158	0,24	4,6
16.08.06.	Left bank	7,0	1,4	10,4	2,7	3,8	9,2	0,26	<0,005	2,65	0,87	0,162	0,44	5,1
	Middle	6,8	1,5	10,8	3,2	4,2	11,0	0,28	<0,005	1,43	2,10	0,200	0,46	5,0
	Right bank	6,8	1,6	10,4	3,2	4,2	11,4	0,29	<0,005	2,65	1,47	0,231	0,79	4,8
29.09.06.	Left bank	7,7	1,2	10,9	4,2	4,2	9,6	0,28	<0,005	0,66	0,38	0,015	0,23	3,6
	Middle	7,9	1,2	10,9	3,7	7,7	13,2	0,15	<0,005	0,66	0,40	0,023	0,23	2,7
	Right bank	7,9	1,3	10,9	3,2	4,1	11,4	0,19	0,008	0,67	0,45	0,008	0,24	2,7
25.10.06.	Left bank	6,4	1,2	10,9	4,4	3,6	9,2	0,21	0,007	0,62	0,76	0,012	0,23	2,6
	Middle	6,4	1,2	10,9	3,7	3,7	9,2	0,25	0,008	0,81	0,69	0,000	0,27	2,7
	Right bank	6,4	1,2	10,9	4,0	3,7	7,9	0,17	0,009	0,66	0,40	0,015	0,22	2,7
27.12.06	Left bank	-	-	13,6	6,9	6,4	14,5	0,15	0,010	2,76	1,70	0,023	0,28	4,0
	Middle	-	-	14,0	4,9	6,1	14,9	0,14	0,010	3,01	1,72	0,015	0,31	5,3
	Right bank	-	-	15,2	6,0	6,4	18,0	0,24	0,008	3,41	1,80	0,023	0,26	5,8

Amur Water Chemical Composition near Bogorodskoe, mg/dm³

Date	Sampling site	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	Cl ⁻	SO ₄ ²⁻	NH ₄ ⁺	NO ₂ ⁻	NO ₃ ⁻	N _{obm}	N _{bas.}	HPO ₄ ²⁻	Fe _{obm}	Si
30.03.06.	Left bank	6,8	1,5	10,8	2,6	5,4	7,4	1,19	0,025	1,17	1,20	0,27	0,054	0,48	2,9
	Middle	6,8	1,5	10,8	2,3	4,4	7,0	1,08	0,026	0,85	1,03	0,27	0,066	0,40	3,5
	Right bank	7,0	1,7	10,8	2,6	7,3	7,4	1,04	0,013	1,26	1,24	0,81	0,046	0,47	2,8
29.05.06.	Left bank	2,9	1,4	6,6	3,8	1,8	5,5	0,52	0,008	0,43	0,74	0,27	0,073	0,27	3,1
	Middle	2,9	1,4	6,6	2,1	5,5	11,0	0,48	0,007	0,46	0,66	0,36	0,081	0,26	2,3
	Right bank	2,9	1,2	6,6	2,1	1,7	11,0	0,50	0,007	0,48	0,47	0,45	0,089	0,23	4,1
27.06.06.	Left bank	4,1	1,1	6,4	2,4	2,1	7,4	0,26	<0,005	0,14	0,90	-	0,050	0,23	3,6
	Middle	4,1	1,1	6,4	2,4	2,0	6,8	0,29	<0,005	0,02	0,33	-	0,119	0,20	3,4
	Right bank	4,1	1,1	6,4	2,4	2,0	7,0	0,26	<0,005	0,07	0,81	-	0,069	0,22	3,7
20.07.06.	Left bank	4,7	1,5	6,4	2,9	2,0	13,2	0,40	0,007	1,02	1,60	1,54	0,150	0,23	4,6
	Middle	4,1	1,4	6,8	2,2	2,0	11,4	0,44	0,007	1,13	1,10	0,72	0,150	0,27	4,1
	Right bank	3,8	1,1	6,4	3,4	5,2	10,5	0,44	<0,005	0,97	1,01	0,18	0,131	0,24	4,8
08.08.06.	Left bank	4,0	1,0	7,2	2,0	3,1	10,3	0,25	<0,005	0,22	0,89	1,81	0,139	0,39	4,2
	Middle	4,0	1,0	7,2	2,7	1,5	7,4	0,27	<0,005	0,22	0,44	2,44	0,108	0,39	3,9
	Right bank	4,1	1,0	7,2	2,0	1,3	7,7	0,16	0,005	0,22	0,69	1,90	0,139	0,38	4,6
28.09.06.	Left bank	5,8	1,1	7,7	3,3	2,7	10,1	0,34	<0,005	0,57	1,77	0,54	0,042	0,45	3,0
	Middle	4,8	1,0	7,7	3,3	2,6	9,4	0,28	<0,005	0,76	2,24	0,72	0,023	0,53	3,2
	Right bank	5,8	1,1	6,9	3,8	2,4	7,4	0,42	<0,005	0,50	1,87	-	0,046	0,61	3,4
28.10.06	Left bank	-	-	8,8	5,6	1,7	9,4	0,43	0,006	0,14	0,41	0,47	0,069	0,44	3,8
	Middle	-	-	9,2	4,6	1,7	10,1	0,27	<0,005	0,11	0,34	0,47	0,046	0,35	3,7
	Right bank	-	-	9,6	3,4	1,9	12,7	0,05	0,006	0,09	0,23	0,37	0,038	0,35	3,8
28.10.06	Left bank	-	-	12,5	4,9	4,7	6,6	0,36	0,006	2,36	1,12	2,24	0,000	0,50	6,3
	Middle	-	-	12,9	5,4	4,4	10,1	0,28	0,006	2,31	1,02	2,24	0,012	0,44	7,3
	Right bank	-	-	12,9	5,6	4,3	9,2	0,20	0,005	2,27	1,02	1,87	0,012	0,40	6,6

Result Analysis

Main Ions

Maximum main ion contents in the Amur water upper Khabarovsk are registered at the very beginning of river freezing due to a high share of Sungary and Upper Amur waters in Middle Amur water. Sungary and Upper Amur water mineralization exceeds 150 mg/dm^3 . During the freezing period the share of these rivers in the Middle Amur run off gradually decreases whereas Bureya and Zeya water share increases. Bureya and Zeya waters contain relatively small amount of dissolved substances (mineralization does not exceed 50 mg/dm^3).

Such specific features of winter hydrological regime cause a gradual decrease of main ions concentrations in the Amur water. That is why in March 2006 these concentrations were 1.3 times lower than in February. Near Bogorodskoe the situation is different. The distance between Khabarovsk and Bogorodskoe (740 km) and slow water current explain the reduction of dissolved matter content at Bogorodskoe much later. That is why in March at Bogorodskoe salt concentrations are higher than at Khabarovsk (Fig. 4). Besides, economic activities in Khabarovsk, Amursk and Komsomolsk-on-Amur also contribute to ion concentration increase in the Amur water.

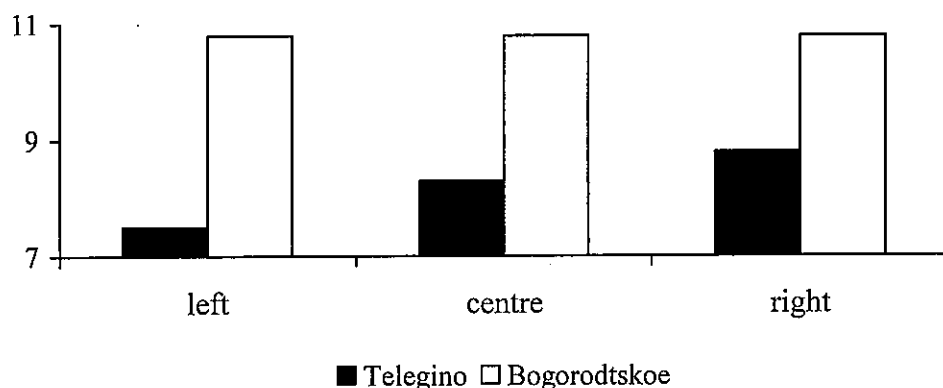


Fig. 4. Calcium ion distribution (mg/dm^3) across the Amur at Khabarovsk and Bogorodskoe in March 2006.

Distribution of main ions across the Amur at Khabarovsk and Bogorodskoe also differs. Near Bogorodskoe ion content is distributed between the stations more or less equally. Upper Khabarovsk the highest ion content is registered at the right bank of the river (Fig.5). Such difference is explained by the impact of Sungari water with higher ion concentrations compared to Amur water at their juncture (Shesterkin, Shesterkina, 2003). At the beginning of March Na^+ and SO_4^{2-} contents in Sungari water near Tunjang city were 14.5 и 28.5 mg/dm^3 respectively and in Amur water near Amurzet village they were 2.1 and 2.9 mg/dm^3 respectively. In December 2005 after the accident at the chemical plant in Jilin (China) SO_4^{2-} content in Amur water near Nizhneleninskoe village was the highest (up to 37.3 mg/dm^3).

At the end of a freezing period calcium ion prevailed in Amur water among cations (52.6% mg-equivalent) and hydrocarbon ion prevailed among anions 73.3% mg-equivalent). Similar water composition was registered near Bogorodskoe. Na^+ , SO_4^{2-} and Cl^- content in water did not exceed $7,5 \text{ dm}^3$, whereas K^+ and Mg^{2+} content did not exceed $3,0 \text{ mg/dm}^3$.

Snow melting water inflow to the river net in spring time caused the change in main ion content. Decrease of Ca^{2+} , Na^+ , SO_4^{2-} and Cl^- and increase of Mg^{2+} and K^+ were registered in Amur water upper Khabarovsk (Fig. 6). Significant decrease of Ca^{2+} , Na^+ , SO_4^{2-} and Cl^- (e.g. Na^+ 2.4 times) is also registered near Bogorodskoe. Behavior of sulfate ion was an exception as its concentration increased 1.3 times.

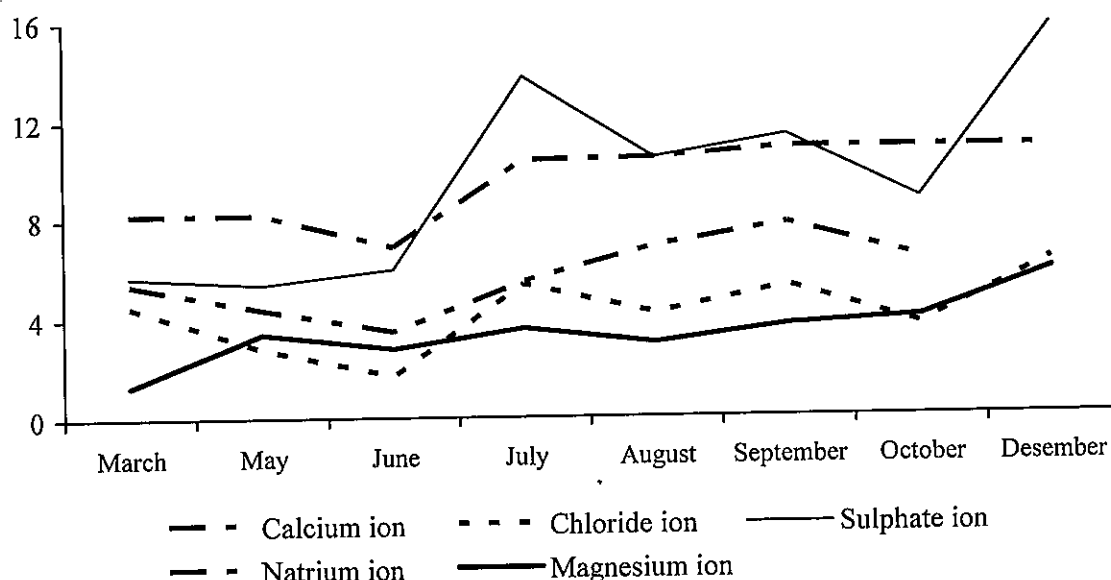


Fig. 5. Dynamics of main ion content (mg/dm^3) in Amur water near Khabarovsk.

More significant changes in water chemical composition are registered during floods. Our studies showed that at this time main ion contents depend much on in which tributary basin the flood is formed (Shesterkin, Shesterkina, 2002). Thus, during the flood in June, formed in the Upper Amur area, main ion contents in water were the lowest in the entire non-freezing period, but during the flood in July and August, formed in the Sungari basin, it was the highest (Fig. 5). The difference in contents of Na^+ , Ca^{2+} , SO_4^{2-} and Cl^- were the highest (1.5-2.0 times).

Near Bogorodskoe the difference in water chemical composition are less evident due to the impact of various Amur tributaries, such as the Tunguska, Anyui, Gur, Gorin. Only SO_4^{2-} makes an exception. Its concentration in water in July was 1.65 times higher than in June.

In autumn the contents of Na^+ , SO_4^{2-} and Cl^- in the Amur water upper Khabarovsk gradually decreased, while Ca^{2+} and Mg^{2+} contents were not changed much. Near Bogorodskoe the situation is quite the opposite. Before freezing time main ion contents there reached the highest values, the only exception being Cl^- .

Biogenic substances

Biogenic substance dynamics differs from the dynamics of main ions. Maximum contents of NH_4^+ and NO_2^- and increased contents of NO_3^- and HPO_4^{2-} were registered in winter low water (Fig.7). Upper Khabarovsk the highest concentrations were registered at the right bank of the Amur. Near Bogorodskoe there is no much difference in water chemical composition across the river. Dissolved iron and silicon contents did not exceed 0.5 mg/dm^3 and 4.5 mg/dm^3 . Total nitrogen content at all the station across the river did not exceed 1.09 mg/dm^3 . Nitrogen compounds are mostly in the mineral form. Upper Khabarovsk their share is 76% and at Bogorodskoe it is 95%.

In spring nitrogen compound contents in water and the difference in their concentrations across the river decreased due to the inflow of snow melting water into the river net. The proportion of nitrogen forms is also changing and the share of nitrogen bound with the organic and suspended substances increased. Iron and silicon compounds did not show much concentration changes.

Significant drop of water level in mid-June (up to 23 cm at Khabarovsk) did not cause much change in the contents of phosphates and ammonia and nitrite nitrogen in river water near Khabarovsk. Nitric nitrogen concentration was the lowest probably due to the growth of plankton. Nitrogen concentration is higher in the suspended state than in the dissolved state. Similar situation was registered near Bogorodskoe, but a little later in time (at the end of June).

Significant changes of biogenic substance concentrations take place in flood time. The flood tide formed in the Upper Amur caused the increase of phosphates and nitric nitrogen concentrations with their maximums during July and August floods, formed in the Sungary basin. Total nitrogen, nitrogen in the suspensions, silicon and iron revealed their maximums at that time as well. Organic compounds that include nitrogen began to prevail among the dissolved nitrogen forms. The distribution of biogenic substance concentrations across the Amur at that time and during the floods was relatively even.

Similar concentrations of nitric and phosphate ions were registered in the Amur water in August 1998 after the most catastrophic in history Sungari floods. When the food reached its peak near Khabarovsk (maximum water discharge was $31\,300 \text{ m}^3/\text{sec}$) the concentrations of nitric (up to 4.3 mg/l) and phosphate (up to 0.34 mg/l) ions reached their non-freezing time maximum of the whole period of observations. Total nitrogen, iron and silicon compounds in water were the highest during non-freezing time. Much difference in biogenic substance concentration distribution across the river was not observed.

Near Bogorodskoe biogenic substances, excluding phosphate ions, in flood time revealed smaller concentrations compared to those ones near Khabarovsk (Table 3). This can be explained by their consumption by the phytoplankton. Also nitrogen content in suspensions was higher than in the dissolved state. That is why in this section of the Amur, as well as upstream, mineral forms of nitrogen were observed in small amounts. Total iron and silicon contents in this water regime phase fluctuated within a small range.

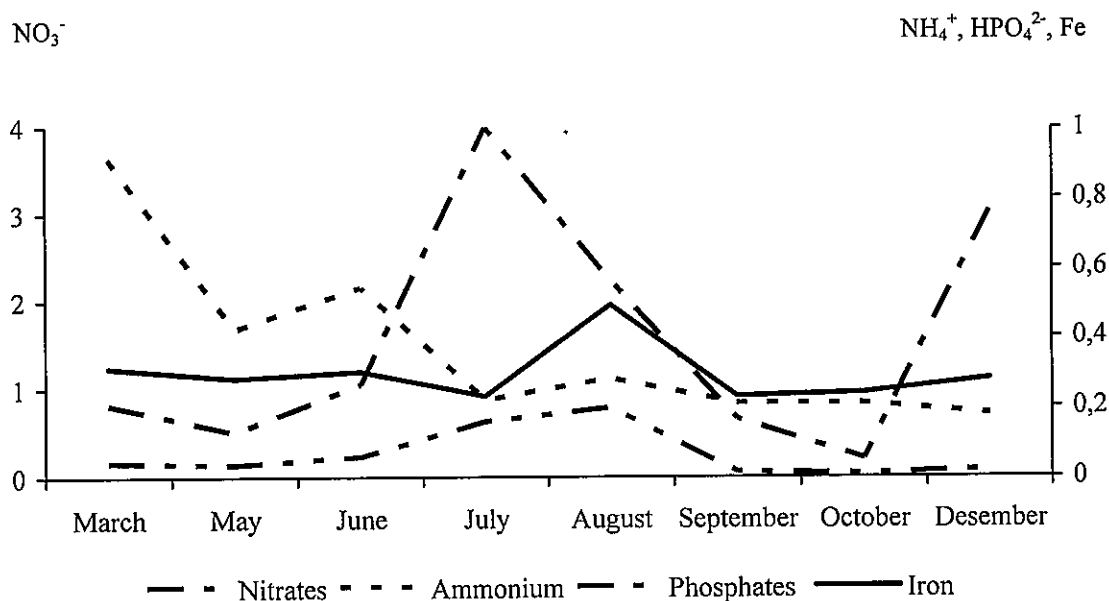


Fig. 6. Dynamics of Biogenic substances (mg/dm³) in Amur Water near Khabarovsk.

In Autumn, when flood subsided biogenic substance contents in water upper Khabarovsk gradually decreased. Moreover nitric nitrogen and phosphate ions showed a significant drop. Concentrations of these substances and also that of silicon in water at that time were the lowest in the whole period of observations. This fact indicates intensive processes in water, such as nitrification and photosynthetic phytoplankton activity. Among the dissolved forms of nitrogen a mineral form started to dominate beginning from this time further on in winter low water.

At that time in the Lower Amur water only total nitrogen content showed significant changes, which can be explained as resulting from floods. That is why, total nitrogen content reached its maximum in this section of the Amur by the end of September (Table 3). Nitrogen containing organic substances prevailed at this time. Their share in the dissolved nitrogen form group was 80%, and in total nitrogen form group it reached 67%. Just before river freezing nitrogen compound concentrations significantly decreased. Biogenic substance concentrations across the Amur were distributed unevenly and their maximal levels were observed at the right bank of the river.

Thus, our studies showed that floods, formed within the Sungari basin had the most significant impact on dissolved substance content dynamics in the Amur water in 2006 and caused increased concentration levels of iron and silicon compounds, nitric nitrogen and phosphates.

Organic Substances

Dissolved carbon concentration in the Amur water at Khabarovsk fluctuated within 6.3 –14.7 mg C/dm³. Maximal concentrations were observed in spring (May 2006) and reached 16 mg C/dm³. This is probably caused by melting waters coming from Sungary and rich in organic matter.

Suspended carbon concentration fluctuated within 0.52 – 1.69 mg C/dm³ or within 5.4 – 17.6% of total organic carbon. The highest concentration was observed in Amur water suspension mater near Khabarovsk during summer floods and reached 2.37 mg C/dm³.

Near Bogorodskoe dissolved carbon concentration in water fluctuated within 6.5 – 11.0 mg C/dm³. Maximal content (11.2 mg C/dm³) was also observed in spring. Suspended carbon concentration fluctuated within 0.25 – 1.39 mg C/dm³, which corresponds to 9.6 – 19% of total organic carbon.

Table 5Dissolved Organic Carbon Content in the Amur Water at Khabarovsk, mg/ dm³

Sampling site, bank	Sampling date								
	29.03.06	31.05.06	27.06.06	19.07.06	08.08.06	29.09.06	25.10.06	08.02.07	29.01.07
left	8,3	12,0	9,4	3,8	8,3	9,8	9,8	7,5	6,7
middle	9,0	16,0	9,8	6,8	7,5	9,0	8,3	7,5	7,0
right	12,3	16,0	10,1	8,3	7,5	8,0	8,5	9,0	7,0

Table 6Suspended Organic Carbon Content in the Amur Water at Khabarovsk, mg/ dm³

Sampling site, bank	Sampling date							
	29.03.06	31.05.06	27.06.006	19.07.06	08.08.06	29.09.06	25.10.06	29.01.07
left	0,54	1,26	2,37	1,83	1,16	1,37	0,57	0,80
middle	0,64	1,08	1,81	1,11	1,03	1,42	0,54	1,10
right	1,24	1,45	0,90	1,12	1,08	1,65	0,44	1,40

Table 7Dissolved Organic Carbon Content in the Amur Water at Bogorodskoe, mg/ dm³

Sampling site, bank	Sampling date							
	30.03.06	29.05.06	27.06.06	20.07.06	08.08.06	28.09.06	21.10.07	27.12.06
left	8,3	10,0	7,5	10,5	5,5	6,8	6,5	6,8
middle	9,8	10,0	6,0	8,3	4,5	7,5	-	6,8
right	8,3	8,0	5,0	11,2	6,5	10,0	-	6,0

Table 8

Suspended Organic Carbon Content in the Amur Water at Bogorodskoe, mg/dm³

Sampling site, bank	Sampling date							
	30.03.06	29.05.06	27.06.06	20.07.06	08.08.06	28.09.06	21.10.07	27.12.06
left	0,72	1,19	0,65	0,83	1,19	1,39	0,28	-
middle	1,47	1,24	0,84	1,34	1,21	1,24	0,23	-
right	0,59	1,14	0,60	0,93	1,42	1,21	0,25	-

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

Main Ions, Biogenic Substances and Trace Metals

Hydrochemical studies were undertaken in the Amur Liman and Sakhalin Bay at the sampling stations as presented in Fig. 7. Water temperature, salinity, pH, oxygen and suspended matter contents were measured in situ. The Interregional Center for Monitoring Hydroenergy Facilities (Accreditation certificate # ROCC RU 0001.515988) at IWEP FEB RAS carried out water sample analysis. Main ions (Na⁺, K⁺, Ca²⁺, Mg²⁺, SO₄²⁻, Cl⁻), biogenic substances (NO₃⁻, NO₂⁻, NH₄⁺, HPO₄²⁻, Si) and trace metals (Al, Mn, Co, Ni, Cu, Fe) were analyzed.

The water in the estuary is well-warmed and little acid (Table 9). Oxygen content in water exceeds 5.2 mg/dm³ and oxygenation is 62.8%. In the vertical section the highest concentration is observed in bottom layers.

In the estuary main ions and biogenic substances are distributed relatively even. Concentrations of main ions are low, and Cl⁻ is of the same level as atmospheric precipitation in Priamurje (Ivanov, Kashin, 1989). Total content of main ions is less 25 mg/dm³.

Nitric nitrogen prevails among the mineral forms of nitrogen. Nitric nitrogen content, which is 2-3 times higher compared to that, registered in 1997 is explained by its discharge from the Sungary River. Increased concentrations of phosphates compared to 2005 can be also explained by the Sungary discharge. The waters are characterized with extremely low concentrations of ammonia and nitrite nitrogen, which is common for this time of the year.

Trace metals are spread rather unevenly. Fe and Al concentrations (Table 9) are the highest. Cu, Ni and Mn contents do not exceed 10 mkg/dm³. Vertical section shows that there are more metals in surface water than in bottom layers.

The Amur Liman is characterized with a complicated current pattern (Solovjev, 1995), which causes a very uneven distribution of water chemical composition within the water area and its profile. Mixing of ultra-fresh Amur water and seawater produce lightly salty and weakly alkaline water with oxygen content more than 6 mg/dm³. In the surface water layers of the liman central part main ion contents are the lowest,

and in its most shallow spots there is no much difference in their distribution in the vertical section. In very deep spots (station 5) main ion concentrations are 5-6 times lower than in the bottom layers.

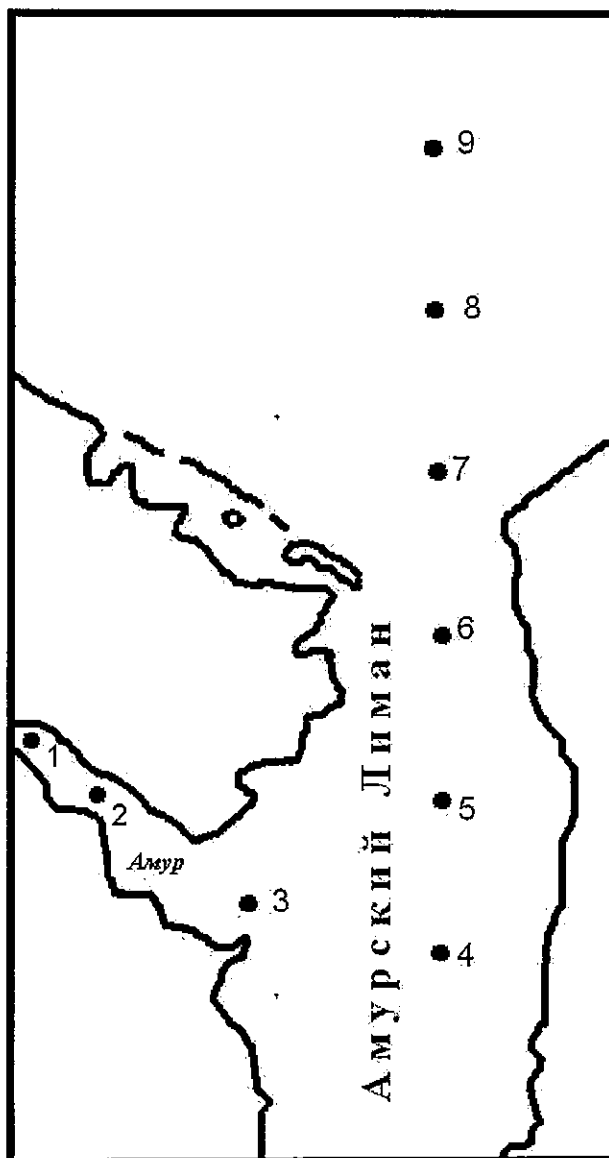


Fig. 7. Scheme of sampling stations in the Amur Liman

Big changes happen to silicon and nitrogen mineral forms. Due to mixing with seawater and plankton consumption, their concentrations decrease and especially ammonia nitrogen shows significant decrease. The lowest biogenic substance concentrations are registered in bottom layers of deep areas. Compared to silicon and nitrogen mineral forms phosphate concentrations remain increased.

Trace metal concentrations are also changed. Concentrations of some metals increase (Mn, Co, Cu), some do not change (Ni) and some decrease in shallow spots through all water thickness and in deep spots only in the surface layers (Al, Fe.).

Table 9

Chemical Composition of Waters in the Amur Liman and the Sakhalin Bay

H	T	pH	S	O ₂	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	Cl ⁻	SO ₄ ²⁻
m	°C		‰		mg/dm ³					
0,0	23,7	6,79	0,0	5,29	3,9	1,3	7,2	2,0	2,4	5,3
6,0	23,6	6,54	0,0	5,58	3,6	1,3	7,2	2,9	2,0	4,4
0,0	23,8	7,14	0,0	5,54	3,6	1,2	7,2	2,4	2,0	6,6
20,0	23,5	6,89	0,0	-	3,6	1,2	7,2	2,4	1,7	6,1
0,0	23,1	6,67	0,0	5,74	3,7	1,2	6,4	3,4	2,0	3,1
4,4	23,2	6,82	0,0	5,93	3,7	1,2	7,2	2,9	2,0	4,4
0,0	22,0	7,61	5,4	6,30	1313,0	98,6	80,6	268,1	3200,1	318,0
4,0	21,6	7,69	6,7	5,56	1326,6	104,2	81,4	263,3	3254,3	460,5
0,0	22,6	7,58	3,3	6,57	831,6	104,2	44,7	129,8	1591,0	208,3
16,6	20,9	7,81	19,0	6,18	5167,8	285,1	221,2	739,3	9003,6	1381,6
0,0	22,0	7,77	5,6	6,45	1556,8	82,2	65,3	206,6	2513,0	350,9
6,0	22,0	7,71	6,7	6,45	1669,6	76,8	67,7	212,0	2567,3	350,9
0,0	21,4	7,73	7,6	6,24	2001,6	109,6	87,8	299,0	3615,9	548,2
7,3	9,3	8,00	-	8,55	3498,2	175,4	137,7	456,1	5966,2	921,0
0,0	20,3	7,87	9,1	6,45	2782,6	131,6	111,6	350,9	5008,0	614,0
9,4	2,1	7,99	20,9	7,44	6671,9	438,6	319,0	1147	11158,0	2236,8
0,0	15,1	8,12	25,2	8,00	6393,9	394,7	287,7	994,6	14825,2	2105,3
25,2	0,3	7,83	31,1	14,0	7366,8	460,5	350,9	1205	17971,0	2368,4

Table 9 continued

H	NH ₄ ⁺	NO ₂ ⁻	NO ₃ ⁻	HPO ₄ ²⁻	Si	Al	Mn	Fe	Co	Ni	Cu
m	mg/dm ³				mkg/dm ³						
St 1, 10.08.06.											
0,0	0,24	<0,005	1,42	0,092	4,9	95,23	5,26	285,65	0,06	1,64	6,10
6,0	0,24	0,005	1,33	0,077	4,9	65,88	5,01	254,07	0,05	1,23	4,42
St 2, 10.08.06.											
0,0	0,18	0,007	1,46	0,062	4,8	134,48	6,26	331,14	0,05	1,63	3,93
20,0	0,15	<0,005	1,42	0,077	4,9	74,17	5,71	281,05	0,04	1,33	2,89
St 3, 10.08.06.											
0,0	0,21	<0,005	1,51	0,085	4,9	119,39	5,05	320,94	0,05	0,81	1,60
4,4	0,12	<0,005	0,97	0,081	4,8	80,95	5,45	301,37	0,05	9,67	6,11
St 4, 13.08.06.											
0,0	<0,005	<0,005	0,58	0,058	4,0	-	16,69	241,14	0,18	1,85	54,14
4,0	0,16	<0,005	0,40	0,069	4,1	5,07	14,76	270,13	0,21	2,22	34,98
St 5, 13.08.06.											
0,0	<0,005	<0,005	0,58	0,096	4,7	0,35	7,99	176,49	0,10	1,23	11,75
16,6	<0,005	<0,005	0,04	0,054	2,0	1,19	7,76	672,36	0,82	5,03	80,94
St 6, 13.08.06.											
0,0	<0,005	<0,005	0,71	0,089	4,4	-	9,30	172,65	0,16	1,67	18,44
6,0	<0,005	<0,005	0,75	0,069	4,2	6,19	10,85	194,07	0,16	1,67	27,78
St 7, 15.08.06.											
0,0	<0,005	<0,005	0,49	0,054	3,9	-	13,09	221,65	0,22	2,02	25,04
7,3	<0,005	<0,005	0,44	0,039	3,3	1,74	12,63	411,92	0,43	3,21	60,04
St 8, 15.08.06.											
0,0	<0,005	<0,005	0,35	0,042	3,5	-	6,57	356,5	0,36	2,81	42,00
9,4	<0,005	<0,005	0,02	0,046	0,3	2,01	1,76	991,8	0,92	6,12	155,3
St 9, 15.08.06.											
0,0	<0,005	<0,005	0,40	0,077	0,6	7,71	5,38	550,2	0,62	5,43	55,17
25,2	<0,005	<0,005	0,02	0,023	0,4	5,15	1,00	1318,9	1,20	8,00	200,9

In the Sakhalin Bay (stations 7-9) pH value, oxygen concentration and salinity (and thus, main ion contents) increase (Table 9). Difference in main ion contents in vertical section becomes less with depth increase. Biogenic substance content in salt water is decreasing and in bottom layers nitric nitrogen and silicon contents drop to detection limits. Ammonia and nitrite nitrogen presence in water is not observed like in the Amur Liman.

With salinity increase Fe, Co, Ni and Cu contents in water also increase. In bottom layers the increase is higher than in the surface layers. That is why the distribution of these metals along the vertical section is uneven (Table 9). Cu shows the biggest difference in its concentrations between the surface and bottom layers. Al content in water starts to increase at water salinity higher 20 ‰, and Mn content decreases. Bigger decrease of Mn is observed in surface waters compared to the bottom water layers.

Organic Substances

Dissolved and suspended organic substance concentrations in water gradually decreased from the Amur Estuary towards the Amur Liman from 6.00 to 2.1 mg C/dm³ and from 0.33 to 0.10 mg C/dm³ respectively. With salinity growth from station 4 (salinity grows from 3.3 to 6.7‰), which corresponds to the first water mixing stage), to station 5 (19.0‰ at the bottom layer) dissolved and suspended organic substance concentrations increase to 10.04 and 0.67 mg C/dm³ respectively. Primary phytoplankton production could be an additional source for both dissolved and suspended organic substances here. At station 9 (salinity 25-30‰) organic substance transformation processes are practically negligible.

Table 10

Dissolved (DOC) and Suspended (SOC) Organic Carbon Content
in Amur Estuary and Amur Liman Waters

№	Station	Horizon	DOC	SOC
			mg C/dm ³	
1.	St 1	surface	6,75	0,20
2.		bottom	7,50	0,22
3.	St 2	surface	6,00	0,16
4.		bottom	6,00	0,16
5.	St 3	surface	6,00	0,16
6.		bottom	6,00	0,20
7.	St 4	surface	6,00	0,33
8.		bottom	5,74	0,32
9.	St 5	surface	10,04	0,67
10.		bottom	9,88	0,51
11.	St 6	surface	8,92	0,32
12.		bottom	6,04	0,24
13.	St 7	surface	7,64	0,15
14.		bottom	4,00	0,17
15.	St 8	surface	4,00	0,12
16.		bottom	4,00	0,10
17.	St 9	surface	2,10	0,16
18.		bottom	2,80	0,10

Organic carbon distribution in bottom sediments is uneven and fluctuates within the range 0.26 mg C/dm³ (St.7) - 3,14 mg C/dm³ (St.5) (Table 11).

Table 11

Total Organic Carbon Content (C_{org}) in Amur Liman Bottom Sediments, g C/kg (dry method)

Station	St 1	St 2	St 3	St 4	St 5	St 6	St 7
C_{org}	0,74	2,84	0,71	0,51	3,14	1,50	0,26

Organic carbon distribution within the sample column is presented in Table 12.

Table 12

Total Organic Carbon Distribution in Column (g/100g soil), Sampled at Station 3

Section #	1	2	3	4	5	6	7	8	9	10	11	12	13
C_{org}	0,49	0,52	0,47	0,89	0,96	1,14	0,55	0,40	0,66	1,28	0,84	0,20	0,32

Organic carbon content in sediments fluctuates within the range 0.20 – 1.28, its mean value being 0.63. Biggest values correspond to the middle part of the column.

References

1. Ivanov A.B., Kashin N.P. Main Factors of the Formation of Chemical composition of Atmospheric Precipitation and Snow Cover in Priamurje // Glaciochemical and Cryogenic Hydrochemical Processes. Vladivostok: FEB RAS. 1989, p. 73-87.
2. Makhinov A.N., Kim V.I. Water Regime of the Lower Amur Floodplain // Vestnik FEB RAS. 1993. #6. P.31-38
3. Protasjev M.S. The Sungary River. Moscow-Sverdlovsk: Ad. Chief Hydromet Service of the Red Army. 1942. 140p.
4. Surface Water Resources of the USSR. The Lower Amur. L. Gidrometizdat, 1970. Vol.18. Far East. Vol.2 692 p.
5. Solovjev A.I. Amur and Liman Bottom Processes and Waterways. Vladivostok: FEB RAS. 1995, 269 p.
6. Shesterkin V.P., Shesterkina N.M. The Sungari Role in Formation of Middle Amur Water hydrochemical Composition in Winter Low Water Level // Biochemical and Hydrochemical Assessment of Terrestrial and Fresh Water Ecosystems. Vol. 13. Vladivostok: Dalnauka, 2003.
7. Shesterkin V.P., Shesterkina N.M. Maximal Ion Concentrations in Middle Amur // Biochemical and Hydrochemical Studies of Terrestrial and Fresh Water Ecosystems. Vol. 12. Vladivostok: Dalnauka, 2002, p. 105-116.
8. Shesterkin V.P., Shesterkina N.M., Forina Yu.A., Ri T.D. Sungari River Hydrochemistry and Amur Water Quality in 2005-2006 Winter Low Water Level // Modern Problems of Regional Development. Khabarovsk: IWEP FEB RAS, 2006, p. 159-162.

4. Hydrochemical Research in the Gassi Lake Basin in 2006

Research Object and Methods

Hydrochemical studies were undertaken in the northeast section of the Gassi Lake Basin on the rivers Babchi, Kartanga including its tributaries Khaso and Malina and near the automobile bridge at Lake Gassi. Water was sampled from close-to-surface water horizons two times, i.e. in July after the floods and at the beginning of September at time of summer low water. As physical and chemical characteristics water temperature and pH were registered.

The following parameters were chosen for sample analysis:

- hardness of water ($\text{Ca}^{2+} + \text{Mg}^{2+}$) with a complex method;
- calcium (Ca^{2+}) with a titrimetric method;
- silicon (Si) in the yellow form of molybdenum silicic acid with photometry
- chlorides (Cl) with a titrimetric method with mercury salt;
- sulfates (SO_4^{2-}) with a titrimetric method followed by photometry;
- sodium and potassium ($\text{Na}^+ + \text{K}^+$) with burning and photometry;
- total organic carbon with dry burning in a quartz tube with oxidation to CO_2 .

Soils at the sampling sites were also analyzed. The following parameters were analyzed:

- pH with water extract;
- exchange bases content (Ca^{++} and Mg^{++}) with a complex method;
- organic carbon (C_{org}) with a bichromate method;
- moving iron in oxalate extract.

Research Results

Soil Characteristics

Rivers of the Gassi Lake drainage (Kartanga, Burga, Uta, Left Khaso and others) flow from a medium-high mountain divide (600-800 m above the sea level), which divides the Gassi Lake Basin and the rivers Anui and Khor. Broad-leaf and coniferous forests gradually change for dark-coniferous forests (spruce, larch). Here starts the zone of mountain brown taiga and brown taiga humic illuvial soils.

Brown taiga soils are characterized with a rather thick forest debris layer, containing peat, moss and needles (section G-1). A humus layer is thin and weakly marked. A mineral part of the profile may contain spots of seasonal gleying. These soils are referred to loam with big pieces of rock (primarily basalt and andesite-basalts). As the mountain slopes are steep, soils contain rock debris and undergo weathering drainage is good and many soil ingredients are easily washed out. Water drainage is of three types: surface, intrasoil filtration and side water flows.

Soil acidity is weak to neutral in the upper horizon and acid in lower horizons. The sum of exchange bases (section G1, Table 1) is not big. Calcium and magnesium increase in the upper AO horizon and in horizon BC close to the soil forming rock. In the first case is results from biogenic accumulation and in the second it is caused by

geochemical processes of mineral weathering inside the soil (basalt rock mostly). Low content of bases in the middle part of the profile results from washing with side water flows peculiar to soils on the mountain slopes. Base leaching with fulvoacid seems to have place. Low pH values indicate acid and even strongly acid medium in the middle of the profile. High concentrations of C_{org} both in upper horizons and the mineral layer are registered. Humus is highly movable and present throughout the entire profile coloring it into light to dark brown shades. Up to 40 cm deep the soil profile is highly ferruginous. Basic characteristics of brown taiga soils include the accumulation of weakly decomposed organic matter in the upper soil horizon, high mobility of humus and iron compounds, the distribution pattern of physical and chemical indicators along the soil profile.

The river Khar and its tributaries Uta, Khaso, Burga and Kholgoso drain a long band from the Sikhote-Alin slopes further to the Middle-Amur plain (200-400 m above the sea level). Broad-leaf and coniferous forests prevail here and in some places they are substituted by small-leaf secondary forests (birch, aspen). Close to the plain larch becomes common. Such forests have brown forest soils (burozems) of loam and clay-with-rock-waste types. Basalt rocks are highly weathered, and soil profiles are very thick. A significant accumulation of clay fractions in such soil makes them moist. Piedmont landscapes have transit and accumulative regime of moisture and substance migration. Typical burozems (section 2-06) have a thin forest debris layer mostly composed of leaves. A humus horizon is well developed, colored in yellow and brown shades and has a high humus content. Excessive moisture on gentle slopes with soils containing clay (especially at the bottom) causes gleying of the mineral part of the soil and thus gleysol and gleysolic types of burozems are formed.

Brown forest soils of broad-leaf and coniferous forests (section 2-06, Table 1) have neutral reaction, A1 humus horizon being an exclusion as having acid reaction. Exchange Ca^{++} and Mg^{++} content is medium but meaningfully higher than that of brown taiga soil. This contributes to partial neutralization of acid products of humus formation. C_{org} content is high in O horizon and indicates high productivity of these forests and intensive accumulation of leaf debris. C content in A1 humus horizon is high and is specific to the burozem-type soil formation. Towards the bottom of the section C_{org} content strongly decreases and 50 cm deep is only 1%. In general, soil formation processes in brown forest soils are of well-marked accumulation character (C_{org} content, biogenic bases, iron compounds).

River bank areas (Kartanga, Khaso, Burga) are composed of gravel and sandy-gravel alluvium and play a great role in surface water filtration. These areas have groves of elms, Korean pine, poplar, Manchurian ash with moisture-loving grasses and humic soils. Most vegetation period they are rather moist owing to close underground water horizons (50-60 cm), but due to a good filtration capacity they are not overmoist. For a short time they are flooded with water and after floods subside, the soil is covered with a thin layer of silt. Morphological structure of soils in the plains indicates an intensive accumulation of humic vegetation remains in the upper part of the profile. Leaf debris (O horizon) is 3-6(7) cm thick with well-marked different fermentative layers. Medium reaction is neutral. Mull horizon (AO) is

usually black-brown or black, uniform, fine-grained and weakly acid (sections 4-06 and 5-06, Table 1). Both horizons have high C_{org} content. It also explains the accumulation of Ca^{++} and Mg^{++} here. Toward the bottom of the profile C_{org} content decreases but is still rather high. The highest concentrations of C_{org} and exchange bases in the organic part of the profile is very specific to mull-gleysol soils to Gassi Lake area and single out this soil type from similar soils of mountain areas.

A big flat valley (30-50 m above the sea level) stretches along the lower reaches of the Karganga river and occupies a significant part of the Gassi Lake Basin. Drainage is weak here and swamping and peat accumulation take place. The valley has pressed and water-resistant clay deposits, which together with overlaying 0.2 – 1 m of peat retain moisture from precipitation and surface water runoff. The growth of peat deposits is slowed with a long freezing period and peat mineralization as well as regular fires and droughts. The Gassi Lake plain landscape is a combination of different types of bogs with specific vegetation and water resource. Close to the rivers water regime may be of flow or static type. Moss and grass bogs form silt-peat and silt-peat-gleysol soils. Peat (T1) and peat-mineral horizons are acid (sections 7-06, Table 1). Organic matter content is high but exchange bases content in peat-containing horizon is not high and reaches only 7 mg-equivalent. Close to the profile bottom it is reduced to 3 mg-equivalent. Sometimes after floods a silt film of organic and mineral composition covers vegetation and peat-gleysol layers. Sedimentation processes in the flood plain cause high ash concentrations in the peat layers.

Most areas are covered with grass and sphagnum bogs with shrub and larch groves. Water regime is static. Peat-gleysol and peat soils are formed here. Peat was sampled in the sphagnum-shrub bog with larches (section 8-06). Peat horizons are acid, organic matter content is extremely high but exchange bases content is medium. Biogenic processes in this bog are characterized with a trans-accumulative regime and depend on oxidation-reduction reaction conditions. Both component accumulation and washing out take place (C_{org} , iron and other compounds).

In general high organic matter reserves characterize Lake Gassi soil cover. But processes of semi-decomposed organic matter and humic substances accumulation in mountain and plain landscapes are different. In soils in upper river reaches slow decomposition of coniferous debris prevails over humification processes. Water and acid-dissolved forms of humic acids are formed in significant amounts. For example, DOC in sample from G-1 section was 34 and 56 mg/dm³ in O and AO horizons respectively (Table 2). High moisture and relatively high drainage capacity of brown taiga soils contribute to C_{org} discharge from the upper soil horizons. Mobility of water dissolved organic matter in brown forest soils is less evident as these soils are more pressed and contain less gravel particles. According to our studies migration of movable humus along the profile is not characteristic to brown forest soils in general. Samples from brown forest soil humus horizon taken between rivers Svetlaya and Uta showed minimal DOC compared to other samples studied (Table 2). DOC in mull-gleysol soil upper horizons of samples taken in Burga, Left Khoso river valleys was increased significantly and reached 130 mg/dm³ (section 4-06, Table 2). The correlation of C_{org} in A and B horizons was taken to identify the differences in mobility rate in the C_{org} profile. Brown taiga illuvial humus soil in spruce and larch

forest (section G-1) it was 8-10 times higher than that of brown forest soil in broad-leaf coniferous forest (section 2-06). This fact indicates intensive moving of humic substances deep down the brown taiga soil profile, and further on to the river.

Concentrations and distribution of moving forms of iron within soil and geomorphologic profile of the basin territory were of most research interest (Table 1). The data obtained indicated high ferritization of soil profiles. In forest soils maximal concentrations of moving iron in the upper horizons are connected with its biological accumulation and in the lower horizons they are explained with high content of iron in basalt rocks. Iron accumulation is also notable in peat horizons of bog soils. The highest oxalate-soluble iron concentration was found in silt sediments in bogs.

Table 1

Physical and Chemical Specifics of soils in the Gassi Lake Drainage System

Horizon, depth, cm	pH (water)	Ca ⁺⁺	Mg ⁺⁺	Moving iron, %
		Mg-equivalent/100 g dry soil		
Mountain brown taiga humic illuvial soil				
A 2-4 cm	6,20	5,6	1,8	3,71
AB 4-10(12)	4,45	3,2	2,3	1,20
B ₁ 10(12)-17	4,36	2,0	0,6	2,60
B ₂ 17-27	4,70	1,5	1,6	2,20
BC 27-37	4,97	1,8	8,2	1,63
BC 37-43	5,43	2,8	4,7	0,18
Brown forest soil (between rivers Svetlaya and Uta)				
AO	5,71	-	-	0,20
A 6-20	4,84	6,8	2,8	3,59
B ₁ 20-32	5,62	3,6	4,8	2,50
B ₂ 32-46	5,55	3,1	2,7	4,39
Mull gleysol soil (Burga River valley)				
AO	6,32	-	-	0,60
A 0-8	5,37	16,0	4,0	2,00
AB 8-15	5,52	6,8	2,0	1,60
AB loam	5,58	2,6	2,6	1,30
Soddy burozem soil (Left Khoso River)				
AO	5,67	-	-	0,80
A 10-15	5,53	12,3	6,3	1,99
AB 27-37	5,37	5,0	4,8	1,60
B 50-55	5,58	5,9	0,4	2,90
Peat humic (Malina River)				
T ₁ 10-15	4,85	4,7	2,3	2,20
TG 20-30	4,68	2,3	3,6	1,90
CG 30-40	5,59	2,0	0,8	1,40
Peat gleysol soil (Babchi River)				
T ₁ 20(30)-42	5,21	5,9	5,6	1,20
T ₂ 42-60	5,24	6,2	3,6	0,40
Silt from bogs (Babchi river)	-			16,57
Silt from Gassi Lake shallow water spots	-			3,50

- not analyzed

Table 2

Organic Matter Content in Soils of Lake Gassi Divine

Horizon, depth	C _{org total} , %	DOC, mg/dm ³
Mountain brown taiga humic illuvial soil		
A 2-4cm	12,54	34,5
Alpr 4-10(12)	14,10	56,5
B ₁ 10(12)-17	15,78	-
B ₂ 17-27	19,82	-
BC 27-37	5,96	-
BC 37-43	3,09	-
Brown forest soil (between rivers Svetlaya and Uta)		
AO	38,92	38,9
A 6-20	6,77	26,6
B ₁ 20-32	0,86	-
B ₂ 32-46	1,04	-
Mull gleysol soil (Burga River valley)		
AO	42,12	126,7
A 0-8	22,01	30,9
AB 8-15	7,20	-
AB loam	6,77	-
Soddy burozem soil (Left Khoso River)		
AO	38,20	-
A 10-15	26,55	52,0
AB 27-37	9,81	-
B 50-55	8,52	-
Peat humic (Malina River)		
T ₁ 10-15	24,40	-
TG 20-30	11,59	41,7
CG 30-40	1,46	-
Peat gleysol soil (Babchi River)		
T ₁ 20(30)-42	37,60	28,0
T ₂ 42-60	45,02	-
Silt from bogs (Babchi river)		
	22,34	-
Silt from Gassi Lake shallow water spots		
	17,62	-

- not analyzed

Surface Water Characteristics

Hydrochemical characteristics of surface water includes such parameters as pH values, main ion concentrations (Na^+ , K^+ , Ca^{2+} , Mg^{2+} , Cl^- , SO_4^{2-}), Si compounds, correlation of main cations (Na^+/K^+ , $\text{Ca}^{2+}/\text{Mg}^{2+}$). For cation correlation ion concentrations were used measured in mg-equivalent/dm³. All the results are presented in Table 3.

One of the important parameters of water quality is pH. In June samples it was within the range 6.04-7.55 and in September samples it was within the range 5.79-7.57. Permissible concentration level (PCL) for pH in fresh water is 6.5-8.5. Samples #10, 6, 9 had pH values lower PCL. In general in Low Amur water pH is within 6.4-6.9. This water is considered pH neutral.

Cations in water have the sequence $\text{Mg}^{2+} > \text{Ca}^{2+} > \text{Na}^+ > \text{K}^+$ (10 cases out of 18), or $\text{Mg}^{2+} \geq \text{Ca}^{2+} > \text{Na}^+ > \text{K}^+$ (5 cases) and rarely $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{Na}^+ > \text{K}^+$.

Hardness of water ($\text{Ca}^{2+} + \text{Mg}^{2+}$) was 0.404-0.649 mmol/dm³ equivalent. Gassi Lake Basin water is characterized as soft. Maximum water hardness values (over 0.500 mmol/dm³ equivalent) were found in samples # 11,7,9 from the Gassi Lake (July), Malina and Babchi rivers and minimum values were in samples # 8,4,10,1 from Left Khoso River (September), Uta River, bog, Kartanga River. Ca ion concentrations fluctuated between 3.3 – 6.4 mg/dm³. Increased values of Ca^{2+} were registered in samples # 1,2,3,4,5 and 7 in September compared to the July samples. It is known that Ca^{2+} is typical for little-mineralized waters. Magnesium ion concentrations in the analyzed samples were 2.3-4.5 mg/dm³. The highest Mg^{2+} concentrations were observed in the Malina River and Lake Gassi (samples # 7 and 11), the lowest were in the Khoso River (upper bridge) and the Left Khoso River (samples # 3 and 8). Content of Mg^{2+} in water noticeable fluctuates during the year: maximum concentrations are usually observed in low water and minimal are registered in flood time.

A well-marked seasonal dynamics of Ca^{2+} and Mg^{2+} distribution was not found.

The value of correlation $\text{Ca}^{2+}/\text{Mg}^{2+}$ is the chief characteristic of metamorphosed waters. In little-mineralized waters Ca^{2+} is the chief chemical component and Mg^{2+} appears with metamorphism. The $\text{Ca}^{2+}/\text{Mg}^{2+}$ value observed in the samples (1-2) corresponds to surface little-mineralized waters.

Sodium ion concentrations in the samples were 1.50-4.63 mg/dm³. The highest Na^+ concentrations were observed in the rivers Burga and Left Khoso (samples # 5 and 8), the lowest was in Gassi Lake (sample # 1). Besides from June to September Na^+ concentrations increased 1.1-2.3 times. Sodium ion concentrations in surface water are determined by physical, geographic and geological specifics of the basin area studied.

Potassium ion concentrations in samples fluctuated in the range 0.22-1.00 mg/dm³. The lowest K^+ concentration was observed in the river Burga (sample # 5), the highest was in the Malina River (sample # 7). Besides from June to September K^+ concentrations increased 1.3-2.5 times. This may be explained with temperature decreasing and vegetation growth slowing. Correlation Na^+/K^+ was 4-18.

In general sulfates are present in all natural waters and are their chief anion. Sulfates in surface waters are distributed unevenly. The content of SO_4^{2-} in the samples studied fluctuated within the range 1.5-7.5 mg/dm³. September SO_4^{2-} concentrations in samples # 1,2,5,7,9 were higher than in July samples 1.4-4.5 times. In samples # 3,4,11 from the Khaso River (upper bridge), Uta River and Lake Gassi SO_4^{2-} concentrations decreased a little (1.1-1.3 times) from June to September. Typical values for the Amur River are 1.3-7.7 mg/dm³. The correlation between pH and SO_4^{2-} values was studied to reveal possible sources of sulfates in water. The analysis of our data revealed that there is no meaningful correlation between them. When SO_4^{2-} value was maximal (7.5 mg/dm³) pH was 5.79 and when SO_4^{2-} was minimal (1.7 mg/dm³) pH was 6.04.

Chloride ion concentrations were in the range 0.7-1.8 mg/dm³. No seasonal dynamic in their distribution was revealed. Maximal Cl⁻ concentrations were observed in the bog, the Babchi and Malina rivers (samples # 10, 9 and 7), minimal concentrations were in the rivers Uta, Khaso (upper bridge) and Burga (samples # 4, 8 and 5).

Silicon is always present in natural waters as being widely spread in mountain rocks. Dissolved Si concentrations in surface waters of Gassi Lake Basin were within the range 2.38 – 9.33 mg/dm³. Seasonal dynamics of Si concentrations was revealed. In autumn Si concentrations were 1.1-3.4 higher. Maximal Si concentration increase was observed in samples from Kartanga river (#1) and minimal increase was observed in samples # 4 and 11 from the Uta River and Lake Gassi. In the Amur water Si fluctuates between 0.1-7.0 mg/dm³, the average being 5.3 mg/dm³. The highest Si concentrations are registered in the upper reaches of the Amur. The Shilka river discharges into the Amur dissolved silicon compounds in big amounts. Si concentration of 9.9 mg/dm³ was registered there.

Increased biogenic substance concentrations may indicate natural (water runoff from boggy areas) and anthropogenic (chemical pollution) sources of surface water pollution. As a rule, they cause water mass productivity increase, which not always can be an indicator of ecological security of the water object.

A more complete hydrochemical analysis of water samples is needed to provide a more detail description of surface water chemical composition and to have a deeper understanding of chemical component migration.

Hydrochemical research conducted in the Gassi Lake Basin revealed nonuniformity in chemical composition of surface waters in that area and seasonal dynamics of silicon compounds and ions of potassium, natrium and sulfates. Water chemical composition in the Gassi Lake Basin is formed under natural and anthropogenic factors including physical, geological and geographic specifics, landscape of the draining area, hydrological regime phases, proportion of surface and underground water recharge and economic activities.

Table 3

***Water Hydrochemical Characteristics of Gassi Lake and Its Rivers
in July and September 2006***

Station number	Sampling place	Month	pH	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	SO ₄ ²⁻	Cl ⁻	Si
1	Kartanga River	July	6,62	2,51	0,50	4,2	2,6	2,8	1,5	2,38
		September	6,95	3,05	0,70	4,6	3,3	5,4	0,9	8,06
2	Khaso River (lower bridge)	July	7,45	2,53	0,36	3,9	2,9	3,2	1,1	8,13
		September	7,01	2,85	0,69	4,9	3,0	4,7	1,0	8,96
3	Khaso River (upper bridge)	July	7,48	–	–	5,3	2,3	2,7	–	8,51
		September	7,41	2,95	0,66	4,6	2,7	2,5	1,1	8,96
4	Uta River	July	7,55	1,55	0,37	4,2	2,5	2,4	0,7	7,16
		September	7,36	3,04	0,59	4,9	3,0	2,0	0,9	7,46
5	Burga River	July	7,35	2,34	0,22	3,3	3,3	3,1	0,8	6,27
		September	7,37	4,63	0,54	6,4	2,3	3,4	0,9	7,46
6	Brook of Burga River	July	6,04	2,35	0,41	6,0	3,2	1,7	1,3	8,13
		September	–	–	–	–	–	–	–	–
7	Malina River	July	7,03	1,77	0,64	5,6	4,5	1,5	1,4	8,35
		September	6,72	3,76	1,00	5,9	4,2	6,5	1,7	9,33
8	Left Khaso River	July	–	–	–	–	–	–	–	–
		September	7,57	4,53	0,98	3,8	2,6	2,4	0,7	8,96
9	Babch River	July	6,83	2,13	0,51	5,8	3,8	3,5	1,1	5,15
		September	6,31	3,07	0,83	4,6	3,1	4,8	1,7	6,34
10	Bog	July	–	–	–	–	–	–	–	–
		September	5,79	2,51	0,50	3,8	2,8	7,5	1,8	9,18
11	Gassi Lake	July	6,97	1,50	0,66	5,6	4,5	6,7	1,2	7,75
		September	7,14	3,44	0,87	5,2	2,9	5,3	1,2	7,84

Organic Substances

Landscape structure of the Gassi Lake Basin, dynamics and amount of precipitation, character and peculiarities of soils specify certain regularities in geochemical migration of organic matter and chemical elements (especially hydrogenous like iron, magnesium, etc.). Gassi basin rivers differ significantly in organic matter content. Uta, Burga, Left Khaso, Khaso (left bridge) showed relatively small DOC and colority values (Table 4). Water samples from the lower reaches of

Kartanga, Babchi, Khaso (lower bridge), Malina rivers which flow through a swampy plain contained DOC 4-5 times more. Water, carried into these rivers from swampy mountain areas during the floods, had high colority values and thus high DOC concentrations up to 39.8 mg C/dm³ (Table 4, a small stream that joint the Burga River). Bog water has even higher DOC concentrations. Our data revealed high DOC concentrations in water in the rivers, running through the plain part of the Gassi Lake Basin. It is especially high during the flood time (July).

The lake itself has high concentrations of DOC (30.0 mg C/dm³ as average) and corresponding high colority values (300⁰ as average) both in low water and in food periods. Organic matter content in the lake water seems to be determined by processes in the lake itself, as well as difficult-to-oxidate organic substances of humic origin, being discharged into the lake from the rivers and surrounding bogs, especially in flood time.

Table 4

Organic Matter Content in Gassi Lake Water (July, September 2006)

Station №	Sampling site	DOC, mg C/dm ³	
		July	September
1	Kartanga River	16,2	27,1
2	Khaso River (the lower bridge)	6,9	12,2
3	Left Khaso River	-	4,5
4	Uta River	8,3	2,4
5	Malina River	36,7	33,6
6	Burga River	3,5	6,0
7	bog	-	51,2
8	Babchi River	18,5	32,8
9	Khaso River (the upper bridge)	6,9	5,1
10	Lake Gassi	30,4	28,0

Conclusion

Ecosystems and soils in the Gassi Lake Basin possess big resources of organic carbon. Their formation specifics are determined by the differences in the biologic cycle of elements in the forest and bog ecosystems. The main source for the dissolved organic matter is organogenous horizons (forest debris, mull, humic and peat soil horizons). Dissolved organic matter is rich in movable forms of humic acids and plays a meaningful role in combining many metals (e.g. iron) and migration of their complexes in surface waters.

One of the most important specific features of humic acids is their ability to combine metals and provide cation exchange. They make nutrient cations like Fe³⁺ available to water vegetation.