HYDROCHEMISTRY OF THE AMUR LIMAN AND THE SAKHALIN BAY

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The Amur Liman extends beyond the Amur river mouth and constitutes a strait between Asia and the northern part of the Sakhalin Island. In the south through a narrow Nevelskoy Strait and Tatar Strait it connects the Sea of Japan with the Sakhalin Bay of the Okhotsk Sea. The liman is 185 km long, 40 km wide and 3-4, 5 m deep. Its western shores are heavily raged and mountainous and eastern shores are sandy and low. Maximum width of the Sakhalin Bay is 160 km. The Amur Liman is covered with ice from November till May and the Sakhalin Bay is frozen till June. Daily tides are of 2 meters.

The main stream in the estuary, excluding that part of it which fills large shoals and dry banks, is nearly equally split into three fairways Nevelskoy, Eastern and Southern. The first goes to the north, the second – to the east and the third first goes along the continent shores to the south and then turns to the southeast. They are 3.5 - 22, 1.5 – 15, 3 – 11 meters deep respectively. Shallow areas are covered with vegetation. The Sakhalin fairway in the eastern part of the Liman runs along Sakhalin shores. It is divided into the northern and southern parts, which are split into Eastern and Western ways. The Sakhalin fairway in its northern part is more that 8.5 km deep [2].

Hydrochemical studies were undertaken in the Amur Liman and Sakhalin Bay in the second decade of August 2006. Location of sampling stations is presented in Table 1. Water was sampled from the surface and bottom layers. Water temperature, salinity, pH, oxygen and suspended matter contents were measured in situ with meter TOA DKK WQC-24 (Japan). The Interregional Center for Monitoring Hydroenergy Facilities (Accreditation certificate # ROCC RU 0001.515988) at IWEP FEB RAS carried out water sample analysis. Major ions (Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, Cl^-), nutrients (NO_3^-, NO_2^- , NH_4^+, HPO_4^{2-}, Si) and trace metals (Al, Mn, Co, Ni, Cu, Fe) were analyzed.

The water in the estuary is well-warmed and little acid (Table). Oxygen content in water exceeds 5.2 mg/l and oxygenation is 62.8%. Our studies in August 1997 near Ozerpakh village revealed higher oxygen content (over 7.8 mg/l) and oxygenation (80%). In the vertical section the highest concentration is observed in bottom layers.

Suspended substances are also distributed in water unevenly. The highest concentrations were observed in bottom layers, and at the deepest station (#2) they reached maximum values (Table). Suspended matter content was 4 times higher at the bottom than at the surface.

In the estuary major ions and biogenic substances are distributed relatively even. Concentrations of major ions are low, and Cl^- is of the same level as atmospheric precipitation in Priamurje. Total content of major ions is less 25 mg/l. In winter low water it increases twice or even more times. Due to low water discharge from Amur marine water impact is quite evident in the estuary. Thus, in March 1998 Cl^- content in water near Nickolaevsk-on-Amur was 8.3 mg/l and near Ozerpakh village it was 19.1 mg/l.

Nitrate nitrogen prevails among the mineral forms of nitrogen. Nitrate nitrogen content, which is 2-3 times higher compared to that, registered in 1997 is explained by the discharge of big amounts of nitrates from the Sungary River in fool time. Increased concentration of phosphates compared to 2005 can be also explained by the Sungary discharge.

NH_4^+ and NO_2^- concentrations are very low due to the consumption by phytoplankton and vegetation. Same concentrations are typical for this time of year and were also observed in August 1997 and 2005.

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

The Amur Liman is characterized with a complicated current [2]. Irregular daily tides in the Sakhalin Bay and half-day tides in the Sea of Japan coupled with changing discharge of the Amur into the Liman cause 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/l. In the surface water layers of the liman central part major ion contents are the lowest, and in its most shallow spots there is no much difference in their distribution in vertical section. In very deep spots (station 5) major ion concentrations are 5-6 times lower than in the bottom layers.

Big changes happen to silicon and nitrogen mineral forms. Due to mixing with seawater and plankton consumption their concentrations decrease and especially ammonia nitrogen show significant decrease. Most low nutrient concentrations are registered in bottom layers of deep areas. Compared to silicon and nitrogen mineral forms phosphate concentrations remain increased (Table).

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.). Such behavior of the studied metals in the Amur Liman has been observed before [3].

In the Sakhalin Bay (stations 7-9) suspended matter content in water and its temperature gradually decrease, and pH value, oxygen concentration and salinity (and thus, major ion contents) increase (Table). Difference in major ion contents in vertical section becomes less with depth increase. Compared to major ions nutrient content is salt water is decreasing and in bottom layers NO_3^- and Si contents drop to detection limits. Ammonia and nitrite nitrogen presence is 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). Cu shows the biggest difference in its concentrations between the surface and bottom layers.

Al and Mn behavior is quite different. 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.

Thus, dissolved mater content in the Amur Liman and Sakhalin Bay depends on the Amur water and seawater mixing pattern, and trace metal concentrations also depend on the processes of sedimentation and desorpsion from bottom layers.

REFERENCES

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2. Solovjev A.I. Amur and Liman Bottom Processes and Waterways. Vladivostok: FEB RAS. 1995, 269 p.
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Table

Chemical composition of Amur Liman and Sakhalin Bay waters

H	T	pH	turbid-ity	S	O_2	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}
m	^oC		g/m^3	$^0/_{00}$	mg/l						
St 1 (53.07 lat., 140.48 long,), 10.08.06.											
0.0	23.7	6.79	52.2	0.0	5.29	3.9	1.3	7.2	2.0	2.4	5.3
6.0	23.6	6.54	84.2	0.0	5.58	3.6	1.3	7.2	2.9	2.0	4.4
St 2 (53.03 lat., 140.57 long,), 10.08.06.											
0.0	23.8	7.14	46.8	0.0	5.54	3.6	1.2	7.2	2.4	2.0	6.6
20.0	23.5	6.89	189.4	0.0	-	3.6	1.2	7.2	2.4	1.7	6.1
St 3 (52.54 lat., 141.16 long,), 10.08.06.											
0.0	23.1	6.67	60.9	0.0	5.74	3.7	1.2	6.4	3.4	2.0	3.1
4.4	23.2	6.82	75.8	0.0	5.93	3.7	1.2	7.2	2.9	2.0	4.4
St 4 (52.50 lat., 141.40 long,), 13.08.06.											
0.0	22.0	7.61	28.0	5.4	6.30	1313.0	98.6	80.6	268.1	3200.1	318.0
4.0	21.6	7.69	30.6	6.7	5.56	1326.6	104.2	81.4	263.3	3254.3	460.5
St 5 (53.02 lat., 141.40 long,), 13.08.06.											
0.0	22.6	7.58	108.3	3.3	6.57	831.6	104.2	44.7	129.8	1591.0	208.3
16.6	20.9	7.81	41.8	19.0	6.18	5167.8	285.1	221.2	739.3	9003.6	1381.6
St 6 (53.14 lat., 141.40 long,), 13.08.06.											
0.0	22.0	7.77	23.3	5.6	6.45	1556.8	82.2	65.3	206.6	2513.0	350.9
6.0	22.0	7.71	18.0	6.7	6.45	1669.6	76.8	67.7	212.0	2567.3	350.9
St 7 (53.26 lat., 141.40 long,), 15.08.06.											
0.0	21.4	7.73	7.8	7.6	6.24	2001.6	109.6	87.8	299.0	3615.9	548.2
7.3	9.3	8.00	21.5	-	8.55	3498.2	175.4	137.7	456.1	5966.2	921.0
St 8 (53.38 lat., 141.40 long,), 15.08.06.											
0.0	20.3	7.87	9.4	9.1	6.45	2782.6	131.6	111.6	350.9	5008.0	614.0
9.4	2.1	7.99	2.5	20.9	7.44	6671.9	438.6	319.0	1147	11158.0	2236.8
St 9 (53.50 lat., 141.40 long,), 15.08.06.											
0.0	15.1	8.12	1.9	25.2	8.00	6393.9	394.7	287.7	994.6	14825.2	2105.3
25.2	0.3	7.83	3.7	31.1	14.0	7366.8	460.5	350.9	1205	17971.0	2368.4

Table continued

H	NH_4^+	NO_2^-	NO_3^-	HPO_4^{2-}	Si	Al	Mn	Fe	Co	Ni	Cu
m	mg/l					μg/l					
St 1 (53.07 lat., 140.48 long,), 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 (53.03 lat., 140.57 long,), 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 (52.54 lat., 141.16 long,), 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 (52.50 lat., 141.40 long,), 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 (53.02 lat., 141.40 long,), 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 (53.14 lat., 141.40 long,), 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 (53.26 lat., 141.40 long,), 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 (53.38 lat., 141.40 long,), 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 (53.50 lat., 141.40 long,), 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