SPECIFICS OF ORGANIC SUBSTANCE GEOCHEMICAL MIGRATION AND PHYTOPLANKTON DISTRIBUTION IN THE SYSTEM AMUR RIVER – AMUR LIMAN

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1. INTRODUCTION

Organic substances (OS) are inseparable components of natural waters. Their composition and concentration in natural waters are determined with a complex of many processes of different nature and rate. Being genetically connected with natural waters organic substance serves as an indicator of water processes and water quality and effects the intensity of life processes in the water object. The presence of organic substances in natural waters is the main living condition for most organisms in various water objects, including lakes, rivers, and seas. There are no ecosystems in biosphere, which are absolutely independent from neighboring ecosystems. That is why there is a constant exchange of organic substances between these ecosystems. At the same time the amount of migrating organic matter is much less than that accumulated in the ecosystems, especially marine ecosystems (Humitake Seke, 1986). Organic substances in ecosystems undergo constant transformations while organisms are alive and produce energy, using organic substances.

Organic substances, dissolved in marine water are qualitatively less diverse than in land water objects. Marine surface water layers are the areas where a process of primary OS regeneration is extensive, similar to vegetation regeneration process in land areas (Datsko, 1959). Further development of other marine living forms depends on the intensity of primary product production, in which phytoplankton- synthesizing and hemo-synthesizing bacteria take part.

The studies of the system "river – liman – sea" will allow revealing mechanism specifics of OS transformation and transport from rivers to seas and oceans. OS behavior specifics in boundary areas have been studied by many scientists both in Russia and other countries (Almazov, 1962; Artemjev, 1993; Environmental Biogeochemistry, 1983 and others).

The aim of this paper is to assess OS concentrations and OS formation regularities in the surface waters in the system "the Amur River – the Amur Liman".

2. RESEARCH OBJECTS AND METHODS

The research was implemented in June 2007 under the Project of the Far Eastern Branch of the Russian Academy of Sciences "Complex Field Research of Natural Environment in the Amur River Basin (2004 – 2008)". As it was carried out in the Amur Liman, the

Tatar Strait and the Sakhalin Bay, it made possible revealing certain specifics of organic carbon discharge with Amur waters into the Amur Liman.

Water was sampled in the surface water layers (0.5 m) in the Amur estuary and in the area of river and marine water mixing, following the adopted sampling site plan as shown in Fig. 1. Organic substance concentrations were analyzed in 23 water samples and various microbiological parameters were analyzed in 19 samples.

Water samples were filtered on board of the research vessel "Professor Gagarinsky" through 0.45 mcm-pore Whatman filters and dissolved organic carbon (DOC) was measured in the filtrate. Then samples were frozen and transported for further analyses to the Institute of Water ad Ecology Problems FEB RAS. Total organic carbon (TOC) and DOC were measured with standard methods for chemical analyses of natural water (Datsko, 1959; Alekin, 1977). Bulk content of organic matter was estimated by multiplying TOC by the coefficient K = 2 [17].

Microbial analyses included such parameters as total number of bacteria (TNB), number of heterotrophic bacteria (HB), saprophytic bacteria (SB), oligocarbophytic bacteria (OB) on standard mediums (Handbook…, 2005). To analyze samples from the river and sea water mixing areas microbial plantings were in media of similar composition with a 3% marine salt additive. Counts were expressed with the number of colony-forming units (CFU) of microorganisms in 1 ml of water.

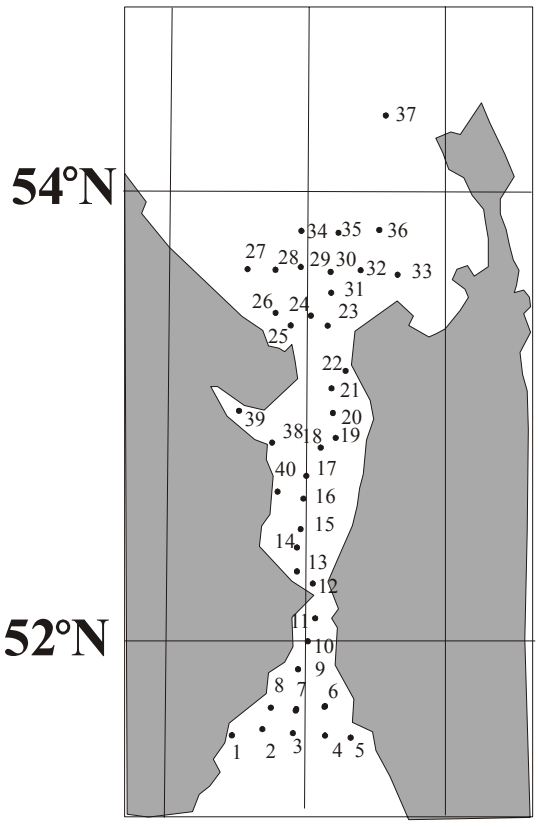

Fig. 1. Water Sampling Station Scheme

3. RESEARCH RESULTS AND DISCUSSION

Organic carbon in studied waters was present mostly in the dissolved form (77.0-97.7%, 90% TOC at average). DOC values varied from 2.1 to 8.4 mg L^{-1} and the mean value was 5.0 mg L^{-1} (Fig. 2). The highest DOC content was registered in the Amur estuary (St. 38-40) and is caused by the river discharge. The area of desalinated water with maximal content of OS of river origin vastly stretches from the Amur Estuary in the north-east direction towards the Okhotsk Sea (from St. 38-40 and further on to St.24). The curve of DOC distribution in the studied waters does not correlate with the desalination line.

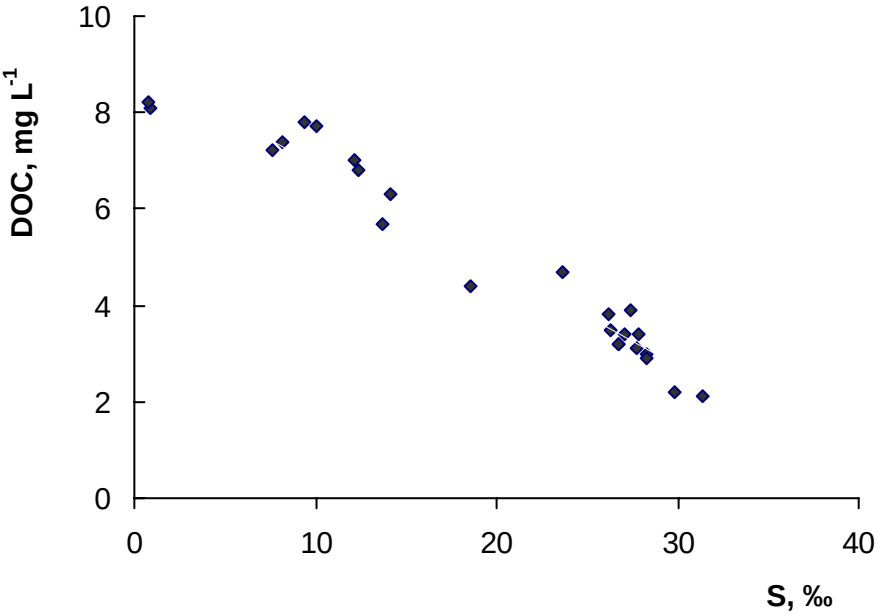

Fig. 2. DOC in the Surface Water Layer in the Amur Liman, the Tatar Strait and the Sakhalin Bay in Correlation with Water Salinity in June 2007. *Note* - salinity at 1-2 m depth*

Due to biogeochemical, and mostly physical and chemical processes (flocculation – adsorption – desorption) on all stages of river and sea water mixing, dissolved (DOS) and suspended organic substances (SOS) undergo inter-changing processes. Most intensive DOS changes into SOS occur in the Amur Liman under water salinity 6-12‰. With salinity increase these processes become more equal.

Microbial analysis showed that TNB fluctuated between 0.62 and 2.83 million cells ml^{-1}. Minimal TNB values were registered in the Tatar and Nevelskoy Straits and near the Chastye Islands. Maximal TNB values were registered at the Station 24, where the Amur stream continues in the direction of the Okhotsk Sea, and lower Nickolaevsk-on-Amur. Areas adjoining the estuary are characterized with big quantity of bacterioplankton that plays the key role in utilization of organic substances discharged from the river.

Table 1. Number of Heterotrophic Bacteria in the Surface Water (counts on standard media)

Station №	TOC, мг L^{-1}	TNB, million cells ml^{-1}	Number of microorganisms, 10^3 CFU ml			SB/HB	HB/SB	TNB/SB 10^3
			SB	HB	OB			
15	4.5	0.89	1.97	0.3	0.08	6,6	0,15	0.45
16	6.0	0.96	0.07	0.7	3.3	0,1	10.0	13.70
17	8.4	1.02	0.17	5.7	-	0,03	33.5	6.00
18	8.3	0.91	0.18	0.3	4.2	0,04	23.9	5.06
22	7.8	1.47	0.18	0.7	8.0	0,01	98.3	8.17
24	7.5	2.84	0.10	0.3	7.4	0,06	16.0	28.40
29	5.9	1.02	0.29	1.2	0.4	0,24	4.1	3.51
32	3.3	1.03	0.06	1.5	0.2	0,04	25.0	17.17
36	7.9	1.23	0.73	0.7	0.4	1,04	0.96	1.68
38	10.9	1.37	0.04	0.9	1.1	0,04	22.5	34.25
39	10.1	1.63	0.26	2.2	5.3	0,09	8.5	6.37
40	11.3	1.08	0.28	0.75	0.6	0,37	2.7	3.86

Number of HB, counted on RPA:10 medium, fluctuated within the range 0.3 – 17.7 thousand CFU ml^{-1}. Maximal values were observed at Station 22 and may be associated with the impact of surface runoff from the Sakhalin Island. High values of GB number were also registered at Stations 17 and 18. The number of OB that utilize low OS concentrations fluctuated from 008 to 8 10^3 CFU/ml. Maximal number of SB, which react to high concentrations of weakly decomposed OS in water, was found at Station 15 near the Chastye Islands. In surface water, sampled at other stations, the number of this bacteria group was much less. SB/HB ratio in water sampled at this station significantly exceeded this coefficient value at other station, including Stations 16 – 18, situated along the Amur water flow. This fact indicates that possibly weakly-decomposed organic substances come with water runoff from the islands and not with Amur water. The reverse ratio HB/SB, which characterizes the eutrophication level, was lower 4 only at Stations 15, 36 and 40. This is characteristic for eutrophied ecosystems (Margolina, 1989). The situation in the sampling period at Stations 15 and 36 seems to be caused with incoming of weakly-decomposed organic substances. According to the State Standard 17.1.3.07 – 82 (State Water…., 2001) the water in the desalination zone studied is ranked quality-class II. Minimal ratio CFU/SB was registered at Station 15, although TOC values were relatively not high. This fact may be associated with effective microbiological utilization of organic substances. Number of halotolerant forms of SB fluctuated between 01. 10^2 – 4.38 10^3 CFU/ml. Maximal bacteria numbers were registered at Station 15 and in the direction of the Okhotsk Sea at Stations 29 and 36 (the Sakhalin Bay) (Table 2). It is caused with specifics of SB monoculture growth and stimulating effect of marine salt.

Table. 2. Number of Indicator Halotolerant Heterotrophic Bacteria in Surface Water (count on medium with a marine salt additive)

Station №	TOC, мг L^{-1}	TNB, million cells ml^{-1}	Number of microorganisms, 10^3 CFU ml^{-1}			SB/HB
			SB	HB	OB	
3	4.1	0.75	0.4	0.20	0.02	0.20
6	3.8	0.62	0.01	0.20	0.03	0.05
7	3.0	0.84	0.02	0.12	0.06	0.17
8	3.7	0.95	Not identified	0.20	0.05	Not identified
11	3.6	0.94	0.08	0.40	0.07	0.20
12	3.3	0.84	Not identified	0.25	0.02	Not identified
15	4.5	0.89	4.38	16.20	0.98	0.27
16	6.0	0.96	0.05	0.90	0.06	0.56
18	8.3	0.61	0.15	3.20	0.09	0.05
22	7.8	1.47	0.13	0.90	1.10	0.14
24	7.5	2.84	0.17	0.30	1.00	0.57
25	3.5	1.08	0.23	0.90	0.02	0.26
29	5.9	1.02	1.91	2.30	0.11	0.83
32	3.3	1.03	0.86	3.10	Not identified	0.27
36	7.9	1.23	1.55	3.80	0.04	0.41

Maximal number of halotolerant HB was registered at Station 15 and at Stations situated in the Sakhalin Bay. SB/HB ratio reveals a significant role of HB in OS utilization.

4. CONCLUSION

The Amur discharges into the Amur Liman organic substances mostly in a dissolved form. At different stages of fresh and salt water mixing water dilution proper does not take place, and transformations of dissolved into suspended substances and reverse transformations take place. Besides, OS accumulation might also take place in the Sakhalin Bay part that adjoins the Amur Liman.

According to the microbial population response the total phytoplankton quantity in 2007 reached 2.68 million cells ml^{-1}. According to microbiological indicators only water at Stations 15, 36 and 40 in the sampling period corresponded to eutrophied water objects. Bacterioplankton quantity depends on river runoff, Amur water level and peculiarities of fresh and salt water mixing. Bacteria, which utilize organic substances of low concentrations, played the main role in utilizing OS in the Amur Liman waters. This is associated with composition specifics of suspended organic substances discharged from the river. SB played a significant OS utilization role in areas, where weakly-decomposed OS are discharged with the river runoff (near the Chastye Islands).

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