IRON CONTENT IN THE MIDDLE AMUR IN WINTER LOW WATER PERIOD

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Iron belongs to biogenic substances which play an important role in phytoplankton development. Monitoring of total iron concentration in the Middle Amur has been carried out by Russian Hydrometeorological Agency since 1940-ies. But in spite of long-term observations their results have not been correlated yet. The present paper attempts to fill in this gap.

To solve the tasks set, monthly water sampling was done during winter low water period 2003-2004 near Khabarovsk at 4-5 verticals, evenly spread across the stream. Random sampling was done in the river boarder zone at 3-5 verticals across the stream from the bank to the Russian border, as well as in the Zeya River near the City of Blagoveshchensk and the Bureya River near Novobureisk village in the middle of the steam. Total iron in the samples was estimated after oxidation with rhodanic kalium [3].

Materials from the Russian Hydrometeorological Agency and from the Heilongjang province Center for Hydrometeorological Observations for the 1942-1988 period were also used.

Chemical composition of Middle Amur water is formed by the water from Upper Amur and tributaries there, the biggest being the Zeya, Bureya and Sungary Rivers. Construction of big water reservoirs resulted in significant redistribution in these rivers' shares in the Amur run-off in winter. In 1944-1975 Amur water was formed mostly by the Sungary (70,5%). Meanwhile the Zeya (14,1%), Upper Amur (11,3%) and Bureya (4,1%) did not much influence the Middle Amur. Activities on the Zeya River caused 1.5 times increase of winter runoff in the Middle Amur and Zeya water portion became dominant (Table 1). Beginning from 2003 the Bureya hydropower reservoir will cause gradual increase of Bureya winter share.

All these changes in Middle Amur water regime not only caused significant ion discharge transformations [7], but iron fate as well. Iron content in the Amur near Blagoveshchensk in March 2001 was registered 0.21 mg/cu dm, whereas the average was 0.15 mg/cu dm. In March 2002 it was 0.34 mg/cu dm, higher but equally spread from the national border mark to the Russian bank. Low concentration of iron in the Upper Amur and insignificant water amounts there result in comparatively insignificant average iron discharge(up to 1.32 t/day). The estimate figure may stand true for the present day as well because Upper Amur hydrological regime has not been changed so much in recent years.

Table 1 Winter (December-March) water discharge in Middle Amur tributaries in 1976-1987

Tributary	Drainage area, sq. km	Discharge cub. m/sec	Portion of total discharge, %
Upper Amur – Kumara*	478 000	103.8	7.4
Zeya – Blagoveshchensk	233 000	768.6	54.7
Bureya – Kamenka	67 400	38.9	2.8
Sungary - Tsyamusy	532 000	493	35.1

* Average discharge for 1899-1962, as after 1963 no surveys have been performed in the national border area.

Much more iron is registered in the Zeya River. Average iron concentration near Blagoveshchensk in March 2001 was 0.58 mg/cu dm and in March 2002 – 0.66 mg/cu dm. For 60 years iron concentration and its fate in the Zeya River has significantly changed because of the hydro-power station operations there. If before its construction (1942-1975) average iron concentration in the river was 0.65 mg/cu dm and its discharge rate – 7.24 t/day, after the station has been put into operation iron concentration was 0.57 mg/cu dm and its discharge rate was 38.02 t/day. In the years, when the station water reservoir was being filled the highest iron concentration (up to 4.6 mg/cu dm) was registered in bottom water horizons in winter [2]. The fact may be explained by little oxygen in water and high concentration of humic substances, which assisted iron penetration into from the bottom sediments. Average annual iron content these years was 0.72-0.85 mg/cu dm. After normal reservoir level was reached oxygen regime improved. Since then bogs and swamped territories of Upper Zeya plain remain the main source of iron in water reservoir. Average annual iron concentration there reduced up to 0.48 mg/cu dm [2].

IVEP FEB RAS research indicated high iron concentrations of 25 mg/cu dm in sedge bogs [1] and 6.3 mg/cu dm in shrub and sphagnum bogs, which belong to Middle and Low Amur watershed with substantial mari and moor areas. Annual amount of iron coming from sedge bogs rages from 0.29 to 2.78 tons and that of shrub and sphagnum bogs is 0.11-0.45 tons of iron [1]. Rivers running through swamped areas carry much iron as well (up to 6.5 mg/cu dm in summer and 50 mg/cu dm in winter) [6]. Quite significant are also iron concentrations in bigger rivers with heavily swamped estuaries and Amur tributaries. For instance, in the Gorin River basin 23% of total watershed (22 4000 sq. km) is covered with bogs and swamped areas. That is why there is much difference between iron content in the middle passage of the river (0.35 mg/cu dm) and its estuary (1.59%) [4].

The most of iron that comes from bogs and swamped areas into rivers and, hence into the hydro-power station water reservoir originates during floods and monsoons rains, i.e. in time, when the reservoir is being mostly filled in. It is quite evident that in winter large amounts of iron, accumulated in during spring and summer in the reservoir, come into the Zeya and later the Amur river.

Thus after the Zya hydro-power station reservoir was filled in, iron content in the Amur river from Blagoveshchensk up to the Sungary junction was determined by its content in the Zeya river. Observations, carried out upper the Sungary junction in 2002, revealed Zeya reservoir significant impact on Middle Amur water chemical composition. Iron concentrations here were more of less evenly spread across the river from the Russian border to the banks. In March 2002 average concentration was 0.61 mg/cu dm and did not differ much from that in Zeya water. The Bureya River impact on the Middle Amur in this respect is not significant as average iron concentration there is 0.17 mg/cu dm and Bureya discharge rate is not high. Thus, average iron concentration in the Middle Amur up to the Sungary junction was 39.84 t/day, Bureya iron concentration including.

High iron concentration was also registered below the Sungary junction. Iron concentrations, registered in March and December 2002, were 0.70 and 0.57 mg/cu dm and evenly spread across the river from the Russian border to the banks, thus proving, that iron in big amounts is transported from the Sungary river.

Much iron in the Amur down the Sungary junction might come with underground water, but qualitative estimates have not been undertaken yet. Our observations near Khabarovsk revealed high iron content in Pryamaya and Kazakevichevo sub-channels. In March 1999 and 2001 iron concentration there ranged from 2.57 to 4.84 mg/cu dm. Places of iron-bearing water inflow were clearly indicated by large accumulations of red and brown iron hydroxide in unfrozen water passages. Chemical composition studies of iron-bearing underground waters by A.I. Trufanov [8] proved that in underground waters with sporadically spread aeration zone iron is present in form of Fe^{2+} and its concentrations fluctuate from 1.4 to 111 mg/cu dm. Ferrous iron concentrations in underground waters of present Quaternary sediments revealed the same concentration fluctuation range with 12.1 mg/cu dm. as its average. Underground waters from Middle Quaternary and Pliocene-Early Quaternary sediments are characterized by smaller amplitude of iron fluctuations, 5-20 mg/cu dm. and 1-54 mg/cu dm. respectively.

In the Middle Amur near Khabarovsk changes in iron composition are more evident. When first hydrochemical research was carried out in 1950-1975 iron concentrations were within 0.20-1.45 mg/cu dm range, with 0.67 mg/cu dm average. Average discharge for many years was 53.2 t/day, meaning that the most of iron came in the Sungary River and the rest originated from bottom sediments and ground waters. Such provision seems possible as the deficit of dissolved oxygen, registered in the Amur river in 1968-1970 and 1975, was caused by low quality of Sungary water.

In 1979-1987 even more significant iron transformations were identified. After Zeya hydro-power station was put into operation, Middle Amur water content grew 1.6 times and hence, iron concentrations became higher. But comparing much higher iron concentrations near Khabarovsk with that of Zeya water near Blagoveshchensk, it may be assumed, that the main sources of iron in the Amur in those years were the Sungary tributary and underground waters. The role of sediments in this respect is minimal or not at all as Amur oxygen regime has been improved [5]. Iron concentrations at that time were in 0.39-1.71 mg/cu dm range and its average was 0.83 mg/cu dm. Such significant hydrological and hydrochemical changes influenced iron discharge rate, which reached 105.7 t/day, i.e. grew twice in between 1979-1987.

Significant iron fate changes are being registered now near Khabarovsk. Bureya reservoir construction caused Middle Amur runoff expansion and certain decrease of iron concentration in water. January 2002 cross profile samples showed 0.92 mg/cu dm, but in January 2004 samples it was 0.53 mg/cu dm. Nevertheless, we can predict 100 t/day iron discharge rate, runoff expansion being taken into account.

Thus for the recent 60 years, iron concentration and discharge in Middle Amur water have changed significantly due to hydro-power industry development in the Russian part of the Amur basin and rapid economy growth in the Chinese. Viewed in multi-year cycle, significant growth of iron concentration in the Amur River is also evident.

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