# BIOGENIC SUBSTANCES IN MOUNTAIN STREAM WATER IN THE LOWER AMUR BASIN

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In recent year active economic activities (timber felling, mining of non-ferrous ores, etc) in taiga regions of the Lower Amur basin heavily impact river water quality. Forest fires cause the most changes of river water chemical composition. Practically every spring and autumn they cause great damage in Priamurjie and every 22-year period they become catastrophic (1954, 1976 and 1998). Less intensive forest fires were in 1968, 1978 and 1988 (Fig. 1).

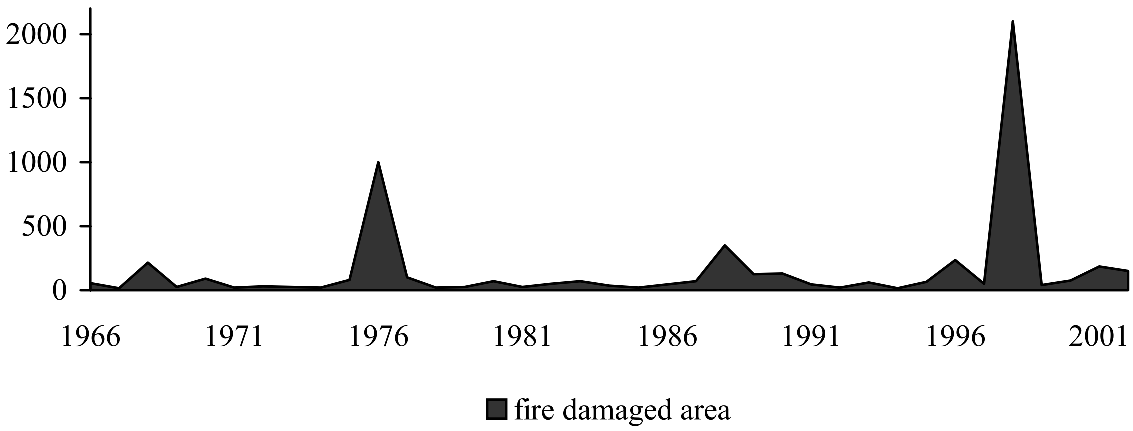


*Fig. 1. Dynamics of forest fires in Khabarovsky krai in 1966-2002.*

Most catastrophic fires occurred in 1998, when 1279 fires were registered in Khabarovsky krai and caused damage to 2.5 million ha (some sources [2] recorded 6,0 mln ha). Fire started in Yakutia and then their epicenter moved to Khabarovsky krai. Atmosphere was heavily polluted with smoke for 5 months due to a stable anticyclone and still weather. In many places vegetation was completely burnt.

Drastic fires in 1998 gave rise to studies of fire impact of chemical composition of taiga river waters. Pyrogenic factor research were undertaken in 1999-2004 in the upper reaches of the Anyui River, which is one of the biggest Amur tributaries. In 1998 165 thousand hectares of forest were burnt there and in 1999-2004 period 2.9 thousand hectares of forest were damaged. The research was focused on small river basins, where no economic activity was developed but damage, caused by fires, and fire intensity were different. Water sampling was carried out 4-6 times a year, when the rivers were not frozen.

Background rivers, which basins were not under fire, were studied for comparison purposes. Thus water mineralization in areas free from karst rocks and mineral underground water inflow did not exceed 45 mg/l. Maximal dissolved matter content was registered in summer low water, whereas in flood time it was minimal.

River water is characterized with high contents of phosphate ions and ammonia nitrogen (Fig.2), maximum concentrations of which were registered in autumn. Total Fe showed the same seasonal dynamics. In resent three years phosphates and ammonia nitrogen have not been registered in water.

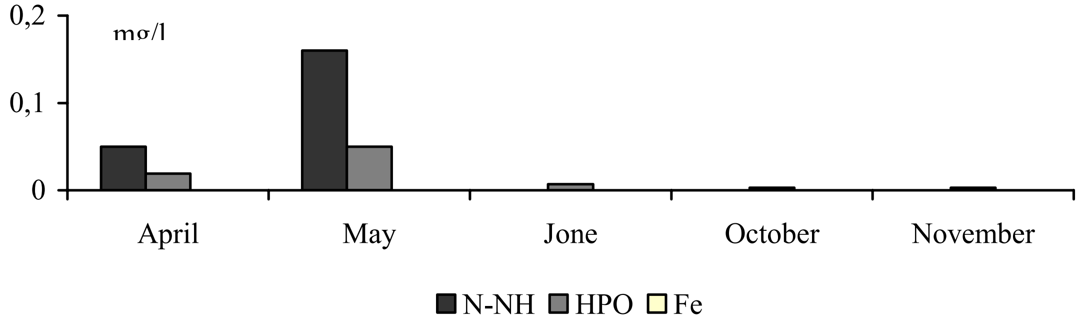


*Fig. 2 Seasonal changes of ammonia nitrogen, phosphates and total Fe in river waters of background Anui basin area in 2004.*

Nitric nitrogen showed a different picture. Nitric nitrogen content in water there was 4 times higher compared to small streams on the eastern slopes of the Sikhote-Alin mountain range. Increased concentrations of nitric nitrogen irrespective of water regime phases were observed throughout 6 years of monitoring and may be attributed to the atmospheric transmission of forest burning products to the studied areas from the other areas under fire, including China. Such conclusions are based on heavy smoke in Lower Amur regions observed in every autumn and well shown on the maps of the Global Forest Fire Monitoring Center (Freiburg, Germany).

Materials on chemical composition of snow cover, formed in the period of much smoke in the air provide other evidence of a high role of atmospheric transmission in the increase of nitric nitrogen concentration in water of taiga streams. In 2003 a maximal nitric nitrogen concentration in snow cover was registered 1.2 mgN/l, where as that of ammonia nitrogen was 2.0 mgN/l. The snow was acid (pH > 4.5) and of sulphate and ammonium composition. Its chemical composition differed much from the chemical composition of show cover in the Everon-Chukchagir depression [1]. Similar situation was observed in the smoked up regions in Khabarovsky krai south in November 2004. Snowfall nitric nitrogen content exceeded 1.0 mgN/l. Chemical composition of snow cover was also sulphate and ammonium.

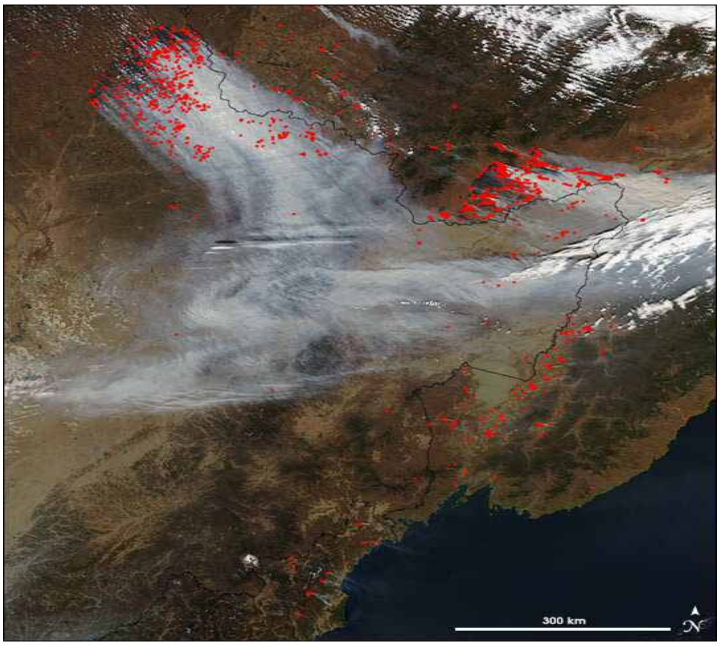


*Fig. 3. Forest fire smoke flames in China and Far-East Russia, October 2004*

American scientists also observed increased concentrations of ammonia and nitric nitrogen in water of small streams, which basins were close to areas under fire [9, 11].

Chemical composition of water in the rivers, draining burnt areas, changes significantly after the fires. It is caused by the accumulation of burnt vegetation and ash components on the surface of drainage areas. It is well known that leaves, needles, shrubs, etc can be completely burnt whereas tree trunks are only charred. Tree trunks are fully burnt only after repeated fires. Thus burnt areas with lots of charred wood appear after single fires and ash material prevails in areas, having suffered two or several fires.

Water in streams (let's rank them type I), draining single fire areas, is characterized with higher mineralization compared to the background areas (Fig. 4). Nitric nitrogen has the highest concentrations compared to other biogenic substances.

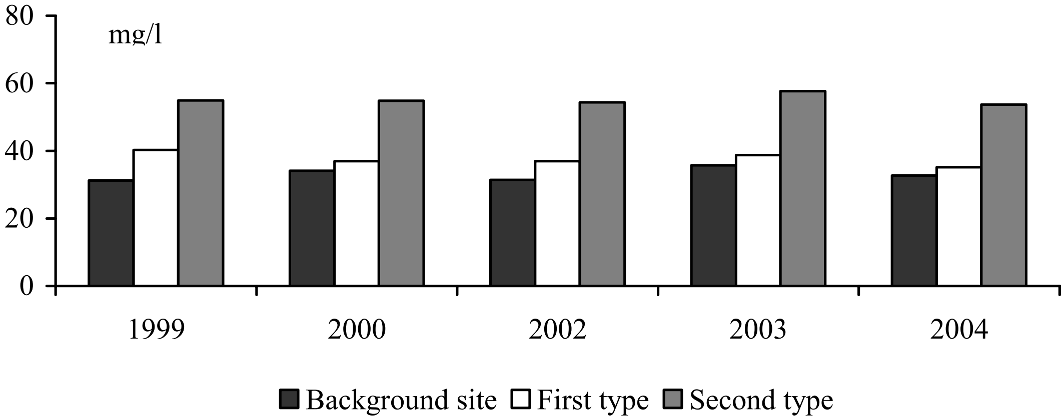


*Fig. 4. Yearly water mineralization of taiga rivers of the Anyui River basin, 1999-2004*

In the first as well as in the sixth year after the fire nitric nitrogen concentrations were more than two times higher in taiga streams compared to background rivers (Fig. 5). The highest nitric nitrogen concentration reached 1.8 mgN/l. Its lowest level was registered in rivers in southeast of British Columbia in the second year after the fire [10]. The increased nitric nitrogen concentrations registered in streams, which drainage area was under the fire, were also reported by other researchers [7, 8, 12].

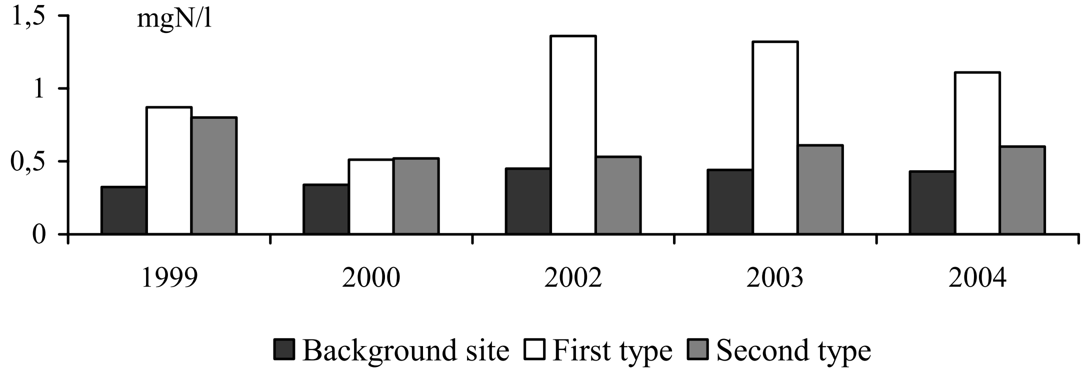


*Fig. 5. Yearly concentration of nitric nitrogen in water of taiga rivers of the Anyui River basin, 1999-2004*

Such significant nitric nitrogen concentrations in taiga streams might be caused by the adsorption of nitrogen compounds from smoked-up air by charred vegetation remnants abundant on the surface of drainage areas. This supposition is proved by multi-year dynamics of this substance (Fig. 6). As a rule, maximum concentrations in taiga streams are registered in dry years, when fires in the Anyui river basin were frequent and there was a lot of smoke in the air. In humid years nitric nitrogen concentrations were 1.2-1.5 times lower as average.

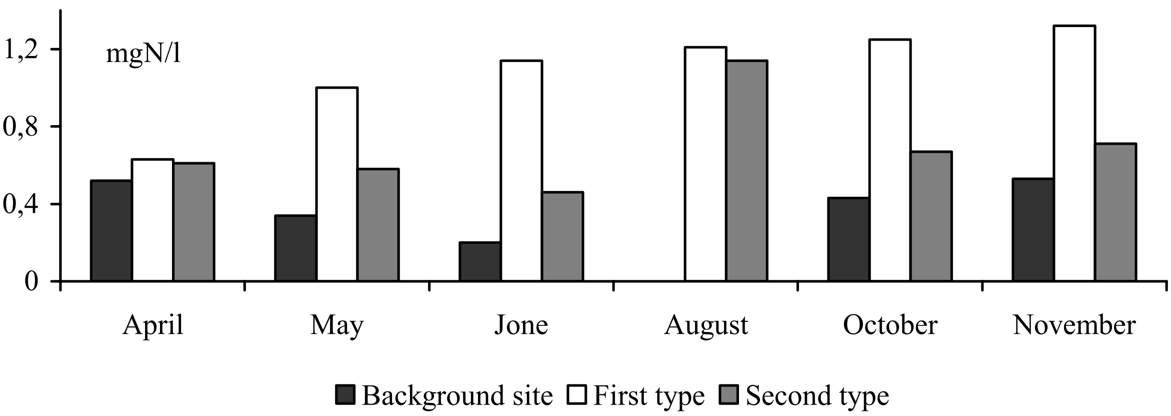


*Fig. 6. Seasonal changes of nitric nitrogen in water of taiga rivers of the Anyui River basin in 2004*

Multi-year average concentrations of ammonia nitrogen, phosphate ions and total Fe in the rivers of this type did not exceed their content in background rivers. Their seasonal dynamics showed no significant changes as well.

In rivers, running through secondary burnt forest (type II) mineralization reaches maximum values mostly due to charred vegetation remnants being burnt (Fig 4). Compared to background site rivers, mineralization here is 1.7 times higher. Phosphate ions showed the highest concentrations, i.e. 2.8 times higher than that one in background area (Fig. 7). The source of consentration increase is ash and charred forest litter, when many substances are washed out with surface runoff in spring snow melting period and during monsoon rains.

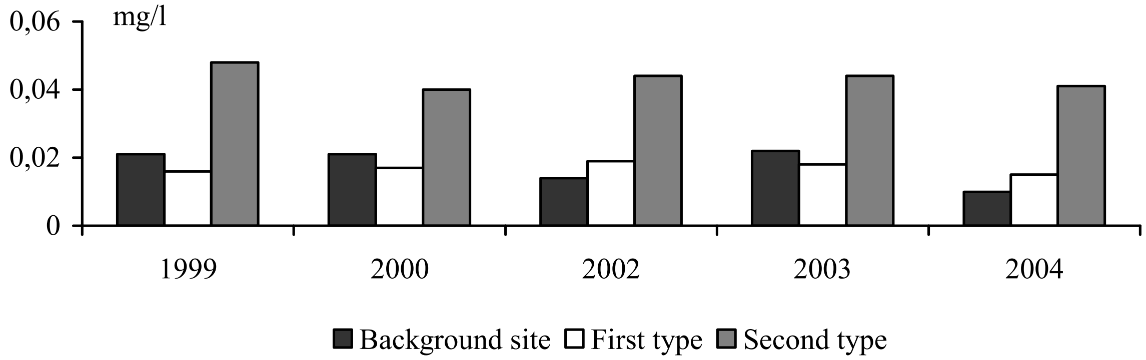


*Fig. 7. Yearly phosphates concentration in water of taiga rivers of the Anyuy River basin, 1999-2004*

American scientists [7], who studied the impact of extensive fires on hydrochemical regime of rivers in the Yellowstone National Park, showed that increased phosphate concentrations in water were observed in 5 years after the fire there. A.R.Tiedemann at all [1978] also reported similar results from studies of a big natural fire impact in the Cascade Mountains in Washington State.

Our data confirm those data. Phosphate content in the second type rivers did not drop lower 0.04 mg/dm. Insignificant seasonal dynamics is a characteristic feature of this river type.

As most of phosphate is bound in various organic substances of organogenic soil horizons and charred forest litter, it would be involved in the geological cycle owing to water runoff into the rivers until natural biogenic flows regenerate. This runoff intensity would gradually decrease and become minimal after vegetation cover is regenerated, ash sources are decreased and phosphate is involved in biological cycle. Studies in Middle Siberia [3] show that pyrogenic factor continues to impact phosphate content in 10-cm upper soil horizon for 4 years after the fire. Phosphate concentrations in water of rivers in various US states were also reported as remaining high in 5 years after the fire [8, 12].

Water in rivers of the both types has high concentrations of nitric nitrogen compared to the background site rivers. As shown in Fig. 4, its seasonal dynamics remain stable.

Concentrations of ammonia nitrogen in water of the second type rivers was maximal only in the first year after the fire. In other years of observation ammonia nitrogen content in streams was insignificant or not registered at all.

Total Fe content in water of the second type rivers was a little higher compared to the background and the first type streams. It is cased by the high role of erosion in Fe flux formation.

Thus concentrations of biogenic substances in water of taiga streams of the Sikhote-Alin Mountain Range vary in a wade range. The highest concentrations of nitric nitrogen are registered in rivers, running through burnt areas, suffered several fires, and maximal mineralization and phosphate ion content were typical to rivers, which drainage areas were burnt twice. Such dynamics of dissolved substances in water of taiga rivers, running through burnt areas reveal that their discharge takes a long time, much depends on concentrations of forest burning products, mostly nitrogen compounds, in the air and their atmospheric transmission from fire disturbed regions.

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