Short communication

ISSN 2658-3518
LIMNOLOGY FRESHWATER BIOLOGY
www.limnolfwbiol.com

The atmosphere above the water area of Lake Baikal during wildfires in the summer of 2019

Khodzher T.V.[1]*, Marinaite I.I.[1], Potyomkin V.L.[1], Zhamsueva G.S.[2], Zayakhanov A.S.[2], Tsydypov V.V.[2], Yakusheva E.P.[3]

[1] *Limnological Institute SB RAS,*
[2] *Institute of Physical Materials Science SB RAS*
[3] *V.E. Zuev Institute of Atmospheric Optics SB RAS*

ABSTRACT. From 24 July to 4 August 2019 onboard the research vessel "Akademik V.A. Koptyug", we conducted comprehensive studies of gas impurities and aerosol in the atmosphere above the water area of Lake Baikal during wildfires that enveloped large areas of Siberia. During the smog above the lake, all analysed parameters in the atmosphere became several times higher. The aerosol content in the atmosphere layer of up to 1000 m above the water area of the lake was three times higher compared to the background values, and we determined the filling of the atmosphere with smoke aerosol to heights of 2.0-2.5 km. Depending on the synoptic and meteorological conditions, the distribution of gas impurities above the lake was rather uneven. The concentration of soot in Southern Baikal was six times higher than the average values in Central and Northern Baikal, and in smoke plumes, it was 25 or more times higher than the background level. 18 PAH compounds also showed a similar distribution pattern where we found a positive correlation with submicron aerosol particles (0.3-1.0 μm). We quantified a dry deposition of impurities from the atmosphere onto the water area of the lake, which is important for the analysis of the composition of the surface Baikal water.

Keywords: wildfires, atmosphere of Lake Baikal, gas impurities, aerosol, soot, PAH

Emissions of smoke aerosol and trace gases from wildfires, whose number is increasing due to climate warming, are one of the significant sources of atmospheric pollution in Siberia, including the Baikal region (Groot et al., 2013). In the summer of 2019, during wildfires that covered large areas of Siberia, the comprehensive studies of gas impurities and aerosol in the atmosphere above the entire water area of Lake Baikal were conducted onboard the research vessel (RV) "Akademik V.A. Koptyug". The measuring equipment used onboard the RV included a LOZA-A2 mobile shipborne lidar and an ECSMETEO acoustic meteorological complex, which are part of the Center for Collective Use "Atmosphere", the 3.02 P-A(O_3), R-310A(NO_x) and S-310A (SO_2) chemiluminescent gas analyzers manufactures by the OPTEK company, a DAS 2702 M diffusion aerosol spectrometer, and a high-volume aerosol sampler.

The atmosphere above the water surface of the lake covers an area of 31500 km^2 and differs substantially at various sites in the composition and nature of the variability of gas and aerosol impurities. At the beginning of the route measurements from 24 to 29 July, the observation site (southwest of Lake Baikal) was under the influence of the low-gradient baric field with reduced pressure. During the formation of a stable air mass in the warm sector of the cyclone, there were high daytime air temperatures. From 28 July to 1 August, during a smog practically throughout Lake Baikal, a relative aerosol concentration in the atmospheric layer of up to 1000 m above the water area of the lake increased and was more than three times higher than background values; the filling of the atmosphere with aerosol was detected to heights of 2.0-2.5 km. A qualitative analysis of continuous measurements of the number concentration of aerosol indicated that the formation of aerosol occurred both directly above the lake and during the introduction from neighbouring areas covered by fires (Qingzhe et al., 2018).

Based on synoptic and meteorological conditions during observations from 24 July to 1 August 2019, we determined both the background concentrations of gas impurities (SO_2, NO_2 and O_3) and their high values during the introduction of polluted air masses from wildfires, industrial complexes of the Baikal region and settlements on lake coast. On 29 July, when the RV passed near the east coast, Sosnovka Bay area in Central Baikal, we recorded the highest SO_2 concentrations, of up to 47 μg/m^3 with the background values of 5-10 μg/m^3, which were caused by the proximity to wildfire sites. During the smoke introduction, the ozone

*Corresponding author.
E-mail address: khodzher@lin.irk.ru (T.V. Khodzher)

Table. Statistical analysis of various types of the soot introduction, M_{BC}, into the water area of Lake Baikal

Types of introduction	Areas	Average M_{BC} ± RMSD, μg/m³	Min	Max	N
Background level	*West coast, from 25 July to 27 July 2019*	0.28 ± 0.09	0.12	0.53	54
	Northeast coast, from 28 July to 29 July 2019	**0.17 ± 0.08**	**0.06**	0.38	40
Anthropogenic impact	*Listvennichny Bay, from 24 July to 25 July 2019, 3 August 2019*	0.59 ± 0.25	0.18	1.06	19
	Baikalsk town, 25 July, 03 August 2019	0.93 ± 0.26	0.59	1.54	18
	Slyudyanka town, 25 July 2019	1.08 ± 0.43	0.55	1.61	5
Wildfires	*Severobaikalsk town, Nizhneangarsk town, 28 July 2019*	1.09 ± 0.38	0.47	2.16	41
	Chivyrkuy Bay – Barguzin Bay – the Turka settlement – the Selenga River delta from 29 July to 1 August 2019	**4.17 ± 0.83**	2.46	**6.33**	104

concentrations decreased to 20 μg/m³, and nitrogen oxides were below the detection limit, with the average background values of 3-7 μg/m³.

The concentrations of soot were approximately six times higher in the atmosphere of Southern Baikal having a developed anthropogenic activity on its coast than the average values in Central and Northern Baikal. The mass concentration in smoke plumes from fires was 25 times higher than the background level, and in some measurements – more than 100 times higher. Thus, the concentration of soot in the atmospheric near-water layer close to the fire site in the area of Sosnovka Bay reached 5 ÷ 6 μg/m³ with the background values of 100 ÷ 200 ng/m³. Table shows the average values of the soot concentrations above the water area of the lake during the cruise, depending on the study area.

Among 18 polyaromatic hydrocarbons (PAHs) detected in the atmosphere above Lake Baikal, fluoranthene, pyrene, benzo(b)fluoranthene, and benzo(k)fluoranthene showed high concentrations. Along the northwest coast, we determined the background total values of PAHs (0.11-0.22 ng/m³). Elevated concentrations (0.41-1.2 ng/m³) were observed in areas subject to anthropogenic impact (near the Listvyanka settlement, the Baikalsk town and the Slyudyanka town). The maximum values of PAHs (0.99-4.6 ng/m³), as well as soot, we recorded from 28 July to 1 August 2019 in smoke plumes on the east coast of Northern and Central Baikal. There was a positive correlation between the concentrations of the total PAHs and submicron aerosol particles (0.3-1.0 μm).

Based on the obtained results, we quantified the dry deposition of various impurities from the atmosphere onto the water area of the lake, which is important for analyzing a potential impact on the composition of the Baikal surface waters.

The study was carried out within the framework of the Russian Science Foundation grant No. 19-77-20058.

References

Groot W. J., Flannigan M. D., Cantin A. S. 2013. Climate change impacts on future boreal fire regimes. Forest Ecology and Management 294: 35-44. DOI: 10.1016/j.foreco.2012.09.027

Qingzhe Zh., Liu Yu., Jia R. et al. 2018. A numerical simulation study on the impact of smoke aerosols from Russian forest fires on the air pollution over Asia. Atmospheric Environment 182. DOI: 10.1016/j.atmosenv.2018.03.052