Short communication

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Ship borne studies of the distribution of PAHs and PM10 in the near-water atmospheric layer of Lake Baikal in the summer of 2016-2017

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ABSTRACT. This work discusses the results of shipborne studies concerning the spatial distribution of PAHs and aerosol particles in the near-water atmospheric layer of Lake Baikal in July 2016-2017. We observed high concentrations of polluting components near the local sourceson the coast of the lake as well as in smoke plumes from wildfires. The low PAH concentrations recorded in 2017in the absence of wildfires were comparable with those of 2002 and 2008. Using the backward trajectory models, we traced air mass movements from the pollution sources to the lake.

Keywords: PAHs, aerosol particles,Lake Baikal

At present, it is important to study the influx of PAHs and aerosol particles through the atmosphere to the surface of Lake Baikal. According to air quality standards in Russia, the daily average concentration of benzo(a)pyrene and aerosol particles should not exceed 1 ng/m^3 and 60 μg/m^3, respectively. From 19 to 30 July 2016 and from 14 to 23 July 2017, 22-34 aerosol samples were collected throughout the water area of Lake Baikal from the board of the research vessel “G. Titov”. The quantitative determination of PAHs in aerosols was carried out by chromatography-mass-spectrometry. Particle count was measured in the size range from 0.3 to 10 μm using a Handheld 3016 IAQ counter, and the mass concentration of particles was calculated. To estimate the spatial extent of the aerosol transport to the lake, a series of detailed calculations was performed using the HYSPLIT model.

We determined the spatial and interannual dynamics of PAHs and PM_{10}in the near-water atmospheric layer of Lake Baikal (Table). The high concentration of PAHs was observed in the southern basin of the lake under conditions of calm and removal of the coastal aerosol from the local sources of the coast near the settlements of Kultuk (0.5 ng/m^3), Tankhoy (0.55-1.3 ng/m^3), Baikalsk (8.7 ng/m^3) as well as near the Selenga shallow waters (0.84 ng/m^3). The maximum values of PAHs were recorded along the west coast, from the Listvyanka settlement to the OlkhonskiyeVorota Strait (40-133 ng/m^3), during the smoke aerosol from wildfires. Maps of backward trajectories of air mass movement to the study area and sites of wildfires in the Irkutsk Region confirm this trend (Fig.).

Among the 18 detected PAHs, naphthalene and phenanthrene had the highest concentration (from 20 to 80%). The total amount of fluoranthene and pyrene, the dominant components of biomass combustion, reached 20-50% of the total mass of the detected compounds, which published data confirm (Wentworth et al., 2018).

In the interannual aspect, the highest PAH concentrations were during wildfires in 2016. Thus, in July 2016, approximately 1 million hectares of taiga burnt in hardly accessible areas of the Krasnoyarsk Krai (Evenkia) and the Irkutsk Region. Wildfires caused smog in Irkutsk, Ust-Ilimsk, Bratsk as well as above the water area of Lake Baikal. In the summer of 2017, in the absence of wildfires, PAH concentrations in the near-water atmospheric layer of Lake Baikal were low and close to the values of 2002 (0.05-1.5 ng/m^3, average 0.28 ng/m^3 (Balin et al., 2007)) and 2008 (0.055-1.4 ng/m^3, average 1.1 ng/m^3 (Golobokova et al., 2011)).

The obtained distribution patterns of PAH concentrations in the near-water aerosol are similar to the PM_{10} distribution (Table). Correlation relationships between the concentrations of PAHs and aerosol particlesconfirmconsistency in their changes.PAHs have significant coefficients of pairwise correlation (0.54-0.6) with submicron particles having diameters of 0.3-1.0 μm.

Based on the 2016-2017 studies, we identified spatial and temporal heterogeneity in the distribution of PAHs and PM_{10} in the near-water atmospheric layer of Lake Baikal. We observed increased concentrations in the vicinity of the anthropogenic sources near settlements and during the smoke plumes from wildfires above the water area of the lake with a six-fold excess

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Table. Minimum and maximum concentrations of PM_{10} (μg/m^3) and PAHs (ng/m^3) in the atmosphere above the water area of Lake Baikal in the summer of 2016-2017.

PAHs/year	2016	2017
Naphthalene	0.11-34	<0.005
Acenaphthylene	<0.005- 2.0	<0.005
Acenaphtene	0.01-10	<0.005
Fluorene	0.01-14	<0.005
Fhenanthrene	0.03-36	0.06-0.6
Anthracene	<0.005	<0.005-0.03
Fluoranthene	0.01-7.5	0.05-0.20
Pyrene	0.01-10.2	0.03-0.3
Benzo[a]anthracene	<0.005-1.5	<0.005-0.03
Chrysene	0.01-3.1	<0.005-0.06
Benzo[b]fluoranthene	0.01-14	<0.005-0.27
Benzo[k]fluoranthene	<0.005-5.0	<0.005-0.067
Benzo[e]pyrene	<0.005	<0.005-0.1
Benzo[a]pyrene	<0.005-6.0	<0.005-0.31
Perylene	<0.005	<0.005
Indeno[1,2,3-c,d]pyrene	<0.005	<0.005
Benzo[g,h,i]perylene	<0.005	<0.005
Dibenzo[a,h]anthracene	<0.005	<0.005
Total PAHs	0.22-133	0.19-1.2
PM_{10}	7.0-40	1.0-5.0

ofthe maximum permissible concentration for benzo(a) pyrene. The results obtained in the summer of 2017, in the absence of wildfires, were close to the background values of 2002 and 2008. The PM_{10} mass concentrations did not exceed air quality standards.

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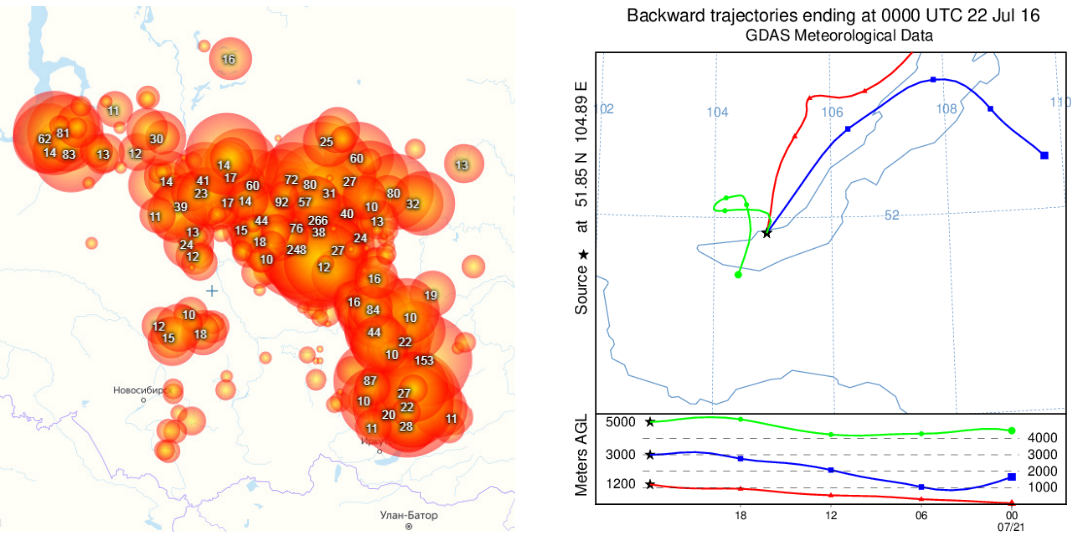

Fig. Map of the number of wildfiresites in the Irkutsk Region and backward trajectories of air mass transport to the west coast of Lake Baikal on 22 July 2016.