Simulation of accumulation of polycyclic aromatic hydrocarbons on the underlying surface in the Southern Baikal region

V.K. Arguchintsev and V.L. Makukhin

Irkutsk State University
Limnology Institute, Siberian Branch of the Russian Academy of Sciences, Irkutsk

Received February 9, 2000

Accumulation of hydrocarbons on the underlying surface in the Southern Baikal region is evaluated by numerical experiments for different seasons.

Polycyclic aromatic hydrocarbons (PAH's) are included in the list of the most important pollutants, first of all, due to their carcinogenic properties.[1] Processes of their spread, transformation, and sedimentation are studied by different methods. Analysis of snow cover samples by the method of high performance liquid chromatography was applied to estimate the level of PAH pollution at the southern shore of the Lake Baikal.[1] The daily mean background concentrations of benz(a)pyrene in Novosibirsk Akademgorodok and its suburbs were determined by the method of low-temperature selective fluorescence and by mathematical simulation on the basis of solution of the inverse problem, i.e., determination of unknown intensities of emission from concentrations measured at different points.[2] The same model was used to reconstruct the fields of specific benz(a)pyrene concentrations near Belovo power plant and Novosibirsk capacitor plant.[3]

In this paper, we study the processes of PAH spread in the Southern Baikal region for some periods several months or a season long by the use of numerical solution of the non-stationary spatial semiempirical equation of turbulent diffusion.[4] The model was earlier applied to calculate concentration fields of sum hydrocarbons at typical meteorological situations in the Southern Baikal region.[5]

We considered the spread of different PAH's emitted by stationary sources and motor cars in the Irkutsk-Cheremkhovo industrial area, Slyudyanka, Baikal'sk, Kamensk, Selenginsk, Ulan-Ude, and Gusinoozersk. The mass PAH flow was estimated on the basis of Refs. 6–11. Statistical characteristics of the wind field used in calculations were obtained in processing of long-term observations on the wind velocity vector.[12,13]

The density of the mass PAH flow was calculated for the area of 500×250 km^2 and 3 km in height above the Lake Baikal surface. The time and horizontal steps were 150 s and 5 km, respectively; the vertical step was set as follows: 20 m up to the height of 300 m, then 200, 500, 800, and 1200 m. The turbulent diffusion coefficients were calculated using equations of the semiempirical theory of turbulence.[5]

Accumulation of PAH's on the underlying surface was numerically simulated for every month. To compare the calculated results with the available experimental data on PAH accumulation in the snow cover, a numerical experiment was performed. The experiment characterized the distribution of the density of the mass PAH flow for the period of snow cover (150 days). The model-derived values of the flow rates turned out to be of the same order of magnitude as the measured ones[1,10] except for the region of Tankhoi where the calculated values were considerably less than the measured ones. This seems to be connected with ignoring of local sources. The mass of PAH's falling onto the surface of Southern Baikal having the area of 9000 km^2 was determined; it proved to be 280 kg.

We studied the annual accumulation of PAH's of 11 kinds constituting about 98% of the whole PAH mass emitted at combustion of organic fuel of different type.[10] Figure 1 shows the distribution of the calculated mass flow rate of the above-mentioned pollutants. The flow rate has maximum values near the sources of emission. The mass of aromatic hydrocarbons settled onto the surface of Southern Baikal per year turned out to be 400 kg.

The estimated contributions of separate groups of plants in pollution of the Lake Baikal are given in the Table 1.

Table 1

Group of plants	Relative contribution, %	
	For period of snow cover	For year
Irkutsk–Shelekhov	1.5	3
Slyudyanka	84	83
Baikal'sk	7	8
Selenginsk–Kamensk	7.5	6

Thus, Slyudyanka plants make the main contribution to pollution of the Lake Baikal; it is almost five times higher than the sum contribution of other sources.

0235-6880/00/06–07 584-02 $02.00

Fig. 1. Isolines of calculated mass flow rate of eleven PAH's, in mg/(m^2·year).

Acknowledgments

The work has been supported by the Russian Foundation for Basic Research (Project No. 98–05–64021) and the Russian Ministry of Education (Grant No. 97–0–13.3–12).

References

1. A.G. Gorshkov, I.I. Marinaite, V.A. Obolkin, et al., Atmos. Oceanic Opt. **11**, No. 8, 780–784 (1998).
2. V.N. Makarov, Yu.N. Samsonov, V.V. Korolev, and V.F. Raputa, Atmos. Oceanic Opt. **9**, No. 6, 532–535 (1996).
3. V.F. Raputa, A.P. Sadovskii, S.E. Ol'kin, et al., Atmos. Oceanic Opt. **12**, No. 6, 521–524 (1999).
4. V.K. Arguchintsev and V.L. Makukhin, Atmos. Oceanic Opt. **9,** No. 6, 509–516 (1996).
5. V.K. Arguchintsev and V.L. Makukhin, Atmos. Oceanic Opt. **12,** No. 6, 525–527 (1999).
6. Yu.N. Udodov, ed., *State Report on the Environment of Irkutsk Region in 1996* (State Committee on Environmental Protection of Irkutsk Region, Irkutsk, 1997), 231 pp.
7. Yu.N. Udodov et al., eds., *State Report on the Environment of Irkutsk Region in 1995* (State Committee on Environmental Protection of Irkutsk Region, Irkutsk, 1996), 131 pp.
8. A.L. Malevskii, ed., *State Report. Ecological Situation in Irkutsk Region in 1994* (Irkutsk Regional Committee on Environmental Protection and Natural Resources, Irkutsk, 1995), 198 pp.
9. *Ecological Situation in Irkutsk Region in 1994. Annual Report* (Irkutsk Regional Committee on Environmental Protection and Natural Resources, Irkutsk, 1994), 204 pp.
10. A.R. Suzdorf, S.V. Morozov, L.I. Kuzubova, et al., Khimiya v Interesakh Ustoichivogo Razvitiya **2**, No. 2–3, 511–540 (1994).
11. S.P. Filippov, P.P. Pavlov, A.V. Keiko, et al., "*Ecological Characteristics of Low-Power Heat Sources,*" Preprint No. 5, ISEM RAN, Irkutsk (1999), 48 pp.
12. Meteorological Monthly. Novosibirsk 1985–1994, No. 22, part 2.
13. Meteorological Monthly. Chita 1985–1994, No. 23, part 2.