MEASUREMENT OF SURFACE CONCENTRATION OF GASEOUS POLLUTANT IN THE ULAN-UDE CITY

A.S. Zayakhanov, G.S. Zhamsueva, Yu.L. Lomukhin, V.P. Butukhanov, and G.E. Barannikov

Buryatiya Institute of Natural Sciences, Siberian Branch of the Russian Academy of Sciences, Ulan-Ude

Received December 19, 1997

Presented are the data on influence of meteorological factors upon the processes of atmospheric pollutant spread and transfer in the Ulan-Ude city. The generalized pattern of formation of the field of air pollution with the carbon oxide from the moving emission source – motor transport – is presented.

In development and implementation of the optimal system for routine monitoring of air basin of a specific local area (industrial center, region), of great importance are preliminary data on peculiarities of formation of pollution fields with pollutants typical of a given region, as well as revealing of relations between levels of pollution concentration in the surface atmospheric layer and the meteorological parameters.[1–4]

This paper presents the preliminary stage on implementation of the system for routine monitoring of air basin in the Baikal region. Earlier, in Ref. 5, we presented the results of experimental study of atmospheric air pollution with sulfur dioxide and carbon oxide and noted some peculiarities of temperature inversion formation in the surface 100-m atmospheric layer over the Ulan-Ude city.

This paper analyzes the results of simultaneous measurements of spatio-temporal changes of gaseous pollutant concentrations, temperature distribution, and wind velocity and direction in the city atmosphere.

MEASUREMENT EQUIPMENT AND TECHNIQUE

To perform route and under-plume observations over the level of atmospheric air pollution, the mobile ecologo-meteorological station was equipped with the gas analyzers: "Palladii–3" for monitoring over carbon oxide (CO), "Sulfur dioxide mod. 8850 analyzerB for observation over the content of sulfur dioxide (SO_2), the measurement-computational complex based on microcomputer "Vesta IK–30," and the meteorological complex. Technical characteristics of the recording-measurement complex are presented in Ref. 5.

To organize monitoring of temperature inversions, 100-m high TV mast situated in the center of Ulan-Ude was used.

Content of gaseous pollutants was studied in two directions: continuous recording of pollutant (carbon oxide and sulfur dioxide) in the city atmosphere at the stationary post and monitoring of the spatio-temporal distribution of gaseous pollutant concentration levels with the mobile complex in different city areas.

MEASUREMENT RESULTS

Power plants TETs–1 and TETs–2 and motor transport are the main pollution sources in the amount of emissions and the total contribution into air pollution in Ulan-Ude. The main components emitted into the atmosphere in combustion of different fuel in power plants and internal combustion engines are carbon oxide (CO), nitrogen oxides (NO_x), and sulfur dioxide (SO_2), soot, hydrocarbons, and other pollutants. Among gaseous substances, sulfur dioxide, carbon oxide, and nitrogen oxides account for a greatest amount of pollutants.

Sulfur dioxide. Sulfur dioxide content in the atmospheric air in Ulan-Ude is mainly determined by emission from TETs–1. TETs–2 power plants have practically no influence on the level of SO_2 concentration, because they are situated far apart from the city and the dominating wind rose prevents the pollution transfer to the city.

SO_2 concentration in the city was monitored at the stationary station located in the building of the Buryatiya Scientific Center, SB RAS. At this point, the influence of emissions from TETs–1 is minimum, and the obtained data can be considered as values of the surface SO_2 concentration averaged over the city.

It follows from observations performed at the stationary station that in summer and fall months the level of SO_2 concentration did not exceed the maximum permissible value. The only exception is the period from May 21 to 31, when the elevated SO_2 concentration was observed caused by influence of forest fires. Meteorological conditions at that period also favor the elevated content of harmful pollutants in the atmosphere. One of the main factors directly affecting the processes of pollutant transfer and spread in the atmosphere is wind velocity and direction.

0235-6880/98/07 637-04 $02.00

Figure 1*a* shows the diurnal behavior of SO_2 concentration recorded on May 27. Figures 1*b* and *c* demonstrate the wind velocity and air temperature distribution for the observation period. One can see from the figures that elevated SO_2 concentration is observed at daytime at weak wind. It can be explained by the fact that with decreasing wind velocity the processes of pollutant spread in the atmosphere slow down and accumulation of harmful substances takes place.

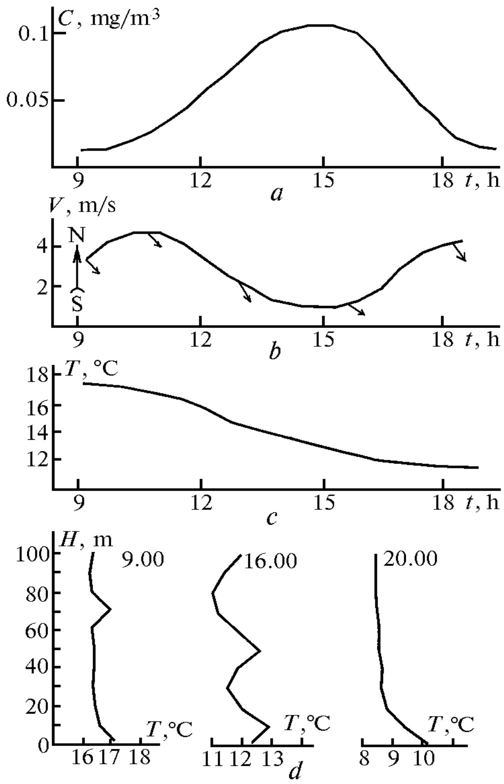

FIG .1. Diurnal dependence: SO_2 *concentration (a), wind direction and velocity (b), air temperature (c), vertical temperature distribution in the* 100-m *layer (d).*

Surface temperature inversions have strong enough effect upon the level of pollutant concentration in the atmosphere. Figure 1*d* demonstrates vertical profiles of air temperature in the 100-m layer at different time. Inversion with insignificant amplitude manifests itself at daytime at calm weather. This circumstance is one of the main reasons of high SO_2 concentration at this time.

Temperature inversions are most often observed in winter season at calm weather.[3] Figure 2 shows the experimental distribution curves of SO_2 concentration obtained for the period from 9:00 a.m. to 12:00 p.m. of December 24, 1996. Distribution of SO_2 concentration at different time tends to increase in fluctuations in evening and night hours. Just in this period temperature inversions are most probable. Unfortunately, the measurement data on vertical temperature distribution in Ulan-Ude atmosphere in winter are absent.

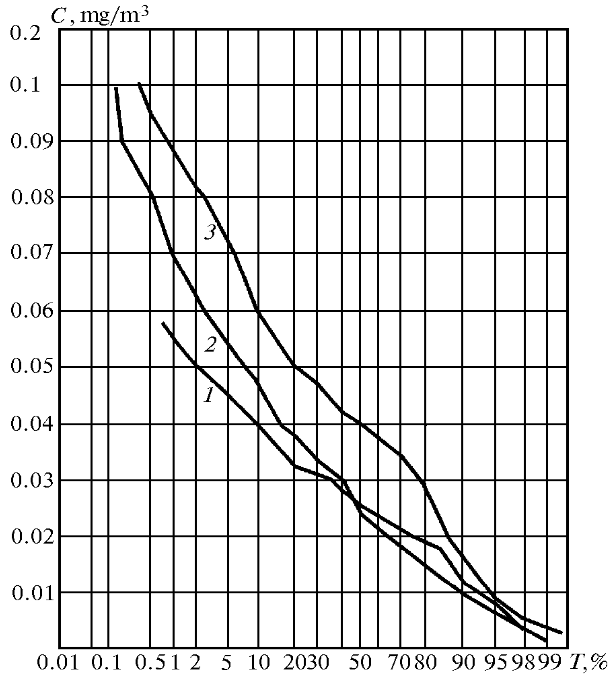

FIG. 2. Integral functions of SO_2 *concentration distribution at different time:* 9:00 a.m. − 12:00 a.m. *(1),* 2:00 p.m. − 5:00 p.m. *(2),* 9:00 p.m. − 12:00 p.m. *(3).*

Carbon oxide. To estimate the general state of surface air pollution with carbon oxide in Ulan-Ude, air was sampled at 20 different points distributed uniformly enough over the city territory. These points were situated at crosses of main roads, in micro-districts, and in under-plume zones. In addition, route measurements of the concentration level of gaseous pollutants were performed in the vicinity of these points. When measuring CO concentration at motorways, traffic intensity was estimated by counting up motor vehicles during 30 minutes and the movement direction was noted. Observations were performed in the period of most intense traffic − in daytime. Meteorological conditions in the measurement period were characterized by calm weather.

Observations have shown that the main source of CO emission in Ulan-Ude is motor transport.

The map of city territory pollution with carbon oxide was constructed on the base of measurement results (Fig. 3). As seen from the figure, maximums of CO concentration correspond to the cross points of main roads.

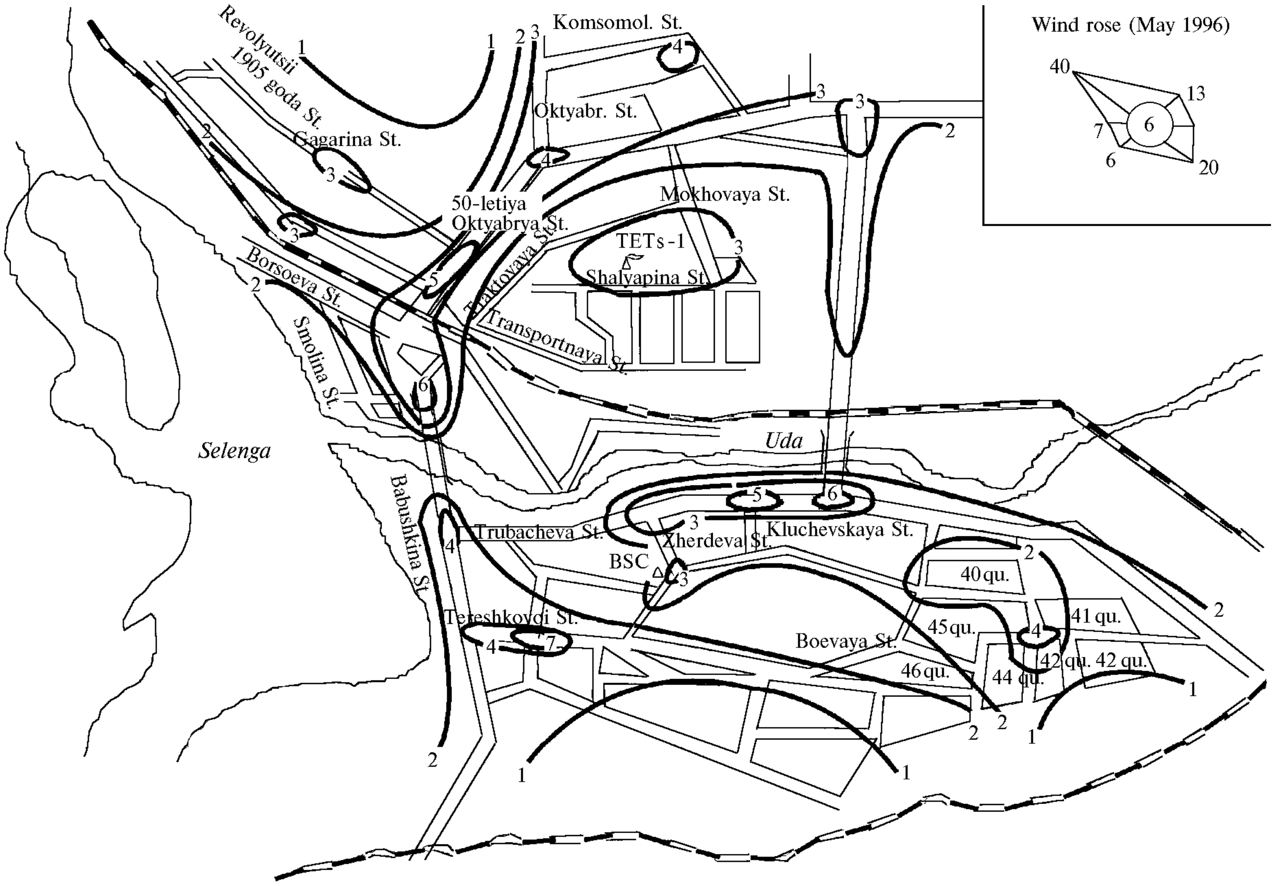

FIG. 3. Distribution of carbon oxide concentration in Ulan-Ude (mg/m^3).

Direct dependence between traffic intensity on roads and CO concentration is observed.

Diurnal behavior. To reveal the diurnal behavior of CO surface concentration, it was continuously measured during two weeks at the stationary station located 30 m far from motorway.

Peculiarity of CO concentration variation in working day is its increase in the morning with maximum observed in the period of most intense traffic. In weekend, the concentration is far lower and changes only slightly during a day. Thus, motor transport as the main source of CO pollution has a significant effect on the character of carbon oxide concentration variation.

It should be also noted that days were observed with CO concentration growth in day hours (11:00 a.m. – 4:00 p.m.), in particular, during moist snow falling, although traffic at this time was significantly decreased. Precipitation completion was accompanied by decrease of CO concentration. Such sharp changes in carbon oxide content in the surface air layer are associated with decrease in intensity of turbulent mixture in the boundary layer attenuating the vertical pollutant transfer (Fig. 4). Maximum of CO concentration in the period from 11:00 p.m. to 02:00 a.m. is likely cause by presence of temperature inversion. CO concentration at this time exceeds the level of daytime values. This example indicates that the level of surface concentration is significantly influenced by temperature stratification even at low intensity of motor transport emissions.

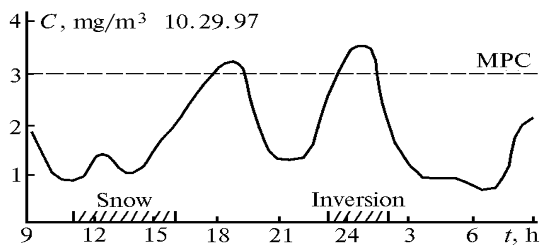

FIG. 4. Diurnal behavior of carbon oxide concentration.

CONCLUSION

This paper presents qualitative data on SO_2 and CO concentration in the atmosphere of the Ulan-Ude city situated at the Baikal region. Significant correlation between surface concentration of gaseous pollutants and precipitation, wind velocity and direction, and temperature inversion was noted. Distribution of carbon oxide emissions over the city territory was estimated.

This study is preliminary and has to be worked out in detail.

ACKNOWLEDGMENT

This work was partially supported by the Russian Foundation for Basic Researches (Grant No. 97-05-96449) and the Ecological Foundation of the Buryatiya Republic.

REFERENCES

1. Yu.S. Balin, B.D. Belan, A.I. Nadeev, and M.V.Panchenko, Atmos. Oceanic Opt. **7**, No. 2, 86–92 (1994).
2. E.Yu. Bezuglaya, G.P. Rastorguev, and I.V. Smirnova, *What Does the Industrial City Breathe*? (Gidrometeoizdat, Leningrad, 1991), 256 pp.
3. E.Yu. Bezuglaya, *Meteorological Potential and Climatic Peculiarities of Air Pollution in Cities* (Gidrometeoizdat, Leningrad, 1980), 184 pp.
4. E.I. Grechko, V.S. Rakitin, E.V. Fokeeva, et al., Izv. RAN, Fiz. Atmos. Okeana 29, No. 1, 11–18 (1993).
5. G.S. Zhamsueva, A.S. Zayakhanov, Yu.L. Lomukhin, et al., Atmos. Oceanic Opt. 10, No. 2, 126–128 (1997).