STUDY OF DYNAMICS OF ATMOSPHERIC POLLUTION BY SO_2 AND CO OVER THE CITY OF ULAN-UDE

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

Buryat Institute of Natural Sciences
Siberian Branch of the Russian Academy of Sciences, Ulan-Ude
Received November 10, 1996

We describe in this paper some results of experimental investigations of the atmospheric pollution by sulfur dioxide and carbon monoxide over the city of Ulan-Ude. The pollution level in the urban atmosphere is found to be rather high. The temperature stratification of the low atmosphere is studied using a mast of 100 m *height.*

INTRODUCTION

When investigating the state of the atmosphere of special interest is the study of the spatiotemporal behavior of meteorological quantities and gas components of the air over a long period of time. In accordance with the program of complex survey of the state of the environment of the Baikal region the experimental investigations of atmospheric pollution by sulfur dioxide and carbon monoxide over the city of Ulan-Ude have been performed using a mobile ecological-meteorological station.

METEOROLOGICAL PECULIARITIES OF THE BAIKAL REGION

The city of Ulan-Ude is located in the area of a very low ventilation power of the atmosphere. The main pollution sources are the heat electric power plants, factories and plants, boilers burning solid fuel. The amount of emissions from industrial enterprises in Ulan-Ude is not so big as compared with that in the other big cities. However, industrial emissions are observed at low altitudes, and they are poorly dispersed under given meteorological conditions.[1]

It is known that the main factors contributing to the pollution accumulation in the atmospheric boundary layer are the calm and the temperature inversions. In the range of temperature inversions the turbulent exchange is greatly reduced that results in the formation of a screening layer and to the aerosol accumulation first in the inversion area and then in the surface layer. Thus the prompt forecast of atmospheric pollution is closely related to early detection of temperature inversions. It was found that in the presence of inversions the impurity concentration level in the surface layer is by 10–60 percent greater than in the absence of inversions.

For monitoring temperature inversions we used TV mast of 100 m height, located at the center of Ulan-Ude.

Measurements of vertical distribution of meteorological quantities have shown that in summer season we can observe all the three types of temperature variation with height determining the impurity dispersal, namely, ground inversion of temperature, elevated inversion, and temperature drop with height.

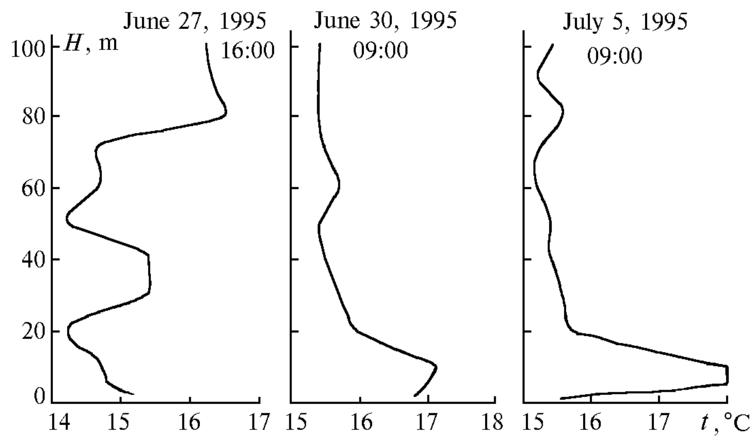

FIG. 1. Vertical temperature profiles.

0235-6880/97/02 126-03 $02.00

Figure 1 shows vertical profiles of temperature taken from the observations made in Ulan-Ude. Figure 1 indicates that there is a temperature inversion in the lower surface layer at 9:00 AM. In this case the temperature inversion is also observed in a higher atmospheric layer with lower depth. In the daytime the elevated temperature inversions of different intensity are observed at different altitudes.

EQUIPMENT AND MEASUREMENT PROCEDURE

The carbon monoxide content in the air was determined by means of a gas analyzer "Palladii-3"; the sulfur anhydride content was measured by means of an American gas analyzer "Sulfur dioxide mod. 8850 analyzer" in the operating mode of continuous recording of spatial and temporal variations of species under study.

The investigation of space-time characteristics of the atmospheric pollution calls for accumulation and processing of significant data arrays on pollutant concentration at different points of space. To solve this problem an autonomous mobile fast operating complex of the instrumentation is necessary together with an effective computational potentialities.

For this purpose we used a measuring-computational complex based on a microcomputer "Vesta IK-30" having: 64 kB RAM and 48 kB of user's RAM; the capacity of ROM is 16 kB; the operation speed (register-to-register) is 0.9 mln. op./s.

To control the recording of CO and SO_2 concentration levels a recorder N-320-3 with a d.c. amplifier was connected to analog outputs of the gas analyzer "Palladii-3" and "Sulfur dioxide mod.8850 analyzer".

MEASUREMENT RESULTS

Sulfur dioxide. The level of air pollution by sulfur dioxide is formed due to the action of natural and anthropogenic sources. The anthropogenic activity has resulted in the industrial sulfur emissions in the atmosphere mostly as SO_2.[2,3]

The location of the heating power station (HPS-1) in the center of Ulan-Ude has motivated a considerable accumulation of sulfur at the territory of the city. In particular, we have discovered that the daily mean concentration of sulfur dioxide is 0.15 mg/m^3 (3 times higher than maximum permissible concentration) using mobile and subplume measurements of sulfur dioxide concentrations performed at distances to 3, 10, 15, and 20 stack heights. The Table I gives the data of sulfur dioxide maximum concentrations during a week in spring of 1995. As follows from the table, the increased values of the maximum peak sulfur dioxide concentrations up to 0.286 mg/m^3 are observed due to low wind velocities (2–4 m/s).

TABLE I.

Date	April 30	May 2	May 3	May 4	May 5	May 7	May 12
SO_2, mg/m^3	0.143	0.228	0.086	0.172	0.286	0.029	0.114

Figure 2 shows the diagram of hourly mean SO_2 variations obtained during subplume measurements. As expected, the largest SO_2 concentrations were observed in the subplume areas of the heat electric power plant-1 (HEPP-1). As the SO_2 measurements showed, a sharp increase of SO_2 concentration in the air was observed if the plume from HEPP-1 was blown toward the gas analyzer (up to 0.286 mg/m^3), and a sharp decrease of SO_2 concentration was observed (up to 0.06 mg/m^3) if the plume was blown away from a gas analyzer at an angle of 90°.

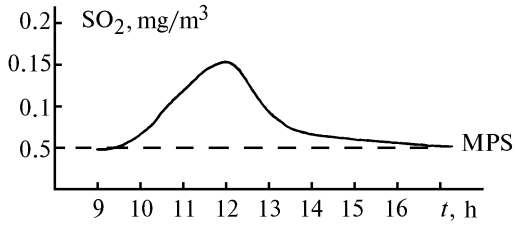

FIG. 2. Hourly mean SO_2 *variations.*

Carbon monoxide. The background of atmospheric pollution in Ulan-Ude is mainly produced by industrial emissions from big pollution sources such as HEPP-1 and motor transport. The contribution of HEPP-1 to CO atmospheric pollution is very large as is shown by the mobile and subplume observations of CO content in the area of HEPP-1. The stack plume of the emissions from HEPP-1 are observed based on visual boundaries of the emission plumes. The air sampling was carried out along the wind direction at different distances from the emission source. The air sampling is also made to control the measurements from a windward side at some distance from the source. The measurements were carried out under various weather conditions at 1.5–2 m height during 6 to 10 hours at different distances from an emission source using known technique.

The mean surface CO concentrations under the plume at distances of 3, 10, 15, and 20 stack heights were C_{CO} = 20; 19; 10; 9 mg/m^3, respectively.

When an observation point is shifted normally to the direction of the smoke plume spread at distances of 100 or 200 m the CO concentration decreases sharply up to the background (mean) urban levels of 2–3 mg/m^3.

At present the motor transport exhausts are the main pollution sources in the cities. The control of motor transport exhausts is of great importance since the exhaust gases are immediately inhaled by men being only weakly diluted in the atmosphere.

To estimate the atmospheric CO pollution level from motor transport, the measurements were carried out along the main roads of Ulan-Ude, where the exhaust gas pollution was enhanced. The points of measurements were selected along the city avenues with a heavy traffic, at traffic light points, near the crosses. The maximum peak CO concentrations and mean values of CO concentration levels were determined from the measurement data at every observation point. The maximum CO pollutions were observed in the area of central market, the most busy area of the city. Maximum values of CO content in the atmosphere during the measurements were 48 mg/m^3.

Figure 3 shows the integral distributions of CO concentration at different crosses. Differences in the distributions characterize the dependence of CO concentration distribution on the intensity of the traffic.

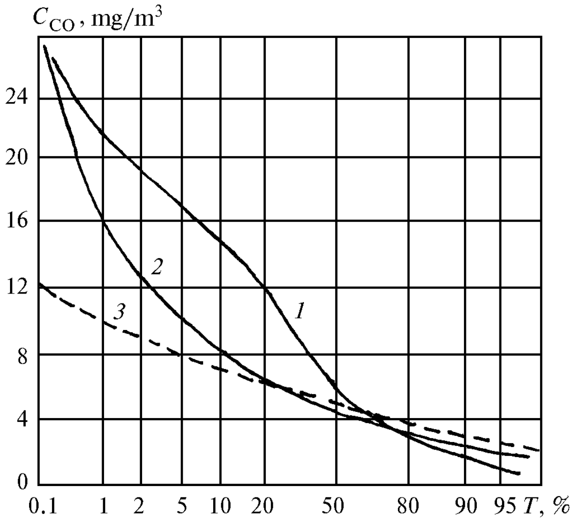

FIG. 3. Integral distributions of CO *concentration at different crosses.*

The investigations revealed that the CO concentration maximum from the motor transport exhausts was observed on the main road. When moving away from the side of the road the measurements revealed a decrease of the CO concentration and the levels of 2–3 mg/m^3 were obtained at distances of 20–30 m.

The CO concentration distribution along the main road was also nonuniform. Figure 4 shows the CO concentration distribution when moving away from the cross along the main road. Figure 4 shows the decrease of the mean CO concentration and the intensity of individual exhausts.

The diurnal behavior of CO concentration was investigated at two points where continuous measurements were made during 24 hours: in a housing estate far from the main pollution sources and in a building located at a distance of 20 to 30 m from a cross.

The amplitude of variation of CO concentration levels in the housing estate varied within the limits of 1–3 mg/m^3. Near the road diurnal behavior of CO content is quite evident. Most often the CO concentration increase was observed in the morning and at night (Fig. 5). This confirms the fact that the atmospheric CO pollution was of local origin connected with the motor transport. The CO concentration maximum in the morning was evidently due to the motor transport activity, because the transport with poorly warmed up motors started its work that resulted in emission of unburned gases. The night maximum is, in our opinion, caused by a gas sink from the above air layers when the turbulence mixing intensity is minimal.

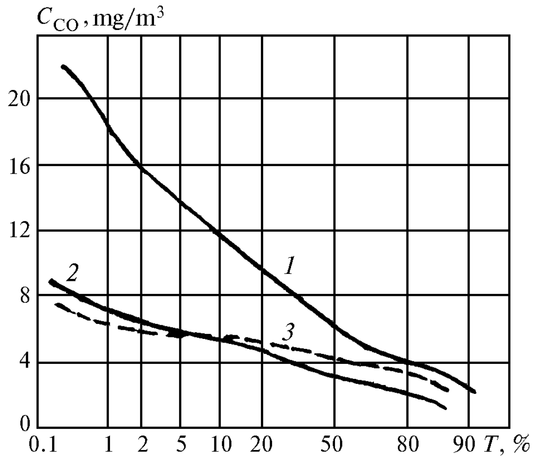

FIG. 4. CO *concentration distributions.*

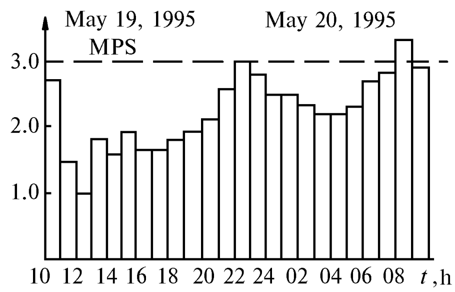

FIG. 5. The daily dependence of CO *concentration.*

The investigations carried out present a new stage in the work on introducing an automated system for monitoring the air of "Gorod" type owing to the support of State Ecological Committee of BR.

REFERENCES

1. B.P. Alisov, *Climate of the USSR* (State University, Moscow, 1956), 128 pp.
2. E.Yu. Bezuglaya, G.P. Rastorgueva, and I.V. Smirnova, *Urban Industrial Emissions* (Gidrometeoizdat, Leningrad, 1991), 256 pp.
3. E.Yu. Bezuglaya, *Meteorological Potential and Climatic Peculiarities of Urban Industrial Pollution* (Gidrometeoizdat, Leningrad, 1980), 184 pp.
4. A.A. Bekker and T.B. Agaev, *Environmental Control* (Gidrometeoizdat, Leningrad, 1989), 286 pp.