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Urban air quality evaluation in Budapest

Gy. Baranka, L. Bozó
*Institute for Atmospheric Physics, H-1675 Budapest,
P.O. Box 39, Hungary*

Abstract

Urban air quality has been monitored by new network system since 1991 in Budapest. Statistical analysis of its data shows which are the most polluted sites in the city. Cumulative distribution of the data set indicates the percents of the exceedence of threshold values during the monitoring period. The average seasonal variations of the air pollutants have been investigated as well. Some possible temporal and spatial feature of air pollutants have been considered. Generally the tendency of NO_2 and CO concentration is decreasing, while TSP and SO_2 levels are similar during the period of 1991-1994.

1. Introduction

The present general air pollution conditions in Budapest (more than 2 million inhabitants over 525 km^2) are mostly determined by the emission from mobile sources (road traffic). The structure of the emission has changed significantly for the last 15-20 years in Budapest due to the "natural gas program". As a result of it the emission of sulfur and nitrogen oxides from the industry as well as space and domestic heating has decreased a lot. The nature of urban air pollution has changed over recent decades. Motor vehicles are now the dominant source.

The annual anthropogenic emissions of CO, VOCs (volatile organic compounds), NO_x and SO_2 - based on survey referring to 1990 - for different source categories are summarized in Table 1.

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Table 1. Annual anthropogenic emissions in Budapest (kt yr^{1})

	CO	VOCs	NO_x	SO_2
Mobile sources	111,500	14,000	7,712	1,663
Industry and energy production	24,949	2,177	8,705	9,095
Space and Domestic heating	10,236	2,794	2,516	12,125
Total	146,685	18,971	18,933	22,883

It should be noted, however, that the emission rate of particulate matter is also giving a significant contribution to the air pollution over Budapest. Its estimated annual total value is around 9 thousand tons.

The number of cars is seven times higher than it was 20 years ago. Most of them are equipped with out-of-date engines without catalytic converters. The average age of the car fleet is over 10 years. The improvement of road infrastructure is far behind the rapid development of mobilization: the total length of public roads is only 50% more as compared to the conditions in the 70's. It can be seen from Table 1. that mobile sources are responsible for the majority of CO (76%), VOCs (74%) emissions in Budapest.

2. Monitoring of air quality

Air quality monitoring has been improved in recent years both in terms of the number of pollutants monitored and the number of sites. However, coverege of urban areas is still thresholded.

The Institute of the Governmental Service for Public Health, Budapest has been operating an air pollution monitoring network in Budapest consisting of 8 stations (Fig. 1) for the measurements of SO_2, NO_x, CO and TSP (total suspended particulate) concentrations since 1991. There are also O_3, and TNMHC monitoring at two of these stations (No.1 and No.4).

SO_2 are measured by pulsed fluorescence, NO_x by chemiluminescence with molybdenum converter, CO by IR detection gasfilter correlation, TSP by ß-ray emission, O_3 UV absorbtion type of monitors. All the substantial meteorological information (wind speed and direction, temperature and

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humidity) are registered by meteo-sensors. Monitors are connected to a telemetric system.

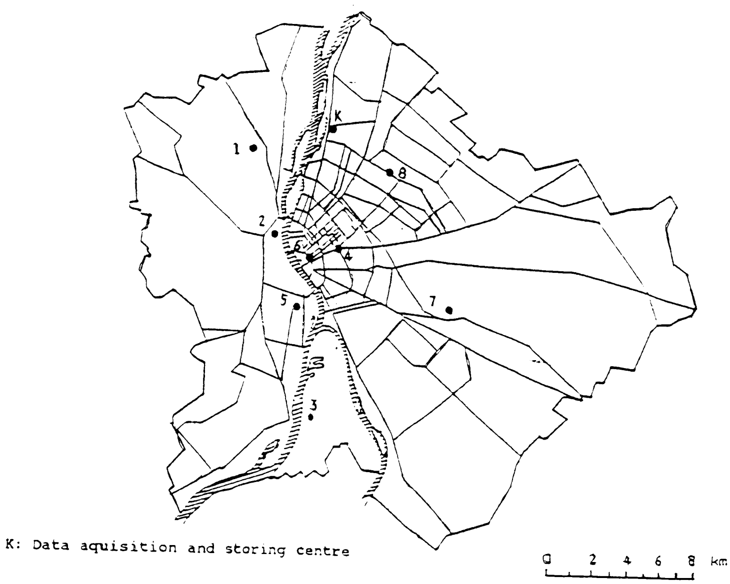

Figure 1. Locations of urban air quality monitoring sites in Budapest

A central data aquisition system collects and stores the data coming from the stations. There are two public display systems in Budapest at two underground stations to inform the inhabitants on the actual air pollution conditions of the downtown area.

The location of monitoring stations is an important consideration in any air quality monitoring network. The stations should cover the industrial, downtown, urban background and suburban area of the city.

For general investigations the stations are divided into two groups. One type consists of four monitoring sites in downtown (No.2, No.4, No.5 and No.6.) The other group involves the remained four stations in suburb, namely No.1, No.3, No.7 and No.8.

The non-real-time analysis of the data gained by means of the monitoring network is carried out in the Institute for Atmospheric Physics. Daily and seasonal variations of the concentrations as well as the characteristics of the actual meteorological situations are considered altogether. Operational period of the new monitoring system in Budapest started in 1991 April. Investigation presented here refers from this date to December 1994.

3. Cumulative frequency distribution of daily averages

Data of concentration measurements of chemicals in the atmosphere often exhibit a log-normal distribution [3]. When the distribution are transposed to cumulative frequencies plotted on log-probability paper, they become straight lines with the slope proportional to the variance and the lines intersecting at the median (cumulative probability of 50%). Generally, the cumulative distribution shows how many percents of the data set (horizontal scale) are under given values (vertical scale).

Similar frequency distribution analysis have been carried out for each stations and pollutants. Two examples of log-normal cumulative frequency distribution plots are illustrated in Fig. 2. for NO, NO_2 and CO. In Budapest pollutants, which have remarkable high concentration (NO, NO_2 and CO) originate from mobile sources. Nitric oxide and carbon monoxide are primary pollutants, nitrogen dioxide is a secondary pollutant, because it is formed from nitrogen monoxide by different chemical reactions in the air [1]. Emission plays great role in the formation of primary pollutant level, while the chemical reactions and meteorological elements dominate the rising of the secondary pollutant concentration. These effects are expressed by their frequency distribution, namely the cumulative distribution of secondary pollutants is more different from lognormal distribution.

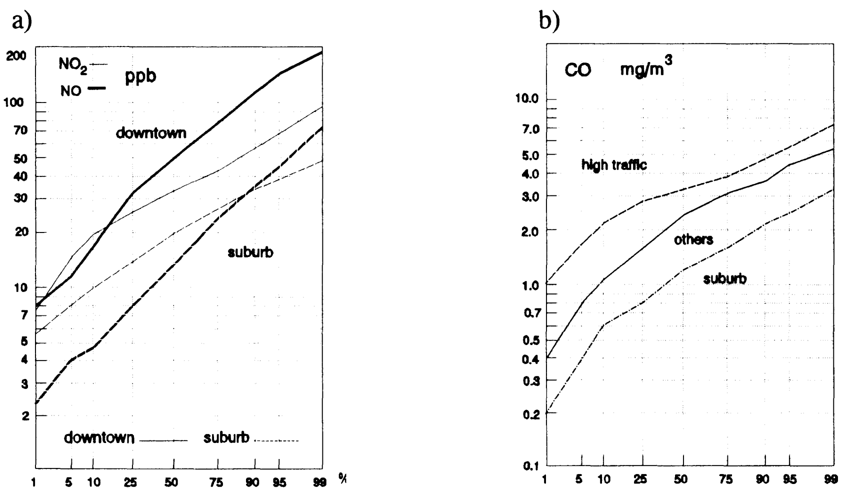

Figure 2. Cumulative distribution of NO, NO_2 (a) and CO b) daily averages during 1991-1994.

In Figure 2.a NO and NO_2 distributions are shown for dowtown and suburb (see above the categories of the stations). The steeper slopes of NO indicate greater temporal variability [2]. High variability is generally due to pronounced seasonal changes in the concentrations of the pollutants (see Fig. 3 below). The curves of suburban values run under curves of downtown data, it is shown that their values are lower.

Another example for showing, how the unusual source emissions and meteorological conditions can affect the cumulative frequency distribution, is the data set from the city-centre commercial site in Budapest. Most of the daily CO are very well approximated by the straight line log-normal plots, illustrated in Fig. 2.b. Concerning CO, the stations are divided into three groups. The first one includes stations under high traffic influences (No.4, No.5), the second one is far from roads (No.7, No.8), and the third one is moderately polluted by CO (No.1, No.2, No.3 and No.6).

Study of the cumulative frequency distributions are very useful, because the threshold values of the air pollutants are decided on the basis of the data distribution of several measuring periods. To evaluate the air quality, the threshold values for the long and short terms are given. The long-term threshold value is the yearly average or the 50th percentile of the daily data set. The 98th percentile value is representative for the maximum daily concentrations. In particulary, the P98 value corresponds to the concentration that is not exceeded for more than 7 days during the year.

4. The seasonal variation of air pollutants

The average seasonal variations of the air pollutants for the period of 1991-1994 are shown in Figure 3. It can be seen that SO_2, NO and CO concentrations have similar seasonal variations with summer minima and winter maxima. NO and CO are the primary pollutants with strong dependence of meteorological conditions, while the cause of the winter high level of SO_2 is the increased domestic emission. Due to the photochemical formation the ozone peaks can be detected in summer. The seasonal variations of NO_2 and TSP are not strongly marked.

It can be seen that the multiyear average concentrations of NO_2, CO, SO_2 and TSP in February are higher than it can be expected. The reason for it is that in general the yearly absolute maxima occur in February at most of the stations. Especially in 1993, when the peaks of above mentioned pollutants were found at every stations in February.

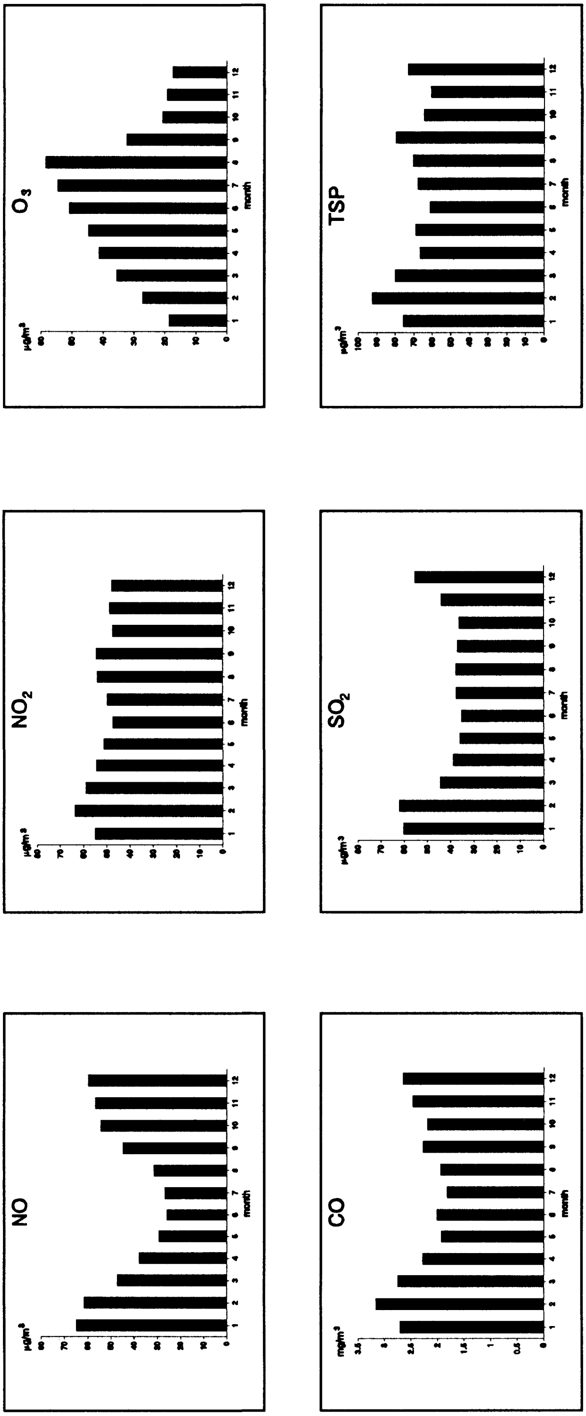

Figure 3. Annual variation of air pollutants during the period of 1991-1994.

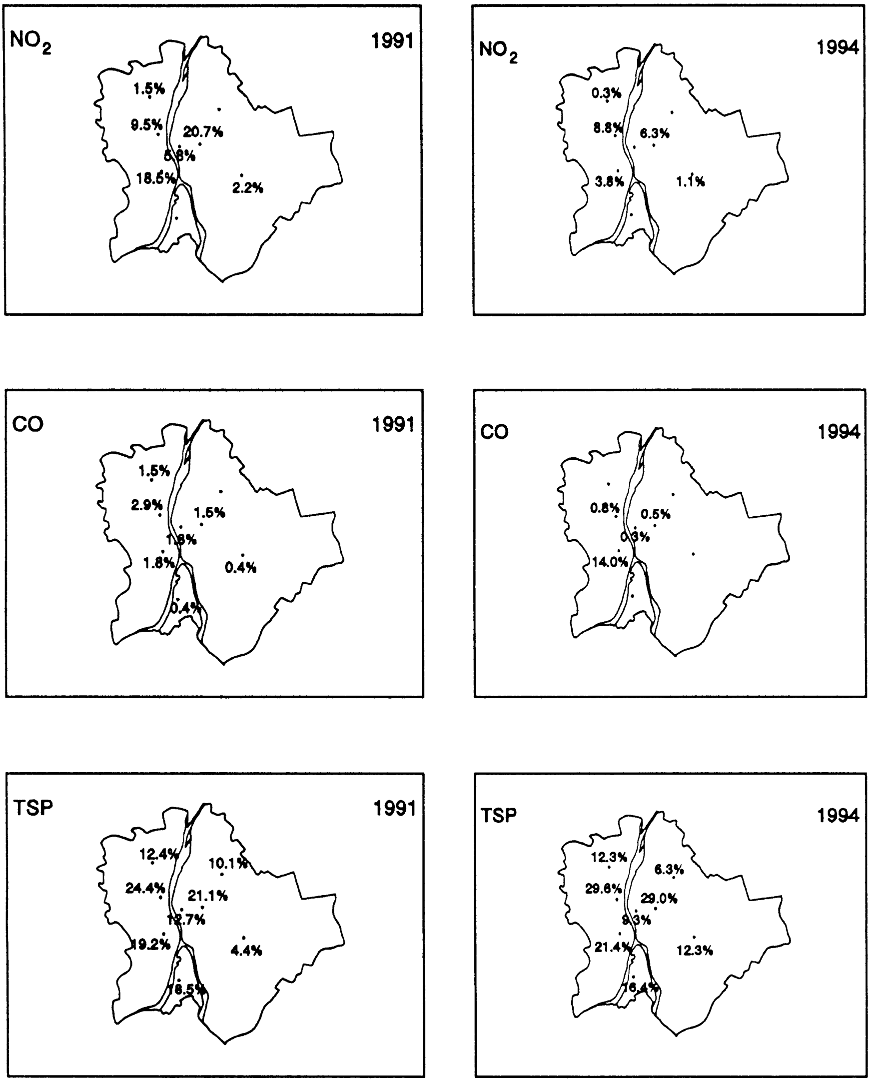

Figure 4. Relative frequency of the exceedences of threshold values.

5. Temporal variation of air pollutans

Average annual variations of SO_2, NO_2, NO, CO, TSP and O_3 for the period of 1991-1994 (operational period of the new monitoring system in Budapest) do not show significant trend. It is obvious that all the pollutants have significant spatial variation in the city. For these reasons we can try to consider some possible temporal and spatial feature of air pollutants.

In the recent period (1991-1994) the temporal variation of air quality in Budapest can be denoted in change of exceedence threshold values as well. NO is missing from evaluation because no threshold value exists. In the case of SO_2 and O_3 there are no exceedences in these years. Relative frequency of the exceedences of threshold values for other pollutants are shown in Figure 4. It is indicated that the amount of exceedence has been decreased since 1991 in the case of NO_2; there was less stations and smaller percents of exceedence in 1994 than before. Generally, the tendency of CO level is decreasing, but at the station No.5. a significant increase was observed. The frequency of TSP threshold values exceedences is similar in the two years with high relative percents in the downtown.

On the basis of our investigations it can be stated that the daily sulfur-dioxide and ozone concentration is not high, but the town are strongly polluted by TSP. Pollutants (NO_2, CO) originated by mobile sources were generally decreased over the period of 1991-1994. It means that motor vehicles are now the dominant source.

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