Investigation of Air Quality in Three Transdanubian Cities

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Abstract – Air quality in cities is the result of a complex interaction between natural and anthropogenic environmental conditions. The extent of the pollution depends on geographic features (structure and quality of the surface, vegetation cover, watercourse), meteorological conditions, the size of the city (industrial activity, road network) and the urban planning policies. Data on CO, NO, NO_2 concentrations measured in three medium-sized cities in Hungary, Sopron, Szombathely and Székesfehérvár are reported. Measurements were performed over a one-year period at selected locations in each city. The average diurnal variations of air pollutants showed very similar tendencies for all three cities. Seasonal variations were also observed, with maximum in compound concentrations over the winter period. Correlation was established between CO and NO_x concentrations.

Keywords: urban air quality / CO / NO_x / diurnal variation

1. INTRODUCTION

Air pollution is one of the most important environmental problems, which is restricted mostly to the cities. The air pollution path of the urban atmosphere consists of emission and transmission of air pollutants resulting in the ambient air pollution. The main sources of air pollution are industrial activity, motor vehicle traffic and emissions from building heating systems (MAYER 1999).

Nitrogen oxides (NO_x) are formed by oxidation of atmospheric nitrogen during combustion. The main part, especially from cars, is emitted in the form of the nontoxic nitrogen monoxide (NO), which is subsequently oxidised in the atmosphere to the secondary "real" pollutant NO_2. High values of NO_2 have a direct toxic effect on living organisms. The emissions can be reduced by optimisation of the combustion process (low NO_x burners in power plants and lean burn motors in motor vehicles) or by means of catalytic converters in the exhaust.

Carbon monoxide (CO) is the result of incomplete combustion with motor vehicles as the absolutely dominant source. The emissions can be reduced by increasing the air/fuel ratio, but with the risk of increasing the formation of nitrogen oxides. Most effective reductions are carried out with catalytic converters (FENGER 1999).

In the European Union there are guidelines in place to restrict immission values of certain pollutants in order to reduce impacts on human health. On renewal of Hungarian air quality regulation (Regulation of the Rural Development 4/2011) were effected in accordance with the EU regulations guidelines.

The aim of this study is to determine the diurnal, monthly variations of air pollutants NO, NO_2, CO in Sopron, Szombathely and Székesfehérvár, to determine statistical relationships of air pollutants in each city, furthermore to analyse their relation to meteorological parameters.

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2. MATERIALS AND METHODS

2.1. Area description

Sopron is located in the north-western corner of Hungary near the Austrian border. The city is at latitude 47°68' N and longitude 16°58' E about 215 m above sea level, and surrounded by Sopron-Mountains. Sopron covers an area of about 169 km^2 and has 60.000 inhabitants. Very few industries are located within the city. The mean annual temperature is 9.9°C, while the mean January and July temperatures are –0.4°C and 20.0°C, respectively and mean annual rainfall at 645 mm. It is one of the most wind-swept cities in Hungary, the prevailing wind direction is NW.

Székesfehérvár lies south of Móri-graben near Lake Velence at 47°12' N and 18°24' E. The city is the county-seat with 102.000 inhabitants covering an area of about 170 km^2. Székesfehérvár is a significant industrial and commercial center. The climate is temperate with mean temperatures during winter and summer at –1°C and 22°C respectively.

Szombathely is located in the western border of Hungary at 47°13' N and 16°37' E. The city is the county-seat covers an area of about 97 km^2 and populated by 79.600 people. The mean annual temperature is 10.8°C, while minimum and maximum monthly mean temperatures are –0.9°C in January and 19.7°C in July, respectively.

2.2. Measurement of the pollutants

The air quality has been monitored by a mobile air testing equipment applying diurnal sampling by methods recommended by directives (MSZ ISO 7996, MSZ 21456/5). CO concentration was measured by nondispersive infrared photometry, NO_x content by chemiluminescence (Horiba APNA-370). Measurements were performed monthly, continuously, in cyclical repetition between March 2011 and Jan 2012 at selected locations in each city. Such monitoring sites were choosen, which represent the main type of urban structure (downtown, residental area, green belt, industrial area). We have used hourly averaged data, and volumes were standardized at a temperature of 293 K and a pressure of 101.3 kPa.

Relevant meteorological parameters, namely hourly values of temperature, relative humidity, wind velocity and direction, were taken into account on analyzing chemical data. Meteorological data were collected from meteorologigal data bank. Data available at http://www.amsz.hu/news.php, http://weatherspark.com.

3. RESULTS AND DISCUSSION

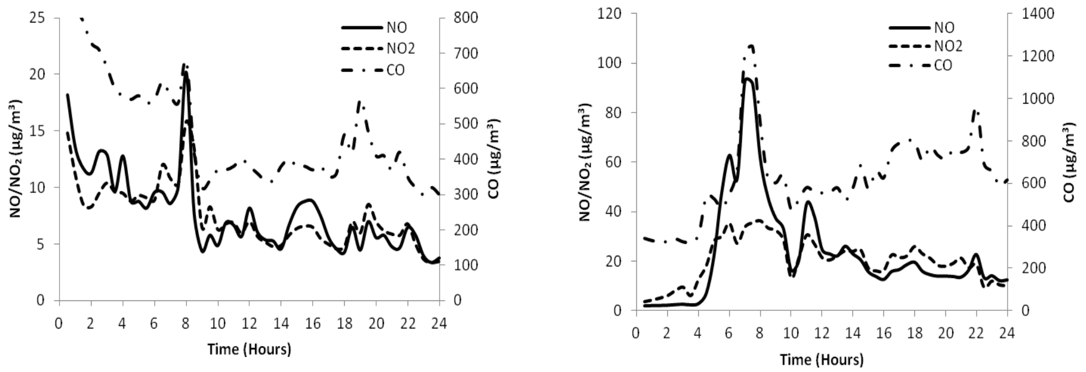
The mean diurnal CO, NO and NO_2 concentrations were below the ambient air quality limit values (*Table 1*) at all sites over the entire period under review. The average diurnal variations of air pollutants showed similar tendencies for all three cities (*Figure 1-3.*). In general, two maximum values were obtained in the daily profiles of air pollutants during workdays correspond to rush hours. The concentration of CO and NO_x are low at night and start to increase about 7 a.m. Maximum is observed in the morning, followed by a decrease toward the afternoon. A new increase is then observed, reaching a second maximum during evening. The NO concentrations are noticeably higher in the morning than in the evening, because the rush-hour is shorter in the morning. In Székesfekérvár and in Szombathely, highest percentile values of NO and NO_2 occur mostly in the evening, while in Sopron occur in the morning.

Table 1. Ambient air quality limit values
(Regulation of the Rural Development 4/2011)

Compound	Interval	Hungarian Standard (µg/m^3)
Carbon monoxide (CO)	1 year	3000
	24 h	5000
	1h	10000
Nitrogen dioxide (NO_2)	1 year	40
	24h	85
	1h	100

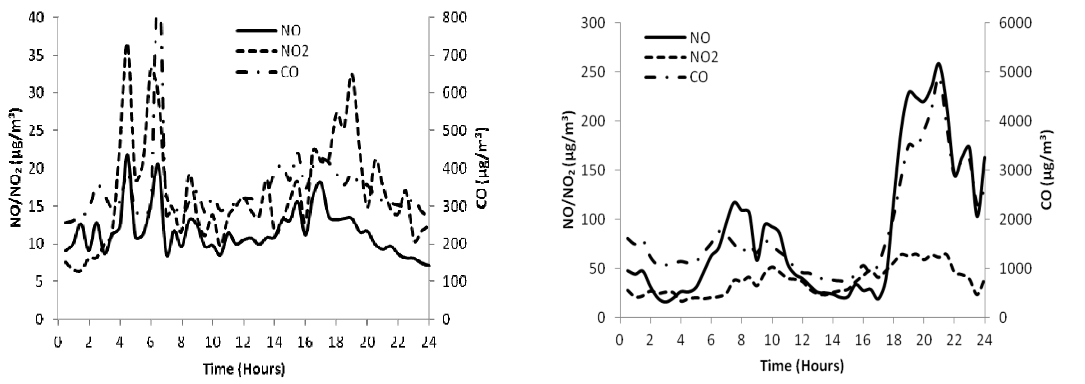
The amount of CO and NO_2 in the atmosphere is greater in the industrial area and at near the busy street (*Figure 4.*). Results indicate that vehicular traffic is the principal source of these pollutants. The highest hourly measured values were of 4571 µg/m^3 for CO and 62.8 µg/m^3 for NO_2 in Székesfehérvár, which were below the 1-h Hungarian standard.

The concentration of CO and NO depends not only on emission, but also on weather conditions. NO concentrations increase when the wind speed decrease, yielding $NO_2/NO < 1$. Wind speed, that is very low in the morning throughout all seasons, shows large differences in the afternoon.



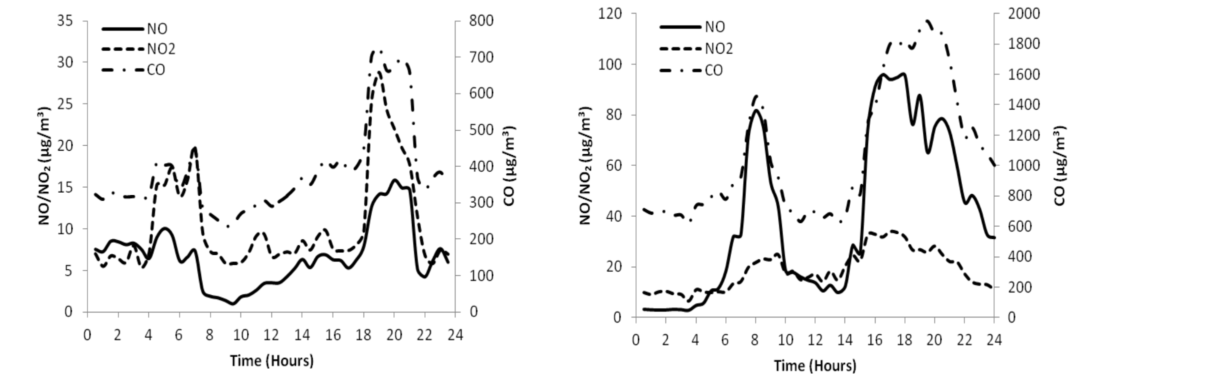
(a) (b)

Figure 1. Concentration of CO, NO, NO_2, represented as 30-minute averages, measured at busy street in Sopron (a) on 26 March 2011, (b) on 10 October 2011.



(a) (b)

Figure 2. Concentration of CO, NO, NO_2, represented as 30-minute averages, measured at busy street in Székesfehérvár (a) on 13 June 2011, (b) on 14 November 2011.



(a) (b)

Figure 3. Concentration of CO, NO, NO_2, represented as 30-minute averages, measured at busy street in Szombathely (a) on 12 May 2011, (b) on 28 November 2011.

The concentration of air pollutants shows greater values in November (*Figure 1-3.*) in correlation with the decrease of the mean wind speed and average temperature. During the cold period of the year, the central heating also plays a significant role. The higher winter values are caused by atmospheric stability with frequent inversions. The lowest values in summer are due to dilution caused by intensive vertical exchange in the atmosphere (MAKRA et. al. 2010).

The distributions of the hourly values of pollutants are very different for workdays, Saturdays and Sundays. *Figure 5*. show the concentrations of CO and NO_2 in a weekend days and in workdays. Most Saturdays and Sundays show not well defined peaks, reflecting a more or less random traffic circulation. On Sundays, concentrations are much lower than on Saturdays and the hourly distribution is even more diffuse.

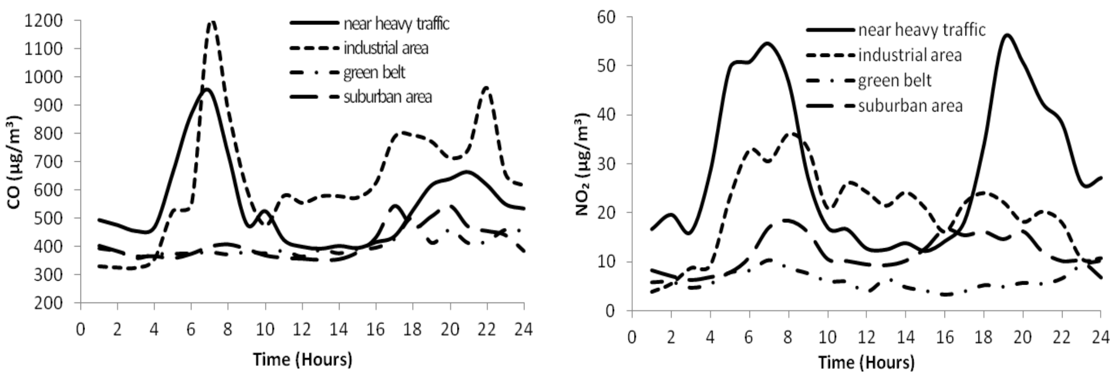


Figure 4. Typical day CO and NO_2 curves at selected locations in Sopron in October 2011

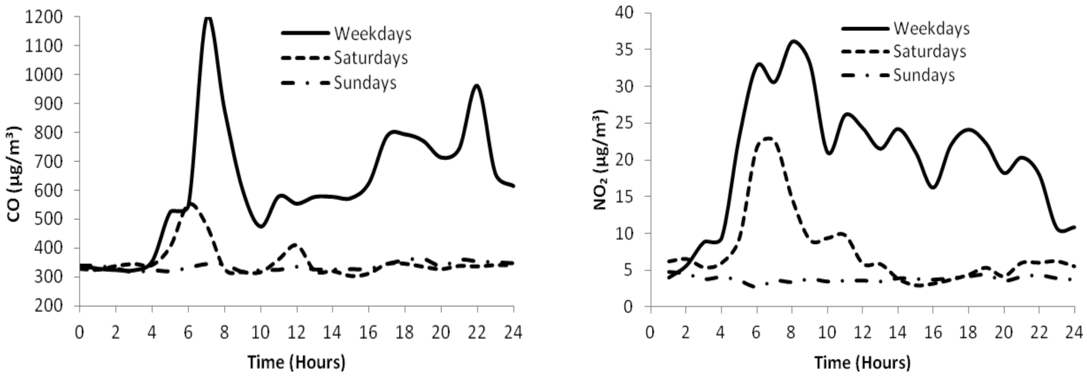


Figure 5. Typical day CO and NO_2 curves at busy street in Sopron in October 2011

The concentrations of CO and NO_x correlate strongly during the measurement period. As an example, *Figure 6.* represents the correlation obtained during November 2011 in Székesfehérvár. This good agreement (R^2 = 0.86) in daily mean values indicates that both compounds have the same principle source.

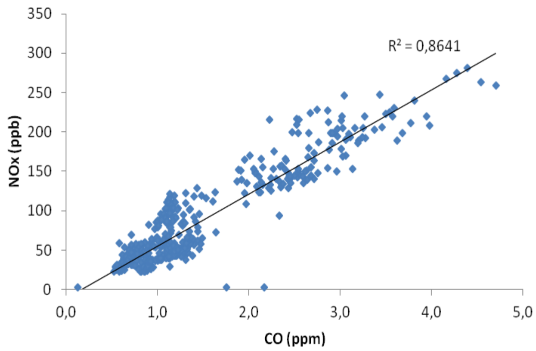


Figure 6. Concentration of CO versus NO_x
for November 2011 measured in Székesfehérvár

4. CONCLUSION

Air quality in cities is getting worse as the population, traffic, industrialisation and energy use increase. Urban air pollutants show typical diurnal and seasonal cycles. Seasonally separated data indicated a maximum in compound concentrations over the winter period. The relatively high wind speed and the geography of the cities do not allow the accumulation of pollutants during most days. The differences in the pollutant characteristics among cities can come from the different city structure, traffic structure, difference in topography.

These air pollution measurements costitute the part of a complex, integrated urban ecological research. Our results, in combination with soil, water quality and plant health examinations, characterize the interactions between the cities and their environment. Results will be represent in thematical maps by geographical information systems.

Acknowledgement

This work was supported by a grant from Hungarian TÁMOP 4.2.1. B-09/1/KONV–2010-0006 research project.

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