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BENZENE IN THE AIR OF ZAGREB, CROATIA – FIRST STUDY

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ABSTRACT

This paper presents the results of the first measurements of benzene concentrations in the air of Zagreb, Croatia. The samples were taken at two sampling sites and analysed every 15 minutes using automatic gas chromatographs. One sampling site was the national monitoring station located in a densely populated city centre with high dense traffic. The other sampling site was a regional monitoring station in the northern part of the city with small population density and low traffic. The measurements were carried out simultaneously at both sampling sites from May 19 to August 16, 2004. The results showed diurnal variations characteristic of urban areas and the influence of traffic, with higher values measured in the morning hours. Both sampling sites showed differences in benzene concentrations between working days and weekends. When comparing benzene levels between the two sampling sites it was found that benzene concentrations were lower in the northern part of the city throughout the sampling period.

Key Words: air pollution, sampling site, traffic.

1. INTRODUCTION

Benzene is a ubiquitous air pollutant, and the general population is permanently exposed to it. The International Agency for Research on Cancer (IARC) has classified benzene as a carcinogen in humans and there is no identifiable threshold below which there is no risk to human health (IARC, 1982; Benzene, WHO, 1993). According to the Directive 2000/69/EC of the European Parliament, the limit value for benzene concentration in ambient air is 5 μg m^{-3} as an annual average (Directive, 2000). In most European countries there is a network of stations for measuring ambient air pollution, including benzene concentrations in the air. There are also some studies (for example MACBETH programme) that were designed to quantify population exposure to ambient atmospheric benzene (Gonzalez-Flesca et al., 2000). Measurements of benzene concentrations in the air in Croatia have been started only recently. Current measurements are continuously conducted at two locations in Zagreb: at the national and regional monitoring station.

The aim of this paper is to present data of the first measurements of benzene concentrations in the city of Zagreb, Croatia and to evaluate if there is significant

difference between benzene concentrations measured at the two sampling sites with different traffic density.

2. MATERIALS AND METHODS

Measurements of benzene concentrations were carried out simultaneously at two sampling sites in Zagreb, Croatia from May 19 to August 16, 2004. One sampling site was the national monitoring station located in a densely populated city centre at the distance of approximately 20 m from two roads (crossroad) with high traffic density. The other sampling site was a regional monitoring station in the northern, residential part of the city with small population density and low traffic. That station was located at a distance of more than 200 m from the nearest road or parking lot. Elevation of the sample inlet was 2.5 m from the ground level at both sampling sites. The fifteen-minute samples were collected and analysed using automatic gas chromatographs (VOC71M, Environnement s.a., France; AirmoBTX 1000, Airmotec, Germany) with PID and FID detectors.

3. RESULTS AND DISCUSSION

The results of benzene concentrations are shown in Figure 1. The average mass concentrations and selected statistical parameters are shown in Table 1. Daily variations of benzene mass concentrations, measured over 90 consecutive days show corresponding variations at both sampling sites. Those variations mainly depend on weather conditions and they were identical at city centre and at the northern part of the town. One-way analysis of variance (ANOVA) shows significant difference ($P<0.01$) in mass concentrations of benzene between the two sampling sites. Over the whole measuring period, higher values were measured at the city-centre sampling location, with the maximum daily average of 5.8 $\mu g\ m^{-3}$. Both sampling sites were selected in order to avoid any effect of stationary industrial sources. Thus, the higher benzene concentrations at the city-centre sampling site are as expected, considering high traffic density of the area.

The Ordinance on Recommended and Limit Air Quality Values base on the Croatian Law on Air Quality Protection defines the following values for benzene:

Recommended value = 2 $\mu g\ m^{-3}$,
Recommended value of 98^{th} percentile = 5 $\mu g\ m^{-3}$,
Limit value = 5 $\mu g\ m^{-3}$,
Limit value of 98^{th} percentile = 10 $\mu g\ m^{-3}$.

All values are defined for 8-hour running averages (Law, 1995; Ordinance, 1996). Although the usual averaging period for categorizing the air quality of the area with respect to benzene involves one calendar year, our results show that the limit value of 5 $\mu g\ m^{-3}$ (also given by the Directive 2000/69/EC of the European Parliament) was exceeded in the city centre on three occasions during the sampling period.

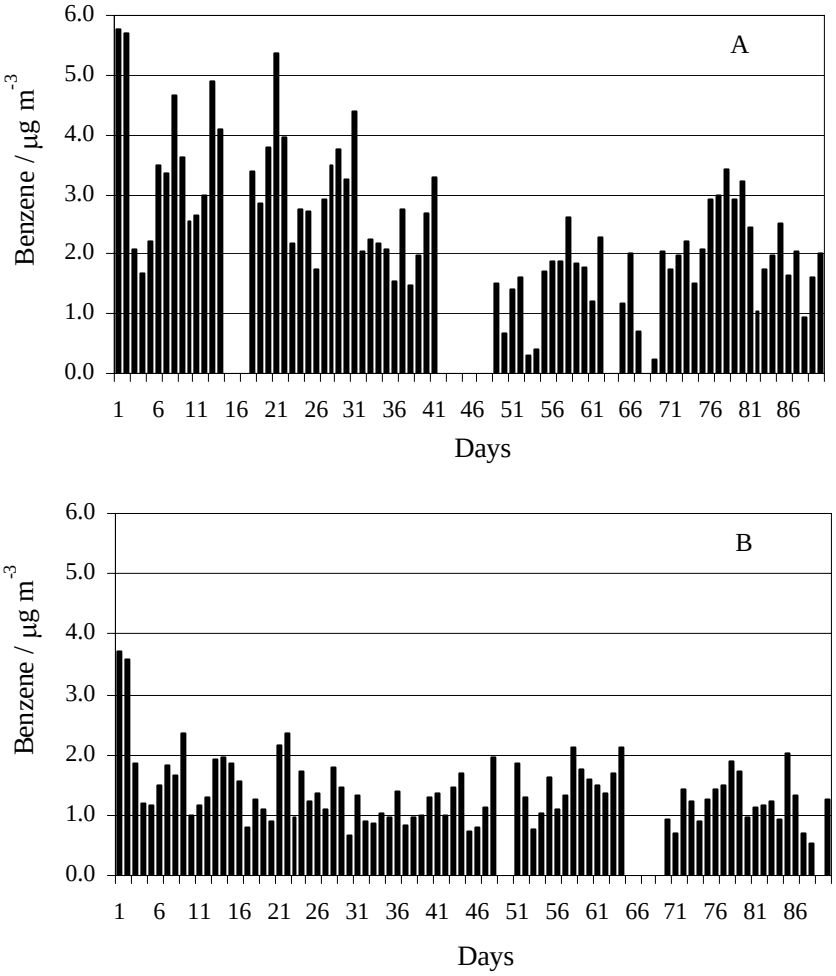

Figure 1. Daily variations of benzene concentrations measured in A) city centre and B) northern part of the town, in the period May 19 to August 16, 2004.

Table 1. Mass concentrations of benzene (µg m^{-3})

Sampling site	N	C	SD	C_{min}	C_{25}	C_{50}	C_{75}	C_{98}	C_{max}
Center	77	2.5	1.2	0.2	1.8	2.2	3.0	5.5	5.8
North	82	1.4	0.6	0.5	1.0	1.3	1.7	2.8	3.7

N - number of samples
C - average values
SD - standard deviation
C_{min} - minimum values
C_{25} - 25 percentile
C_{50} - median
C_{75} - 75 percentile
C_{98} - 98 percentile
C_{max} - maximum values

Diurnal variations of benzene concentrations measured at the sampling sites located in city centre and in the northern part of the town are shown in Figure 2.

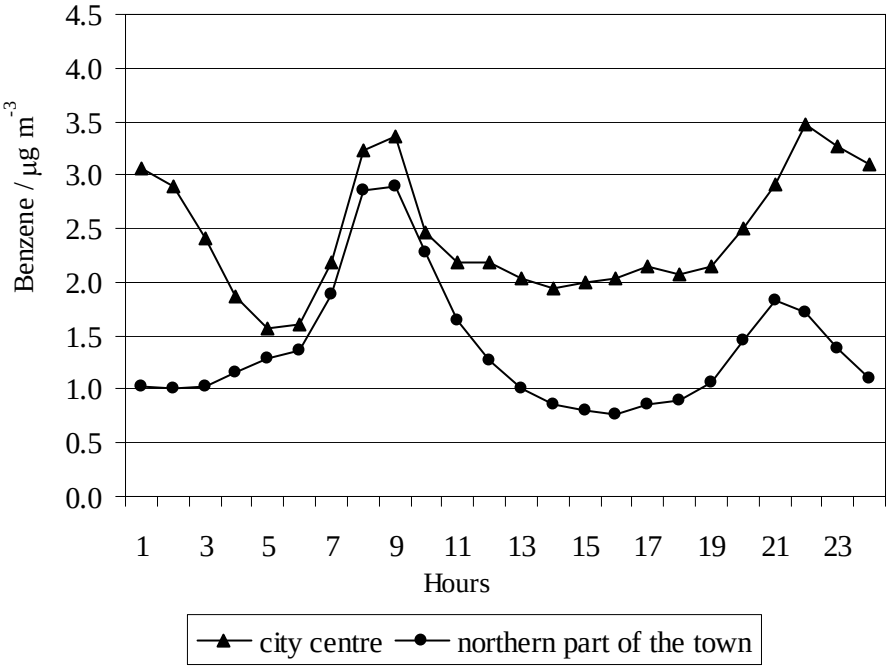

Figure 2. Diurnal variations of benzene concentrations measured at two sampling sites.

Trends are very similar at both sampling sites. Mass concentrations of benzene start to increase at 6 a.m. and they reach the daily maximum between 8 and 9 o'clock in the morning when most people start to work. Personal cars are still preferable instead of public transport, so morning traffic jams are very often. After 9 a.m. the benzene levels start to decrease. Another maximum, observed in the evening hours, can be explained in Figures 3 and Figures 4 with separate values for weekends (Saturday, Sunday) and working days (Monday to Friday). Differences between benzene concentrations measured on weekends and on working days in city centre are shown in Figure 3. Figure 4 presents diurnal variations on working days and on weekends measured in the northern part of the town.

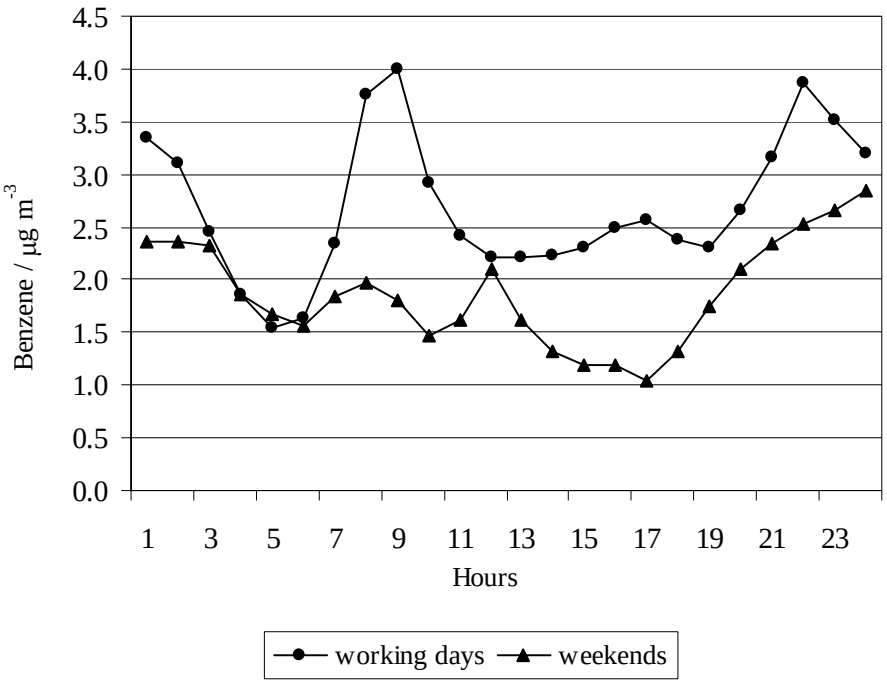

Figure 3. Average hourly values of benzene concentrations measured in the city centre.

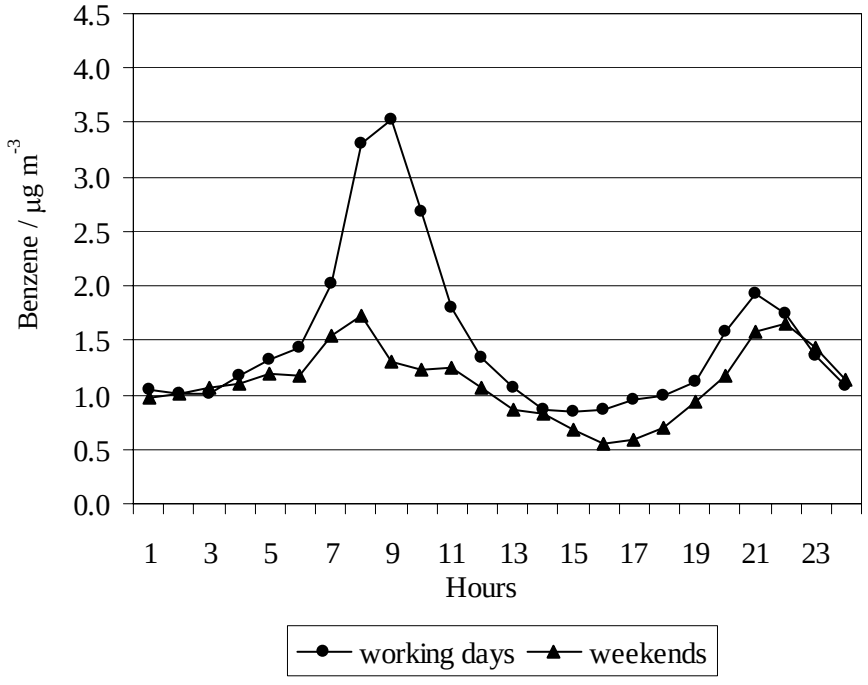

Figure 4. Average hourly values of benzene concentrations measured in the northern part of the town.

Diurnal variations of benzene concentrations between working days and weekends differ on both sampling sites. Different trends between sampling sites was also found. Elevated values were measured on working days, and also at the sampling site in city centre. The maximum daily values from 8 to 9 a.m. during the working days were not observed on weekends. The increase in benzene levels was observed in city centre in the evening hours, especially on weekends. All results indicate strong influence of traffic as a major source of benzene concentrations in the air of Zagreb, Croatia.

4. CONCLUSION

First measurements of benzene concentrations in the air of Zagreb, Croatia, are presented. Concentration levels of benzene showed significant difference between the two sampling sites with higher traffic-related values at sampling site in city centre. Limit value of 5 $\mu g\ m^{-3}$ was exceeded on three occasions in city centre. Diurnal variations showed maximum values between 8 and 9 a.m. at both sampling locations. Benzene concentrations measured on working days and on weekends confirmed the influence of traffic.

REFERENCES

Benzene, 1993. Environmental Health Criteria, No. 150, World Health Organization, Geneva.

Directive 2000/69/EC of 16 November 2000. Official Journal of the European Communities, L 313, 13.12.2000, p. 12-21.

Gonzalez-Flesca, N., Bates, M. S., Delmas, V., Cocheo, V., 2000. Benzene exposure assessment at indoor, outdoor and personal levels. The French contribution to the life MACBETH programme. Environmental Monitoring and Assessment 65, 59-67.

IARC, 1982. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. International Agency for Research on Cancer, Lyon, 29, 93-148.

Law on Air Quality Protection in Croatia, 1995. Official Gazette No. 48, 1452 (in Croatian).

Ordinance on Recommended and Limit Air Quality Values, 1996. Official Gazette No. 101, 4198 (in Croatian).