Proceedings of the Third International Symposium on Air Quality Management at Urban, Regional and Global Scales. pp. 1484-1488, 26-30 September 2005, Istanbul – Turkey

PILOT AIR POLLUTION INVESTIGATION AT ZAGREB CROSSROADS

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ABSTRACT

Concentrations of PM_{10}, lead and Benzo-a-pyrene (BaP) contained in PM_{10}, and nitrogen oxides were measured during two weeks at seven Zagreb crossroads (two measuring sites per crossroad) and compared to daily average levels monitored at local network stations. This study was performed as a part of the SILAQ project (Sofia Initiative for Local Air Quality). The results show a small concentration increase in regard to daily concentrations measured at local network stations. Concentrations of all investigated pollutants were higher in the afternoon than in the morning, as a consequence of pollutant accumulation during daytime and dilution over night.

Key Words: PM_{10}, Nitrogen Oxides, Traffic Air Pollutions, Urban Air

1. INTRODUCTION

The air quality surveillance in Croatia started in Zagreb in 1962 with the measurement of deposited matter. PM_{10} and $PM_{2.5}$ measurements were established in 1998, of polycyclic aromatic hydrocarbons (PAHs) in 2000, and a measurement network for NO_2 was established in 1994. The monitoring of spatial and seasonal variations of pollutant concentrations levels in Zagreb (Šega and Fugaš, 1984; Čačković at al., 2001) has started since 1984. In addition, influence of long–range transport on gases concentrations (Klaić, 1996) as well as influence of weather conditions on airborne particle concentrations (Bešlić at al., 2003) have been recently investigated.

Traffic density in Croatian cities (especially in Zagreb) has rapidly increased over the last decade. At the same time, major pollution sources such as heating plants and house heating have become less significant because solid fuel has been replaced with natural gas. In order to estimate the influence of traffic on urban air pollution under these new conditions, this pilot investigation was performed at seven Zagreb crossroads for two weeks and the results were compared with the monitoring network data.

2. METHODS

The investigation was performed at seven Zagreb crossroads from 23 October 2002 to 5 November 2002. Some are situated in the street canyons of the city center, while others are at open space locations. Two samplers were set up at each crossroad to avoid the wind influence on pollutant concentration levels. Two samples were collected daily per measuring site, from 6.00 to 13.00 hrs and again from 14.00 to 21.00 hrs. Portable air samplers (Air Metrics, U.S.A.) were placed at the height of 1.70 meters above the ground level. PM_{10} samples were collected on Whatman quartz filters with the diameter of 47 mm, while gaseous pollutants were collected in Tedlar bags. Cumulative samples were collected throughout the weekdays and weekends, representing weekly averages for weekdays and weekends. Filters were preconditioned for 24 hours before and after sampling, and weighted using microbalance Mettler Toledo MX-5. PAHs were analyzed using the Varian Pro Star high-performance liquid chromatograph (HPLC). Nitrogen oxides were analyzed using the automatic sampler Environnement s.a., model AC 30M.

3. RESULTS

PM_{10} was monitored at one measuring site only, located in the northern, residential part of Zagreb. For this reason, Table 1 shows TSP concentrations in Zagreb center, PM_{10} concentrations in the northern part of Zagreb and at crossroad measuring sites during the weekdays. It should be pointed out that the results obtained at the network measuring sites represent the average of daily samples over weekdays or weekends respectively. The results show higher PM_{10} and TSP concentration levels at the crossroads than at the network measuring stations for both morning (6 – 13 hrs) and afternoon (14 – 21 hrs). Furthermore, the afternoon concentration levels were higher than the forenoon concentrations.

Table 1. PM_{10} concentration levels in $\mu g/m^3$ during weekdays

	TSP	**PM_{10}**	**PM_{10} – crossroads**	
	Center	North	6 -13 hrs	14 – 21 hrs
N	6	10	28	26
AVG	**62.2**	**33.3**	**67.59**	**78.16**
STD	13.10	10.73	26.75	42.77
MIN	43.00	20.84	10.48	10.00
MAX	84.60	61.12	116.19	217.62

Table 2 shows weekend PM_{10} concentration levels at the northern sampling site and crossroads forenoon and afternoon concentration levels. Weekend concentration levels are lower than weekday concentrations because of lower traffic density. But again, higher afternoon concentration levels were observed.

Lead content in PM_{10} determined in the samples collected at the crossroads are shown in Table 3. Again, concentrations measured at the crossroads were higher than those measured at the network site. Higher lead concentrations were determined in the afternoon samples.

Table 2. PM_{10} concentration levels in µg/m^3 during weekends

PM_{10}	North	**Crossroads**	
		6 -13 hrs	14 – 21 hrs
N	4	14	14
AVG	**29.53**	**49.28**	**64.60**
STD	10.27	33.50	50.66
MIN	20.84	4.05	3.57
MAX	46.32	86.84	137.60

Table 3. Lead concentration levels in ng/m^3 at the crossroads, in the city center (TSP) and the southern (PM_{10}) regular monitoring station

Pb	Center	North	**Crossroads - weekdays**		**Crossroads - weekends**	
			6-13 hrs	14–21 hrs	6-13 hrs	14–21 hrs
N	6	10	28	27	14	14
AVG	**69.7**	**62.8**	**74.3**	**110.4**	**53**	**100.2**
STD	27.6	25.8	56.2	64.2	35.4	4.4
MIN	36.4	19.5	0	1.7	2.1	5.5
MAX	106.5	118.9	186.7	229	133.6	315.5

Table 4 shows higher BaP concentrations at the crossroads than at the network station located in the northern part of city. The concentrations were higher on weekdays than on weekends, and in the afternoon than in the morning.

Table 4. BaP concentration levels (ng/m^3)

BaP	North	**Crossroads - weekdays**		**Crossroads - weekends**	
		6 -13 hrs	14 – 21 hrs	6 -13 hrs	14 – 21 hrs
N	14	28	27	14	14
AVG	**1.70**	**2.64**	**3.74**	**1.91**	**2.69**
STD	1.14	0.91	2.77	0.93	1.20
MIN	0.46	0.84	1.05	0.57	0.96
MAX	5.07	4.69	15.68	3.78	4.31

Tables 5-6 show NO and NO_2 concentration levels measured at the crossroads. Higher concentration levels were observed on weekdays and in the afternoon for both pollutants.

Table 5. NO concentration levels measured at the crossroads (μg/m^3)

NO	Crossroads - weekdays		Crossroads – weekends	
	6 -13 hrs	14 – 21 hrs	6 -13 hrs	14 – 21 hrs
N	41	35	12	15
AVG	**183**	**199**	**103**	**130**
STD	58	95	54	89
MIN	56	15	23	24
MAX	319	456	216	358

Table 6. NO_2 concentration levels measured at the crossroads (μg/m^3)

NO_2	Center	Crossroads – weekdays		Crossroads – weekends	
		6 -13 hrs	14 – 21 hrs	6 -13 hrs	14 – 21 hrs
N	14	41	35	12	15
AVG	**42**	**126**	**133**	**65**	**86**
STD	9	43	62	28	48
MIN	27	59	31	27	31
MAX	60	252	279	133	215

4. CONCLUSION

Despite shortcomings (short investigation period and non comparable averaging periods), this investigation suggests that traffic significantly contributes to the air pollution in Zagreb, primarily by exhaust emission as well as by the re-suspension of the dust from the ground.

Samples at the crossroads were collected when traffic density was high. This is the main reason for the higher concentration levels of all pollutants in comparison with regular network site measurements. Higher afternoon pollution level for all pollutants is the result of pollutant accumulation during the day and its dilution over night.

This pilot investigation should serve as the basis for future investigations of traffic influence on local air pollution in Zagreb. The next step would be to establish a correlation between traffic density and pollutant concentration levels.

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