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Air pollution

INFLUENCE OF TRAFFIC ON THE AIR POLLUTION IN SKOPJE

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Abstract. In the course of the project "The Study on Air Pollution Monitoring System in the Republic of Macedonia", financially supported by Japanese Government and realised by Japan International Cooperation Agency (JICA), the influence of the traffic on the air pollution in Skopje was studied. The investigation was realised by registration of traffic volume of the vehicle (divided in 5 categories) at 75 measuring points (crossroads, boulevards, streets) and of vehicle speed (at 50 points) as well as determination of the concentration of NO and NO_2 in the air next to 4 crossroads and 2 boulevards. This investigation was performed by 450 students, continuously in two days (workday and holiday). From the obtained results it can be concluded that on most of the measuring points the traffic volume is very large. For example, on measuring point No 46 the number of vehicles passed in 24 h on weekday is about 110 000 and during holiday about 95 000. The number of buses (using diesel) on some points is very large (on some crossroads over 5000). Measuring of the distribution of nitrogen oxides shows high concentration of NO_x on almost all measuring points.

Keywords: traffic, exhaust gases emission, air pollution, NO_x, Skopje.

AIMS AND BACKGROUND

Skopje, as a capital of FYR Macedonia, represents an administrative, cultural, industrial and traffic center, which according to the 1994 census, has 650 000 inhabitants, representing around 30% of the total population of the state.

The Skopje basin, with its orographic and climatic characteristics, has very unfavourable (from ecological aspect) topoclimatic specifics. The average evaluation of the valley is 260 m. The mean annual air temperature for 30 years period is 12.5 °C. The temperature inversions in the Skopje basin are present in every month oh the year, especially during the winter months and anticyclone conditions, with all negative manifestations. During the winter months, the Skopje valley is characterised with increased frequency of days with fog, mainly of radiation character. There are 63 foggy days average annually. There are winds coming from all directions and interdirections in the Skopje valley, but alongside the river Vardar and the whole valley the wind Vardarec is predominant coming

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from the northwest, southeast and south direction. In the city part of the valley the west wind is frequent, with average annual frequency of 124‰ and average annual speed of 1.2 m/s.

These climatic characteristics of the Skopje valley, the concentration of industrial capacities and population, lead to disorder of adopted air quality standards.

EMISSION OF THE POLLUTANTS FROM THE TRAFFIC

A large amount of pollutants are being emitted in the ambient air through the system for taking the waste gases of the vehicles such as: CO, VOC (volatile organic compounds), NO_2, SPM (suspended particulate matter), SO_2, lead compounds, through the combustion of the fossil fuels in the engines and VOC emissions together with the evaporation of the fuels from the vehicles. The CO_2 emission is treated in the statistics as a pollutant deriving from the traffic.

The emissions of CO, VOC, and SPM are the result (reason) of the uncomplete combustion of the fuel and at the same time of the changeable traffic density and driving conditions. They depend of the way of driving, motor type, size and condition, and of the measures undertaken for reducing the emission (for example exhaust converters). SPM are also the results of the presence of uncombusted matters in the fuels and the catalytic treatment of the exhaust devices. SPM (used in statistics) excludes the presence of lead.

The high inner temperature in the engines during combustion is a reason for producing NO_2. The emission of NO_2 depends also of the engine (vehicles) load.

The emission of SO_2 and lead is a result of the presence of sulphurous compounds and/or lead compounds in the motor fuels. The sulphurous compounds derive from the crude oil, and the leads are added as antidetonating agents. The CO_2 emission depends on the content of the carbon in the fuel.

In the FYR Macedonia the pollution of the ambient air from the traffic is actual for the bigger city settlements, especially in Skopje.

In Table 1 the overview of the vehicles number and structure is given for the year 1993 as one of the extreme years when in Skopje extreme air pollutions appeared[1]. It can be observed from the table that a great number of vehicles (cars, buses and trucks) passes the territory of the city of Skopje and their percentage is: 38.0, 42.5 and 37.0, respectively. This leads to high degree of air pollution in Skopje caused by the traffic.

Table 1. Overview of the vehicles number and structure

	Types of vehicles						
	motor-cycle	cars	buses	commer-cial vehicles	special vehicles	tractors, working vehicles	trailers
In FYR Macedonia (total)	3003	289979	2921	20104	6563	6648	7624
Private sector (No)	2893	275339	366	10402	1357	5019	2541
Percents (%)	96.3	94.9	12.5	51.7	20.7	75.5	33.3
In Skopje	709	110332	1242	7457	1888	383	1327
% from total vehicles	23.6	38.0	42.5	37.0	28.7	5.7	17.4

Certain meteorological conditions in the territory of the city and around (anticyclyc stable weather with the appearance of temperature inversions) during the winter period of the year (October-March), plus the emission of harmful matters from the heating plants (stationary sources) lead to episodes with enormous pollution.

Such a condition in Skopje appeared in January 1993 and is one of the most extreme. Therefore, as a characteristically year 1993 will be taken for calculation of the pollution matters emission deriving from the traffic.

In Table 2 data for 1993 about the length of the traffic lines and number of vehicles (mainly buses) of the enterprises for public transportation are shown, for the FYR Macedonia and Skopje. From the total number 697 of vehicles for the city transport in the state in 1993, 471 were in Skopje which represent 67.57%. If we add to this number 110 332 cars, 7454 trucks, other buses, motorcycles, etc., unfavourable picture of high level of pollution is produced for the traffic in Skopje.

Table 2. Data about the traffic lines length and number of vehicles

	Routes at the end of year		Vehicles at the end of year		Passengers carried (1993)	Kilometer passed by vehicles (1993)
	total	length (km)	total	recently purchased		
FYR Macedonia	443	15 148	697	28	138 582	27 664
Skopje	73	1063	471	21	124 130	18 018
% in Skopje	16.47	7.0	67.57	82.0	89.57	65.13

In the calculation of the emission of pollution materials the following dimensions are adopted:

- the mean value for specific weight of the petrol's to be 0.740 kg/l;
- the mean value for specific weight of the diesel petrol to be 0.840 kg/l.

The factors of emission for certain pollutants to be:

- the content of lead in the petrol to be 0.6 g/l;
- only 95% of the sulphurous (S) is transformed into SO_2;
- only 75% of the lead (Pb) is emitted through the exhaust gases (exhausts).

Using the emission factors as well as the fuel consumption in the FYR Macedonia and Skopje, the emissions of the pollutants are calculated (see Table 3).

Table 3. Pollutants emissions

	SO_2 (t/year)	VOC (t/year)	CO (t/year)	NO_2 (t/year)	Pb (t/year)	TSP (t/year)
emission of harmful matters from petrol in 1993						
FYR Macedonia	73.6	7360	40 480	3680	82.8	552
Skopje	27.6	2760	15 180	1380	31	207
emission of harmful matters from diesel petrol in 1993						
FYR Macedonia	383.4	93.72	7668	7668	-	1278
Skopje	61	1492	1220	1220	-	203
total emission of harmful matters from traffic in 1993						
FYR Macedonia	457	16 732	48 148	11 348	82.8	1830
Skopje	88.6	4252	16 400	2600	31.0	410
In Skopje (%)	19.4	25.4	34.0	22.9	37.5	22.4

The represented numeric values for the emission of harmful matters should be taken as orientation ones due to the fact that in FYR Macedonia there is no adopted methodology for calculation (estimation) of the emission of harmful matters and also due to the fact that in this case experiences from other countries are used, members of EU (Holland, England) with certain modifications for our conditions.

Anyway, the represented numbers once again prove the fact that the ambient air in Skopje is engraved with pollutants deriving from the traffic and, therefore, as a priority measures for the reduction of such pollution the electrification of the public transport (tram, trolleybus) is proposed and the use of the unleaded petrol, gasification, introducing liquid gas as a fuel in the taxi cars, etc.

SURVEY OF MOBILE POLLUTION SOURCES

Mobile source survey was performed in two days: weekday and holiday for 24 h at 75 points (5 areas with 15 intersections/area)[2]. Locations of those points are shown on a map of the city Skopje. 24-hour traffic volumes in two, three or four direction at each location were counted in each hour by 5 types of vehicles: passenger car, small truck (s.t.), large truck (l.t.), bus and trailer. Stopwatchers for 10 vehicles at each point also measured driving speed in each hour at 50 points.

According to the results of the survey, there are significant differences in the fluctuation patterns of the hourly volumes between that of normal weekday and holidays.

The traffic volume for weekdays shows an increase after 7:00 in the morning and this increase in traffic volume continues until midday, after which it continues to decrease from midnight to sunrise. On the other hand, the traffic volume for holidays, was found to reach the peak at around 12:00 and 23:00, reflecting a distribution pattern consisting of two peak times. The reason for this could be due to the fact that during holidays people mostly revolve around leisure activities and private activities as compared to economic activities on weekdays. Although the daytime traffic volume for weekdays is higher than that for weekends, the difference is not significant (Figs 1 and 2).

As for the traffic volume during peak hours, the number of vehicles along major roadways was calculated to be from 3000 to 8000 vehicles per hour. There

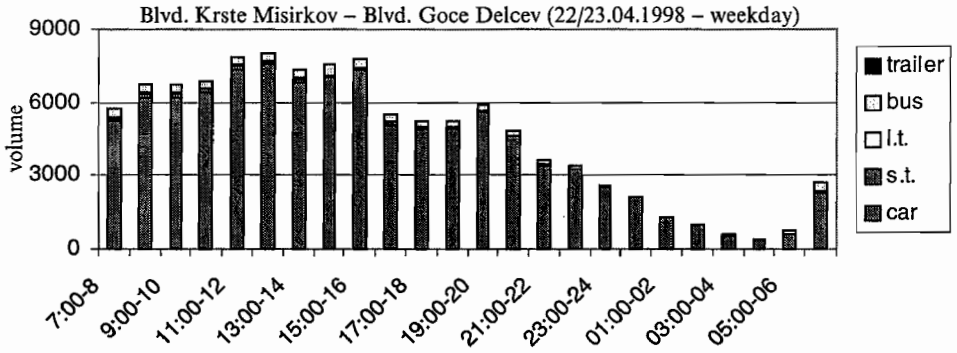

Fig. 1. Daytime traffic volume for weekdays

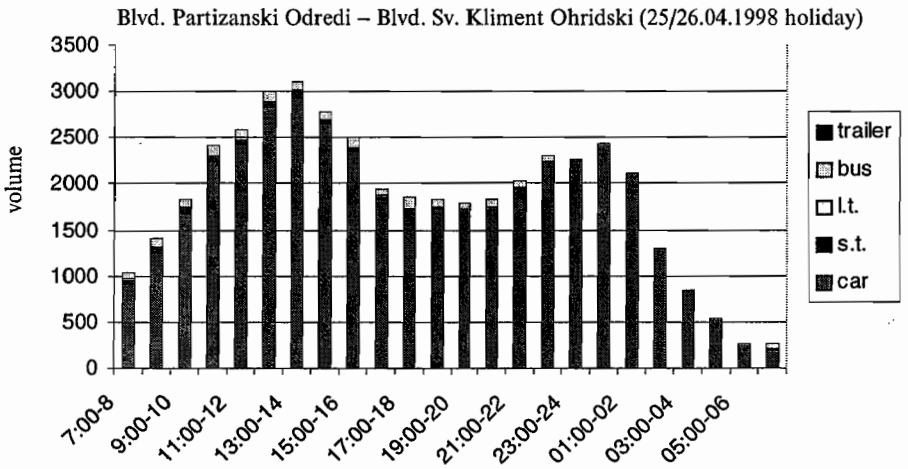

Fig. 2. Daytime traffic volume for weekends

are also cases whereby the number of vehicles at cross-junctions were found to exceed 100 000 vehicles. For example, at measuring point Blvd. Krste Misirkov – Blvd. Goce Delcev, the number of vehicles passed in 24 h on weekday is about 110 000 and during holiday about 95 000. The number of buses (using diesel) at some points is very large (on some crossroads over 5000).

As for the types of vehicles along major roadways passenger car is the largest in numbers, followed by bus, small truck, and large truck. When comparing weekdays with holidays, it is observed that more buses passed on weekdays.

On some measuring points the speed of vehicles was found to be very high: more than the limit of 60 km/h.

AIR QUALITY IMPACT ANALYSIS OF MOBILE EMISSION SOURCES ALONG MAJOR ROAD-WAYS

The distance attenuation of concentration of NO_x (NO and NO_2) was surveyed by the simplified sampler and portable vane direction anemometer in order to understand the characteristics of NO_x pollution by mobile emission along major road-ways in Skopje.

Determination of the concentration of NO and NO_x was performed by the simplified sampler at 6 measuring points: at 2 points for two directions and at 4 points for four directions. Attenuation from 4 main intersections (20 points/ intersections) was at 0, 20, 50, 100 and 150 m and for 2 cross sections (10 points/ cross section) was at 0, 10, 20, 40 and 100 m.

The declining concentrations of NO_2 and NO_x in accordance with the distance from edges and intersections on roads are shown in Fig. 3.

Measuring of the distribution of NO_x shows high concentrations of NO_x on almost all measuring points.

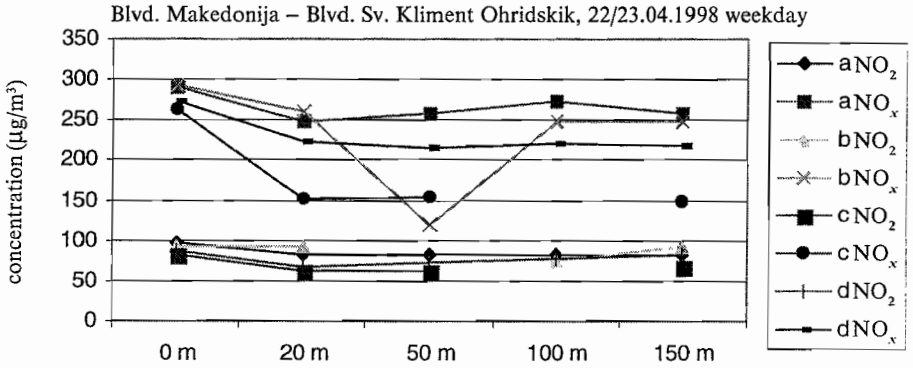

Fig. 3. Declining concentrations of NO_2 and NO_x in accordance with the distance from edges and intersections on roads
a, b, c, d – 4 different directions at each location

AIR POLLUTION MONITORING SYSTEM

The 4 ambient air quality-monitoring stations were set up in 1998 in the western and central sides of the urban areas, the eastern industrial zones and in a new town.

According to automatic continuous monitoring data, the concentration level of CO in the air exceeds that required by the environmental standards for almost every case except for Station 1. In the heating season the environmental standards have been exceeded for all the cases for all the monitoring stations.

As for the non-heating season, the automobile transport is the main CO polluter and it was thought that the high CO concentration at Station 2 and Station 4 has been influenced by such automobile emission as compared to Station 1 (Fig. 4).

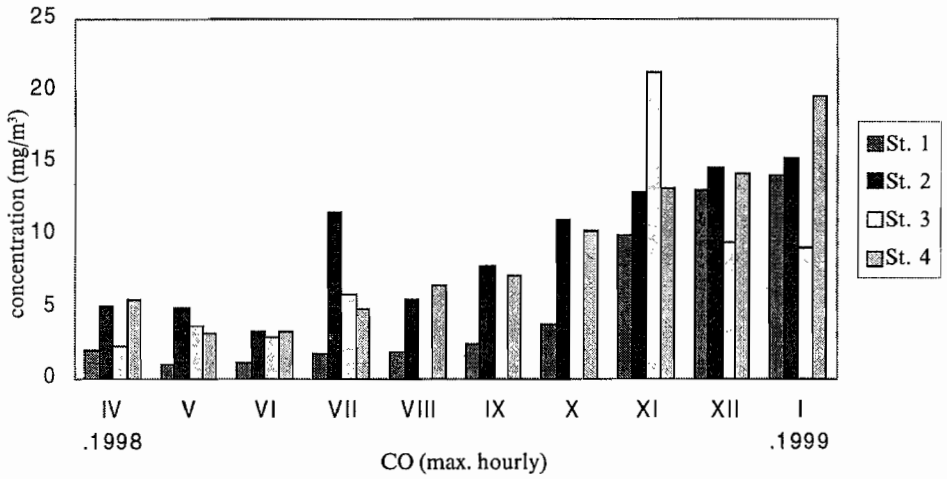

Fig. 4. CO concentration level

SPM concentration level in the air exceeds the standard value in most cases in all monitoring stations. High concentration is observed: the highest value of daily average value is 244 mg/m^3 and the highest hourly value has 1360 mg/m^3. Aberrant hourly concentration such as 209 mg/m^3 in the 98% has not merely resulted from stationary source and exhaust gas from vehicles. It can be resulted from suspended dust. Because of weak wind in Skopje, the atmosphere tends to be still. It is known that this phenomenon makes SPM concentration level high. Dry air is another characteristic of Skopje, and it causes occasional strong wind. It can be estimated through the experience that could raise large amount of sands. Moreover, the automobiles also raise a cloud of dust (Fig. 5).

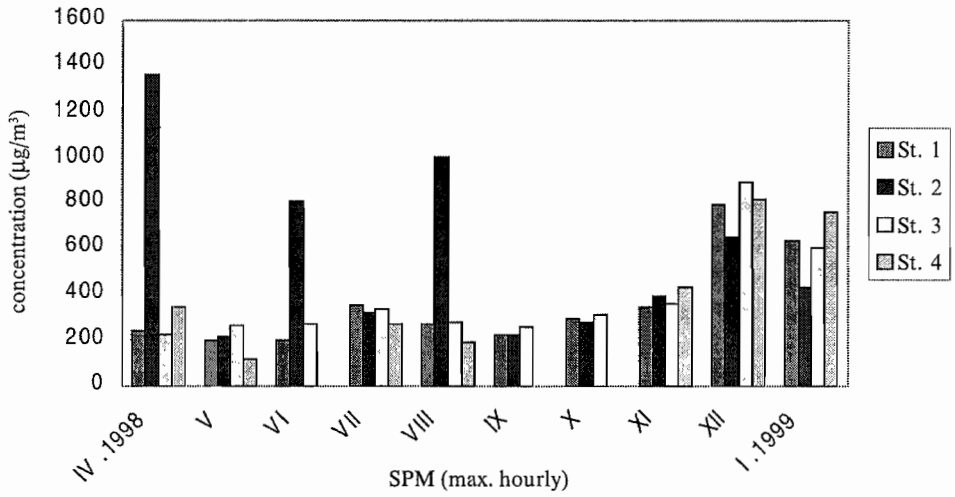

Fig. 5. SPM concentration level

CONCLUSIONS

The analysis of the results of the studies done with several air pollutants in the city of Skopje shows that their concentrations exceed those of the adopted air quality standards:

- High concentrations of CO, SO_2 and black smoke, especially during the winter (heating season) and specific meteorological conditions which help the increase of air pollution.
- Exceeded values of SPM.
- Presence of lead above MPC.
- Possible increased presence of other pollutants not involved with present monitoring, and emitted by the industry and the traffic.

Skopje is one of the most polluted towns in FYR Macedonia which can be seen from the conditions analysis, therefore, the reduction of air pollution must be treated with attention, planning strategy and an effective application of appropriate measures.

The air pollution in Skopje with Pb, NO_x, SPM comes from the heavy traffic in the city. By introducing electrification of the public traffic in the city, the level of those pollutants that comes from the traffic will be reduced. Another important measures will be: use of unleaded oil; replacement of older vehicles with newer ones; higher control of the gas emission from the traffic vehicles which is not done till today, except during their registration; to direct the traffic out of the central city area which is most violated, to plan zones without traffic, i.e. walking zones.

For the reduction or mitigating of the abovementioned unfavourable conditions, the following measures are suggested: gasification, introducing liquid gas as a fuel in the taxi cars, the public traffic, etc.

The preventive action in decreasing and separating the reasons for high air pollution is the most economical way in the battle for the environmental protection.

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