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STUDY OF TRAFFIC-RELATED URBAN PM POLLUTION AT DIFFERENT LOCATIONS

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The overall purpose of this study was to determine the ratio of $PM_{2.5}$ in PM_{10}. Measurements of suspended particulate matter were continuous and carried out at four sampling points in Veszprém with two high volume samplers. The primary point of view in choosing the site of samplings was the investigation of the effect of the road traffic on the $PM_{2.5}$ and PM_{10} concentrations. Results show that the $PM_{2.5}/PM_{10}$ mass fraction mainly depends on the effect of vehicular traffic. Furthermore it was also found that the daytime concentrations differ from the overnight ones. Taking the $PM_{2.5}/PM_{10}$ ratios and calculating the $PM_{2.5}$ concentrations from the PM_{10} data measured by the Hungarian Air Quality Network it can be concluded that many steps must be taken by the local governments in Hungary to fulfil the limits and target values for $PM_{2.5}$ laid down in the directive 2008/50/EC of the European Parliament.

Keywords: DHA-80 high volume sampler, suspended particulate matter, limit value, target vlaue, $PM_{2.5}$, PM_{10}, $PM_{2.5}/PM_{10}$ mass ratio.

Introduction

Among air pollutants particulate matter (PM_{10} coarse fraction and $PM_{2.5}$ fine particles) plays an important role in causing serious health effects so the European Union deals with them as special importance. In the last decade studies of the short-term effects of PM – based on association between daily changes in PM_{10} concentrations and various health outcomes – were conducted all over Europe. In general, results indicate that PM increases the risk of respiratory death in infants under 1 year, affects the rate of lung function development, aggravates asthma and causes other respiratory symptoms such as cough and bronchitis in children. $PM_{2.5}$ seriously affects health, increasing deaths from cardiovascular and respiratory diseases and lung cancer. Increased $PM_{2.5}$ concentrations increase the risk of emergency hospital admissions for cardiovascular and respiratory causes; and PM_{10} affects respiratory morbidity, as indicated by hospital admissions for respiratory illness. [1]

Air quality control is one of those fields where many steps were taken by the European Union recently. The Committee amis to establish a comprehensive strategy through which the air quality might be preserved for a long time.

A new directive was established out of turn in favour of the reduction of particulate matter concentration. Directive 2008/50/EC – on ambient air quality and cleaner air for Europe – was released on 21 May 2008. Limit value for PM_{10} has already been known from previous directive (96/62/EC) but $PM_{2.5}$ was never before controlled. By now new air quality objectives are set for $PM_{2.5}$ including the limit value and exposure related objectives – exposure concentration obligation and exposure reduction target.

Member nations got patience time while they have to make arrangements for staying under these limit values. [2, 3]

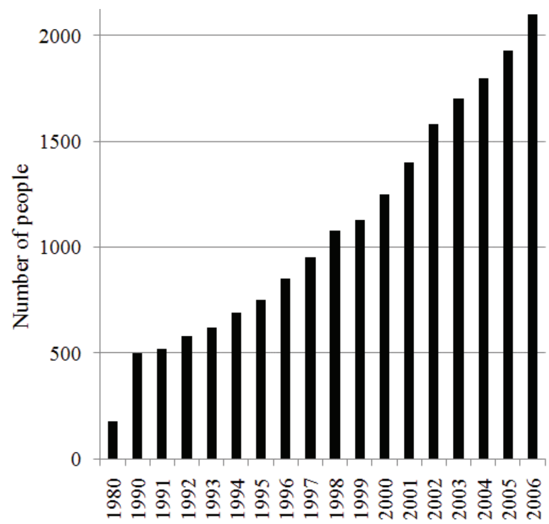

Figure 1: Number of people suffering from asthma in Budapest (1980–2006)

Experiences during air quality control definitely show that changing social-economical circumstances have modified the significance of some air pollutants in the last decades. Traffic originating components are coming to the front where particulate matter plays an important role for its chemical composition, pollution extent and health effect *(Fig. 1)* [4].

We have quite a few $PM_{2.5}$ measuring data in Hungary. Continuous fine particulate measuring occurs only at four places therefore for arrangement plans only the PM_{10} concentrations can be used.

Our aim was in the course of work to make us able to estimate the $PM_{2.5}$ fraction from the available PM_{10} concentrations.

Materials and methods

Measurements for determining the fractions of PM_{10} and $PM_{2.5}$ were carried out in harmony with the MSZ EN 12341:2000 and MSZ EN 14907:2006 standards that are the Hungarian versions of those ones that were worked out by CEN, European Committee for Standardization.

Two DHA-80 High Volume Samplers of the same kind *(Fig. 2)* were used simultaneously. One of them was operating with a PM_{10} pre-separator, the other one was equipped with a $PM_{2.5}$ pre-separator. Both appliances correspond to the reference requirements.

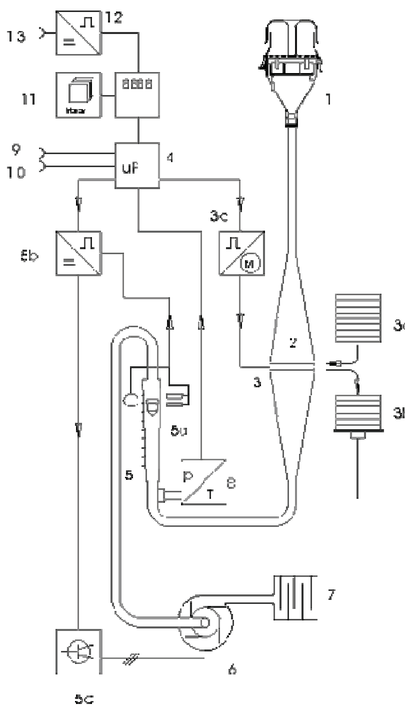

Figure 2: DHA-80 High Volume Sampler (HVS)

Fig. 2 shows the operating system of a HVS. The air is sampled via a sampling probe (1), using a sampling tube, vertically from the top to the bottom through the filter (3) placed in the flowing chamber (2). With DHA-80, changing of filters is done automatically. After the filter, the transported air quantity is measured using a flow meter with a floater (5). Its double photo-sensor (5a) optically senses the floater position. In connection with the control electronics (5b, 5c), the capacity of the blower (6) is adapted to the rpm control, so that the air quantity keeps the set-point value.

Air pressure and temperature are measured upstream the flow meter and continuously averaged by the controller. A real-time protocol states sampling volumes yielding from the sampling time and controlled volume flow as the core information. The air is released from the instrument with reduced noise through the noise baffle (7).

Air-borne dust particles in the sampled air are separated on to Ø 150 mm filters. The flown filter diameter is 140 mm. Sequent gravimetric and analytical analysis could be conducted depending upon the pollutants of interest. The filter conditioning is very important in order to achieve reproducible results. DHA-80 has a container of 15 filters stretched in filter holders. They were changed automatically to the flow position at the pre-set time.

The selected air flow rate is controlled by a flow meter. This value should be calibrated first at the beginning of a measurement, using a gas meter or a secondary standard, e.g. an additional flow meter. During air sampling, the pump flow rate is dynamically controlled, so that this limit value is kept at good reproducibility and at long-term stability despite the deposited filter flow resistance and the sampled ambient air pressure/temperature variation. An integrated microprocessor unit controls the filter changes at the exact pre-set time and collects all relevant data and events. Hereby the air quantity flowing through the filter is defined with high accuracy. [5]

Results and discussion

Continuous measurements of suspended particulate matter were carried out at four sampling points in Veszprém with two high volume samplers.

The overall purpose of this study was to determine the ratio of $PM_{2.5}$ in PM_{10}. The primary point of view in selecting the site of samplings was the investigation of road traffic effect on $PM_{2.5}$ and PM_{10} concentrations.

Among these sites *(Fig. 3, Table 1)* we can find such places where the effects of traffic have low importance and places where effects are remarkable in point of air quality.

Figure 3: Sampling sites

Before the series of measurements we carried out parallel measuring with the two samplers (with the same pre-separators, PM_{10} - PM_{10}, $PM_{2.5}$ - $PM_{2.5}$) to see whether data we measure matches with the accuracy criteria or not.

Table 1: Sampling sites in Veszprém

Places	EOV
Laboratory of Central-Transdanubian Inspectorate for Environment, Nature and Water 4 Patak Square	563035E 195511N
Bárczi Gusztáv Elementary School 12 Batthyány Street	564798E 196206N
Hospital 5 Mártírok Street	563771E 194645N
Balaton Shopping Centre 20-28 Budapest Street	564298E 195187N

From the statistical examination results *(Table 2)* it can be concluded that measuring data fulfil the instructions related to the accuracy that is $K_{95} \leq 5$ µg/m^3.

Table 2: Comparison of the two HVS samplers (equipped with the same pre-samplers)

D_i (µg/m^3)	$D_i^2/2n$	$\sum D_i^2/2n$	S_a	K_{95}
0.7	0.082	PM_{10}		
0.7	0.082	0.223	0.47	2.03
0.6	0.060			
0.6	0.060	$PM_{2.5}$		
0.1	0.002	0.077	0.28	1.20
0.3	0.015			

Measurements were carried out for two days for 12-12 hours (concentrations of a whole day can be determined from the half-day data) after this for another three days for 24 hours at each places. The half-day measurements were started at 18^{00} and 06^{00}. The aim of this division was to control how PM pollution changes at night time when traffic is low and in the daytime when traffic is heavy.

4 Patak Square (Laboratory of Central-Transdanubian Inspectorate for Environment, Nature and Water)

Ratio of $PM_{2.5}$ in fraction PM_{10} changed between 60 and 70% *(Fig. 4)*. Probably the higher ratio of $PM_{2.5}/PM_{10}$ *(Table 3)* is due to the rain whilst sedimentation of coarse particles (PM_{10}) occurs. Concentration of PM_{10} was lower on this day as well. Effect of traffic has no importance on this site.

Table 3: $PM_{2.5}$ and PM_{10} concentrations during 24-hour measuring [µg/m^3]

Date	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	$PM_{2.5}/PM_{10}$ (%)
11-12 Sept.	27.9	20.1	72.0
14-15 Oct.	34.6	22.9	66.2
15-16 Oct.	45.3	28.0	61.8

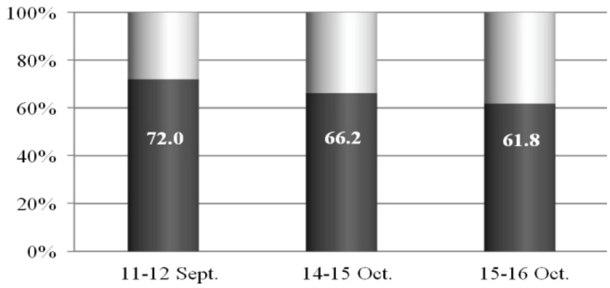

Figure 4: Ratio of $PM_{2.5}$ in PM_{10} [%]

12 Batthyány Street (Bárczi Gusztáv Elementary School)

This place cannot be regarded obviously to be a so called “background station”. Traffic is not determinant but we should not leave it out of consideration.

From the 24-hour-data it emerges that the ratio of fine particles increases above 70% *(Fig. 5)* that is ca. 10% higher than values on Patak square. Difference may be due to the vehicular traffic that is not far from this measuring point. Considering *Fig. 6* it can be stated that ratios of $PM_{2.5}$ in PM_{10} are higher at night time (18:00–06:00) than in daytime. We can conclude that a bigger part of the coarse fraction settles out in the late evening hours when traffic and air motion decrease.

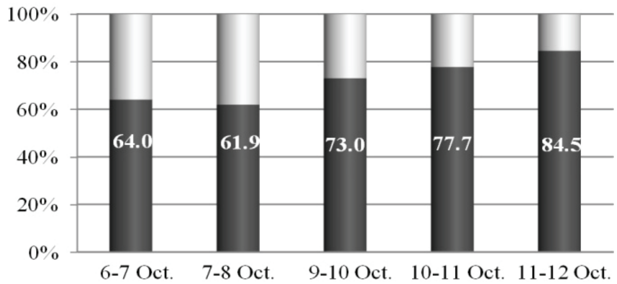

Figure 5: Ratio of $PM_{2.5}$ in PM_{10} [%]

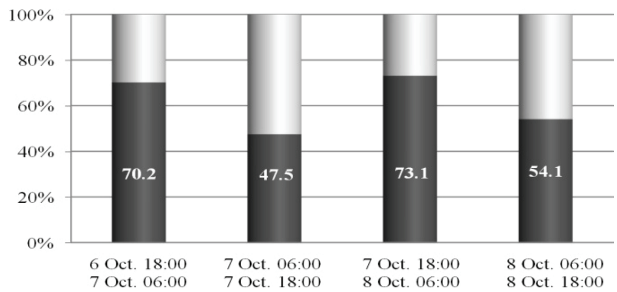

Figure 6: Ratio of $PM_{2.5}$ in PM_{10} [%]

5 Mártírok Street (next to Hospital)

Ratio of $PM_{2.5}/PM_{10}$ was around 70% during the whole week we measured. Weather was not the same on every day and these changes appear in the concentrations as well *(Table 4)*. Weather was rainy on the last days, during this time around both type of concentrations decreased. Half-day values *(Fig. 7)* vary on the same way as in the previous case (Fig. 6).

Table 4: $PM_{2.5}$ and PM_{10} concentrations during 24-hour measuring [$\mu g/m^3$]

Date	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	$PM_{2.5}/PM_{10}$ (%)
29-30 Sept.	21.3	14.9	70.0
30 Sept. – 1 Oct.	24.3	16.2	66.7
1-2 Oct.	22.1	15.1	68.3
2-3 Oct.	19.2	12.5	65.1
3-4 Oct.	9.0	6.2	68.9

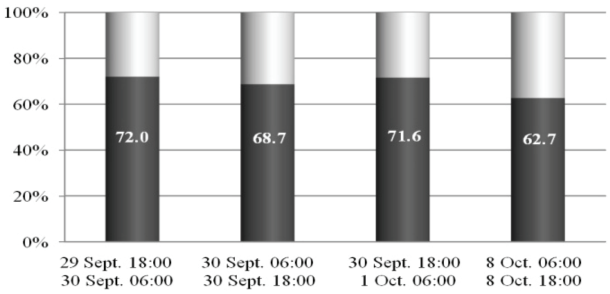

Figure 7: Ratio of $PM_{2.5}$ in PM_{10} [%]

20-28 Budapest Street (Balaton Shopping Centre)

Almost all week was wet. First day of the week was the rainiest, next days there was just drizzling. *Fig. 8* shows that rain has stopped for a while in the middle of the week and as a result of it concentrations started to increase. As rain appeared again values started to decrease. It is evident that particulate matter is settled out from the ambient air.

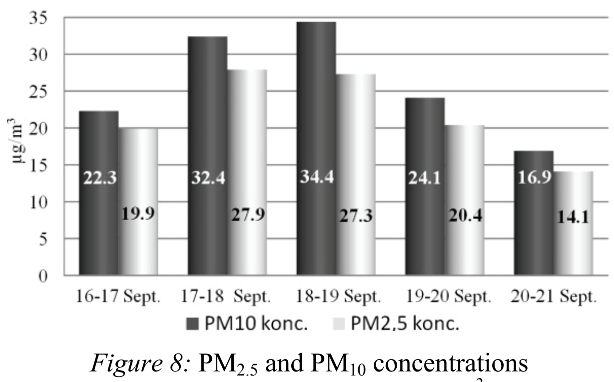

Figure 8: $PM_{2.5}$ and PM_{10} concentrations during 24-hour measuring [$\mu g/m^3$]

It can be explained at first with heavy traffic because Budapest Street has the biggest vehicular traffic among the four selected sites. Dust can be derived from exhaust pipes, from abrasion of rubber tyre and mountings of motor vehicle. These particles are continuously stirring so they stay in the ambient air.

Another fact is that exhaust gases can be characterized primarily by the PM_1 and $PM_{2.5}$ fractions therefore these ranges will be the most significant part in PM_{10}. Settling out of coarse fraction can be observed as well *(Fig. 9)* such like in the previous cases.

We must mention one more possible explanation for the high amount of $PM_{2.5}$ in PM_{10}. It may happen that the non-wetting agglomerated particles fall apart to finer particles under the influence of rainy days.

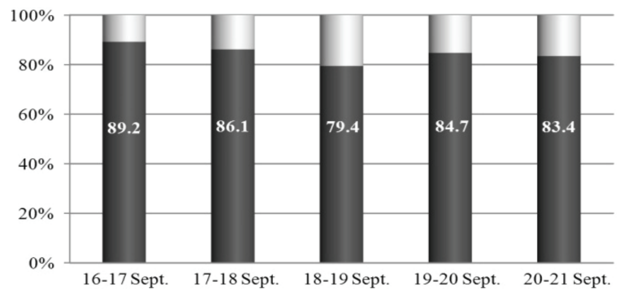

Figure 9: Ratio of $PM_{2.5}$ in PM_{10} [%]

Summary

$PM_{2.5}$-PM_{10} measurements on different kind of places show that the mass ratios of $PM_{2.5}$ in PM_{10} are broadly speaking similar at those places where the effects of traffic are not remarkable.

As we can see it below (in *Table 5*) places that are hardly influenced by vehicular traffic have a $PM_{2.5}/PM_{10}$ ratio of 69%, but where this effect is significant the $PM_{2.5}/PM_{10}$ ratio increases up to 85% *(Fig. 10)*. Difference is conspicuous. These facts confirm our aspect that traffic might be the most important reason for PM_1-$PM_{2.5}$ (fine particle) pollution.

Table 5: Confidence interval determined from the $PM_{2.5}/PM_{10}$ scatterings

Places	Patak Street	Batthyány Street	Mártírok Street	Budapest Street
Average of $PM_{2.5}/PM_{10}$ [m/m%]	66.7	72.2	67.8	84.6
Average of the similar sites [m/m%]	68.9			84.6
Scattering [m/m%]	6.4			3.6
K_{95}	±3.9			±4.5
Confidence interval [m/m%]	**68.9 ± 3.9**			**84.6 ± 4.5**

Apart from the measuring sites we experienced that the $PM_{2.5}$ ratio was always higher at night time (18^{00}–06^{00}) than in the day time (06^{00}–18^{00}).

Because of the measurements' short time the calculated ratios are just estimations. To have more exact values many more measurements are needed.

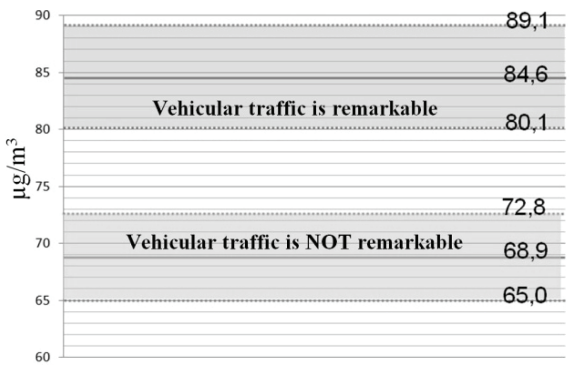

Figure 10: $PM_{2.5}$ and PM_{10} concentrations during 24-hour measuring [µg/m^3]

The Ministry of Environment and Water accomplished a nationwide measuring together with the Inspectorates for Environment, Nature and Water in 2005 and 2008 through the whole year. The type of their measuring sites in Veszprém were similar to our ones. One of them was the same (Budapest Street) and the other one was like Patak Street that is a kind of "background" station. Average of their measuring data in 2005 is 37.8 µg/m^3 and it was 21.0 µg/m^3 in 2008. If I take our ratios as a norm we have to realise that the $PM_{2.5}$ concentration would be at the former one 32.0 µg/m^3 and in the latter case it would be around 14.0 µg/m^3.

We must see that $PM_{2.5}$ concentrations increase above the target value (20 µg/m^3) without doubt at those places where traffic is remarkable. Serious arrangements are needed everywhere to be able to fulfil limit values set in the directive 2008/50/EC. [6, 7]

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