ANALYSIS OF PARTICULATE MATTER (PM_{10}) CONCENTRATIONS IN LATVIA

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1. Introduction

The national assessment of the Latvia's particulate matter (PM_{10}) data covers the emissions of gaseous pollutants and particulate matter and the PM_{10} concentrations in urban and traffic areas over 2000-2005. The concentrations have been recorded at the air quality monitoring stations of the Latvian Environment, Geology and Meteorology Agency and Riga City Council.

Exceedances of PM_{10} concentration were closely looked at against short- and long-term air quality limit values, specified in European directives. With this in mind, and human health in particular, the quantitative and qualitative impacts of meteorological parameters were analyzed.

The assessment provides an analysis of the relationship of meteorological parameters and PM_{10} levels in urban and traffic areas. Meteorological conditions were analyzed, with special emphasis on the air pollution episodes caused by the wind (speed and direction), temperature, humidity, rainfalls, and daily and seasonal variations. The study was performed in order to identify the meteorological conditions that would cause extremely high particulate matter concentrations in agglomerations and urban areas in particular.

2. Measurement network and methods

Particulate matter (PM_{10}) monitoring started in 2000. Since then, the observational network has been greatly improved. The geographical position of the monitoring stations and a description of the sites and the changes are shown in Figure 1 and Table 1.

Figure.1. Geographical position of PM_{10} monitoring stations in Latvia,
(yellow- operated stations, blue – planned stations)

Table 1

Measurement sites, Latvia

No	Measurement site	Period of observations	Site type	Method, equipment
1	Riga, Centre	2000 - 2002	Traffic station	Beta gauge, SM200
2	Riga, Brivibas	2003 - 2005*	Traffic station	Beta gauge, SM200
3.	Riga, Tvaika	2003 - 2005*	Urban-industrial	Beta gauge, SM200
4	Riga , Valdemara	2003 - 2005*	Traffic station	Beta gauge, Horiba
5.	Liepaja	2000 - 2005*	Traffic station	Beta gauge, SM200
6.	Ventspils	2000 - 2005*	Urban background	Beta gauge, SM200
7.	Rezekne	2001-2004	Urban background	Beta gauge, SM200
8.	Rucava	2002	Rural background	Beta gauge, SM200

* monitoring is being continued

At present, 5 urban stations are carrying out monitoring of PM_{10} , with 3 of them (traffic and urban-industrial stations) in the capital city of Riga (764329 inhabitants) and 2 in the western part of Latvia, in the biggest towns of Ventspils (43928 inhabitants) (urban-background station) and Liepaja (89448 inhabitants) (traffic station).

The PM_{10} measurements at the EMEP station Rucava were performed in the period from July to August 2002. The measurements were stopped because of a technical problem.

In order to meet the requirements of EU Directives, it is planned to resume the measurements at Rezekne and Rucava, Zoseni (EMEP), the rural station at Nigrande and the urban background station in Riga.

3.Pollution sources

During the last 15 years, a significant decrease in total emission of gaseous pollutants has been observed. In 1990 -2004, the total SO_2 emission has decreased by 96.1%, NO_X by 42.9% and NH_3 by 72%. The reduction occurred mainly due to the use of fuels with a lower sulphur concentration as well as switching from solid and liquid fuels to natural gas and biomass, significant changes in industrial activity (Figure 2).

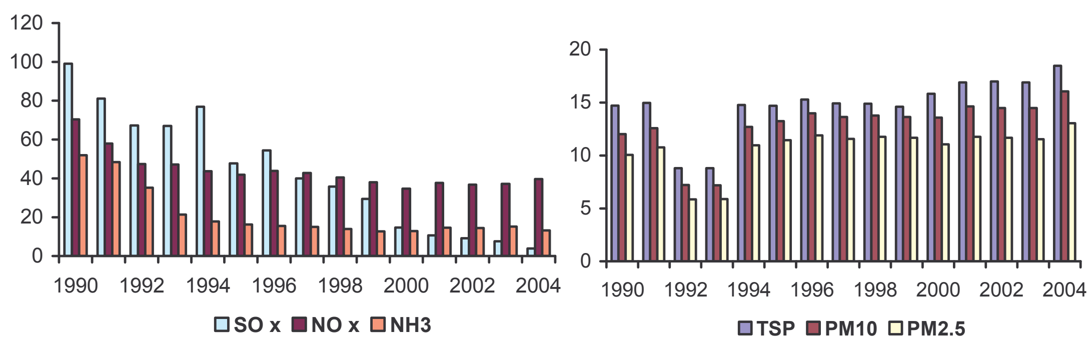

Figure 2. Total emissions of gaseous pollutants and particulate matter in Latvia ,Gg

Primary particulate matter emission has no significant changes, from 2000 to 2004 particulate matter emission have increased by 15% it is because amount of used fuel is increased as well as number of livestock.

The assessment of the PM_{10} emission was carried out according to the EMEP 50x50 km^2 grid for 8 emission source categories. It has show that most of pollution sources are situated in the central (capital city included), south-western (Liepaja) and south-eastern (Daugavpils) parts of Latvia.

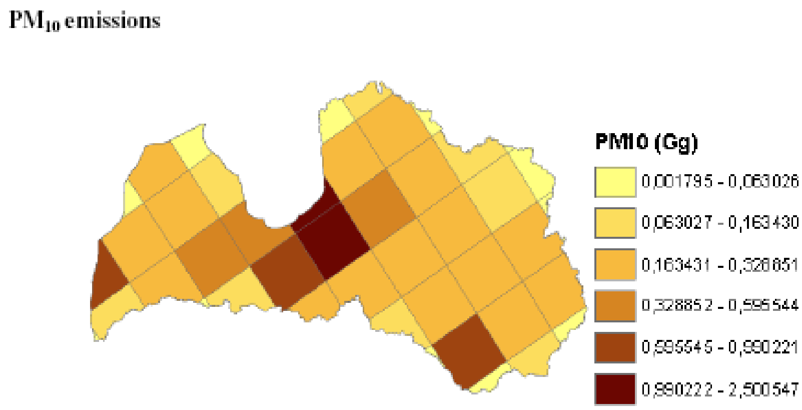

Figure 3. Total PM_{10} emission within EMEP grid cells (50x50 km^2), 2000.

The main sources of PM_{10} emissions are the commercial and residential sectors. Combustion of wood and wood products accounts for 71.7% of total PM_{10} emission, against 10.2% (industries), 8.9% (transport) and 5.8%(agriculture).

The long-range pollution transport significantly contributes to PM_{10} pollution level due to the geographical position of the country (entry of pollution from the major polluting areas in central Europe) and close proximity of the sea. The main pollutants are nitrates, sulphates, ammonium compounds as well as the primary particulate matter. The secondary particulates forming by oxidation of SO_2 and NO_X and in reactions with ammonia. The long-range pollution transport accounts for 80% of oxidized sulphur, 75% of oxidized and reduced nitrogen of total deposition of pollutants onto the territory of Latvia.

In addition, there has been a large contribution from natural sources, e.g. soil dust and sea spray.

4. Results

4.1. Exceedance of EU limit values

The monitoring results are presented in Table 2 and clearly testify to the fact that PM_{10} is one of the problematic pollutants for the whole area of Latvia.

Results of particulate matter (PM_{10}) monitoring

Table 2

No	Measurement site	Year	Frequency of observation	Annual mean value, ug/m^3	Daily maximum value, ug/m^3	Hourly maximum value, ug/m^3	Number of exceedances of 50 ug/m^3 value
1.	Riga, centre	2000 2001 2002	daily	59* 54 58	116 176 215	n.d.	* 92 109
2.	Riga, Brivibas	2003 2004 2005	daily	56 52 54*	156 106 137	n.d.	105 99 *
3.	Riga, Valdemara	2003 2004 2005	hourly	54 48 48	229 109 166		139 137 124
4.	Riga, Tvaika	2003 2004 2005	daily	27* 31 32	61 99 92	n.d.	* 23 32
5.	Liepaja	2000 2001 2002 2003 2004 2005	daily	41* 41 44* 49 45 43	103 126 138 172 149 99	n.d.	* 65 * 78 86 69
6.	Ventspils	2002 2003 2004 2005	daily	25 16 15 18	78 127 48 55	n.d.	20 3 0 3
7.	Rezekne	2001 2002 2003 2004	daily	36* 51* 39 38*	158 250 185 98	n.d.	* * 35 *
8.	Rucava	2002	daily	52*	99	n.d.	

n.d. – no data
* less than 50 % of measurements

An EU annual limit value of 40 ug/m^3 of PM_{10} and a limit value of 50 ug/m^3 for daily average of PM_{10} for more than 35 days was exceeded at the observation stations in Riga and Liepaja during 2000-2005. At all other stations, annual average concentrations exceeded an upper assessment limit of 14 ug/m^3 .

During the 2005-year 66 % of PM_{10} concentrations were under 50 ug/m^3 limit value but in 34 % of cases this limit value was exceeded (figure 4).

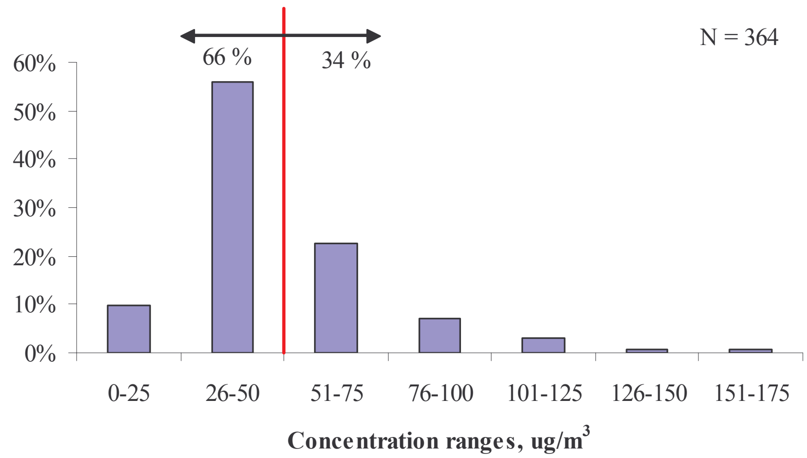

Figure 4. Distribution of PM_{10} concentration at station Riga,Valdemara, 2005

Random PM_{10} measurements at the EMEP station in Rucava in July-August 2002 showed the levels similar to those at the traffic stations in Riga, with an average value of 48 ug/m^3 (Figure 5).

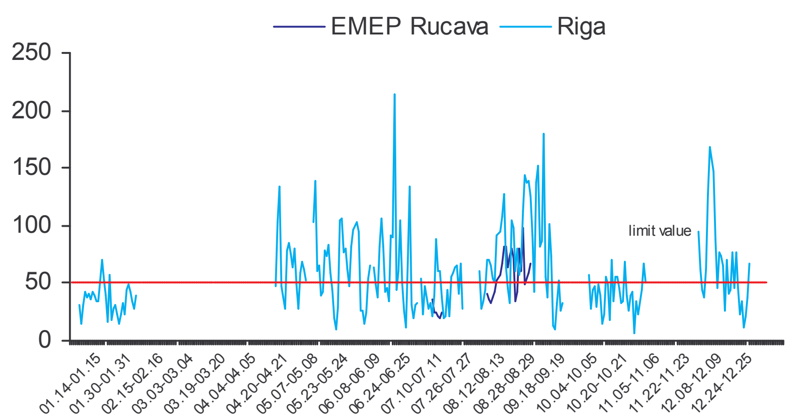

Figure 5. Dynamics of PM_{10} daily (ug/m3) concentrations at EMEP (Rucava) and traffic (Riga) stations , 2002.

Annual average transboundary concentrations of PM_{10} in Latvia in 2004, calculated with the Unified EMEP model ranged within 5 to 10 ug/m^3.

The PM_{10} annual average concentration for the traffic stations in Latvia was in generally higher compared to other European countries (Figure 6).

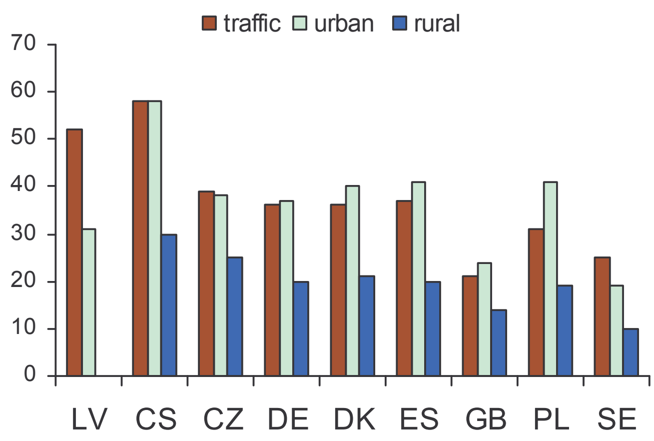

Figure 6. Annual average concentrations of PM_{10} (ug/m3) in Latvia and other European countries, 2004

4.2. Hourly, daily and monthly variations

The causes of daily variations between the heavy polluted days and the days of good air quality were analyzed. The analysis involved testing of each individual variable; identification of the mathematical expression of the relationship and compilation of a list of key indicators that cause particulate matter pollution.

In comparing the hourly and daily variations at the station in Riga (Valdemara), concentration maxima were recorded in the morning, with a stable decreasing tendency over the rest of the day. Some differences (37% on average) were identified during the week days and on weekend (Figure 7). The situation was alike at other stations.

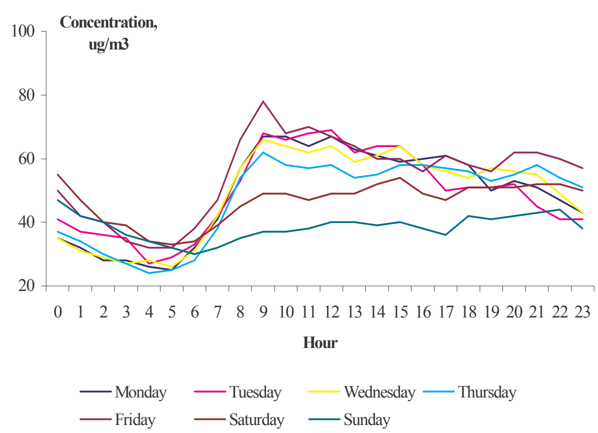

Figure 7. PM_{10} hourly and daily variations at station Riga, Valdemara, 2004

An analysis of monthly variations showed the highest values during February-April (Figure 8).

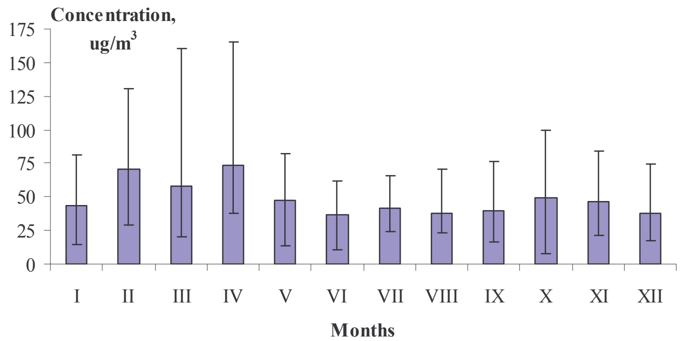

Figure 8. PM_{10} monthly variations at station Riga, Valdemara, 2005

The seasonal variations were calculated for the astronomical seasons: winter: from December, 22 till March, 20; spring: from March, 21 till June, 21; summer : from June, 22 till September 22; autumn : from September, 23 till December, 21.

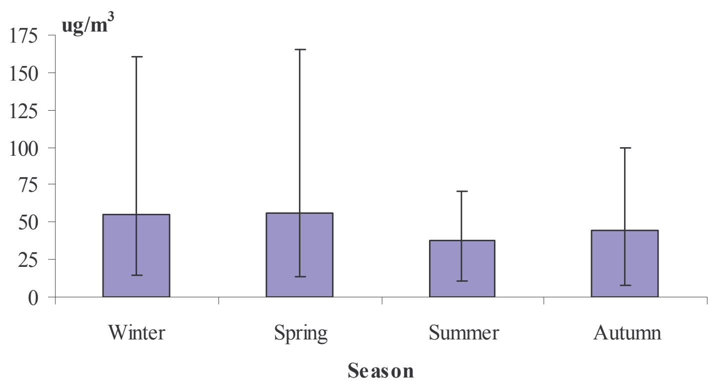

Figure 8. PM_{10} seasonal variations at station Riga, Valdemara , 2005

The highest concentrations and variation range of PM_{10} were observed in the spring and winter (Figure 8).

4.3. Influence of meteorological parameters

Precipitation significantly influences the particulate matter pollution levels. On days with precipitation, particulate matter concentrations are lower comparing to clear sky days (Figure 9).

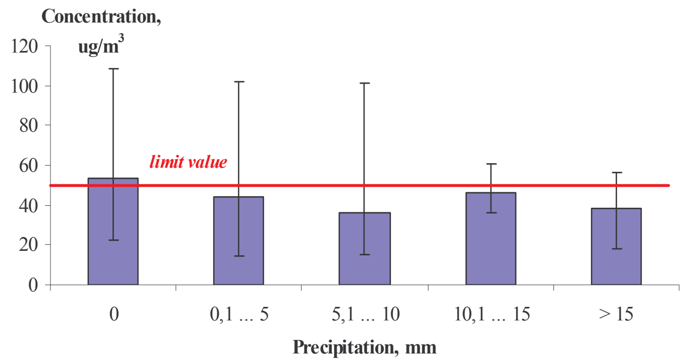

Figure 9. PM_{10} daily concentrations on days with and without precipitation at station Riga, Valdemara, 2004.

On the so-called dry days (days without or poor precipitation), the daily limit value was exceeded in 94 % of the cases (figure 10).

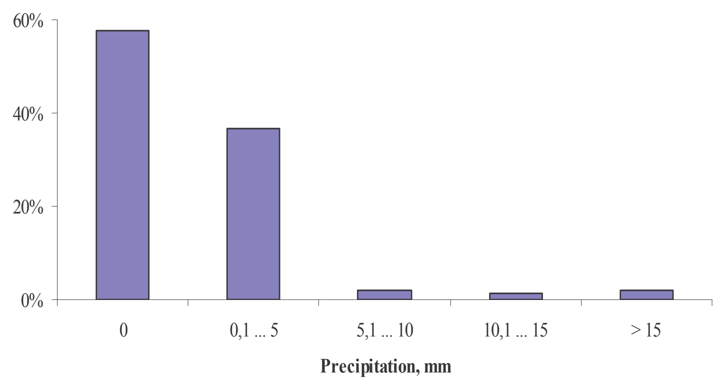

Figure 10. Cases of exceedance of PM_{10} of the daily limit value on days with and without precipitation at station Riga, Valdemara, 2004.

The wind is one of the dominant factors that effect the particulate matter pollution level. In East, South-East, and South winds (direct impact of traffic, because station is located at the left border of the street, the PM_{10} concentrations exceeded the daily limit value.

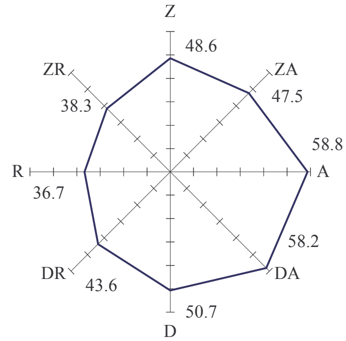

Figure11. Wind rose of PM_{10} concentrations at station Riga, Valdemara, 2004.

Concentrations of over 100 ug/m^3 of PM_{10} increases in a wind speed of 5.5-7.9 m/s (Figure 13).

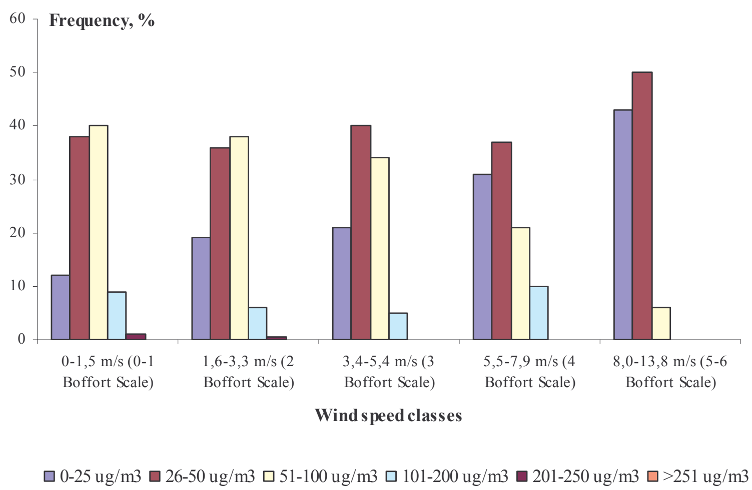

Figure 13. Dependence of PM_{10} concentration on the wind speed week days at station Riga,Valdemara, 2004.

During spring time some relationship was found between PM10 concentrations and relative humidity for one particular wind speed diapason (5.5-7.9 m/s), which has been selected as a transition switch for concentration specific weight changes from lower to higher one (Figure 14).

The lowest PM_{10} hourly concentration under definite meteorological conditions (wind speed of 5.5-7.9 m/s, relative humidity of 0-25 %) is 89 mkg/m^3 (Figure 15). Normally, such meteorological conditions have occurred 15 times per year, with 14 of them in spring.

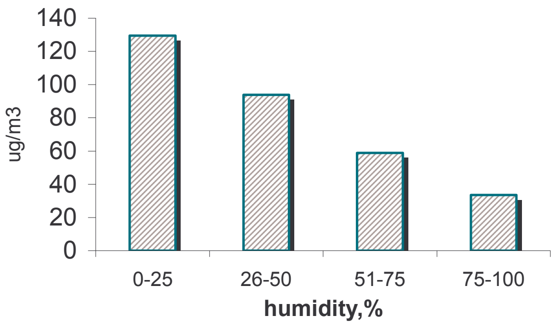

Fig14. Spring PM_{10} average concentrations versus relative humidity (wind speed 5.5-7.9 m/s)

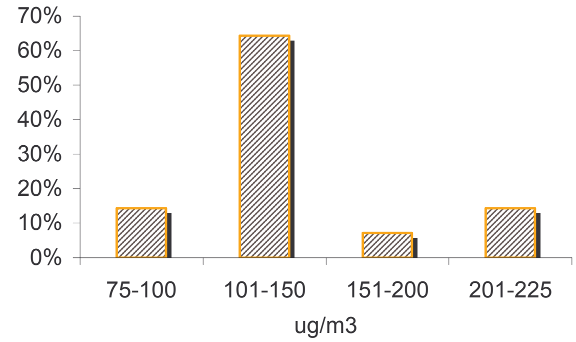

Fig15. Spring PM_{10} concentration distribution (wind speed 5.5-7.9 m/s, relative humidity 0-25 %)

Correlation coefficients of main pollutants and meteorological parameters were estimates as linear best to fit coefficients (Table 3).

Correlation coefficients of main pollutants and meteorological parameters in Riga at Valdemara Street (2004)

Table 3

	PM_{10}	Benzene	NOx	O3	Xylene	Toluene	Wind speed	Wind direction	Temperature	Global radiation	Relative humidity	Atmospheric pressure
PM_{10}		0.29	0.35	0.16	0.20	0.22	0.01	0.01	0.001	0.02	0.06	0.02

5. Conclusions

- PM_{10} is one of the pollutants of great concern for the whole of Latvia. Despite the decreasing tendency for gaseous pollutant emissions, stable and high PM_{10} pollutions levels have been determined for 2002-2005. EU annual limit value of 40 ug/m3 for PM_{10} and daily limit value of 50 ug/m^3 was exceeded during last years.

- concentrations of PM_{10} at rural background (EMEP) station Rucava in July-August of 2002 were at the levels measured in urbanized territories.

- Meteorological parameters such as precipitation, wind speed and direction has significant influence to PM_{10} pollution levels at some particular cases (specially at high pollution episodes), only strong direct relationship wasn't found. On dry days (days without or poor precipitation), the daily limit value was exceeded in 94% of the cases. During the spring time when wind speed varies between 5.5-7.9 m/s and relative humidity is very low (0-25 %) hourly PM_{10} pollution levels could increase till 100-150 ug/m^3 . Normally 15 such specific meteorological conditions have occurred per year with 14 of them during the spring.

- Some linear relationship between PM_{10} concentrations BTX and NOx was stated, the highest of them – NOx (R^2 = 0.35).

References

1.Central Statistical Bureau (CSB) in Latvia, 2006.
2. Latvian's informative inventory report, submission of Latvian CLRTAP data in 2006
3. Transboundary particulate matter in Europe, Status report 4/2006, CCC&MSC-W, 2006.