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PM LEVELS AND I/O RATIOS OF PM IN THE SCHOOL LOCATED IN THE NIŠ CITY CENTER, SERBIA

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Schoolchildren exposure to PM

Indoor air quality in educational buildings is of great importance since children and students spend a large part of their time in the classrooms.

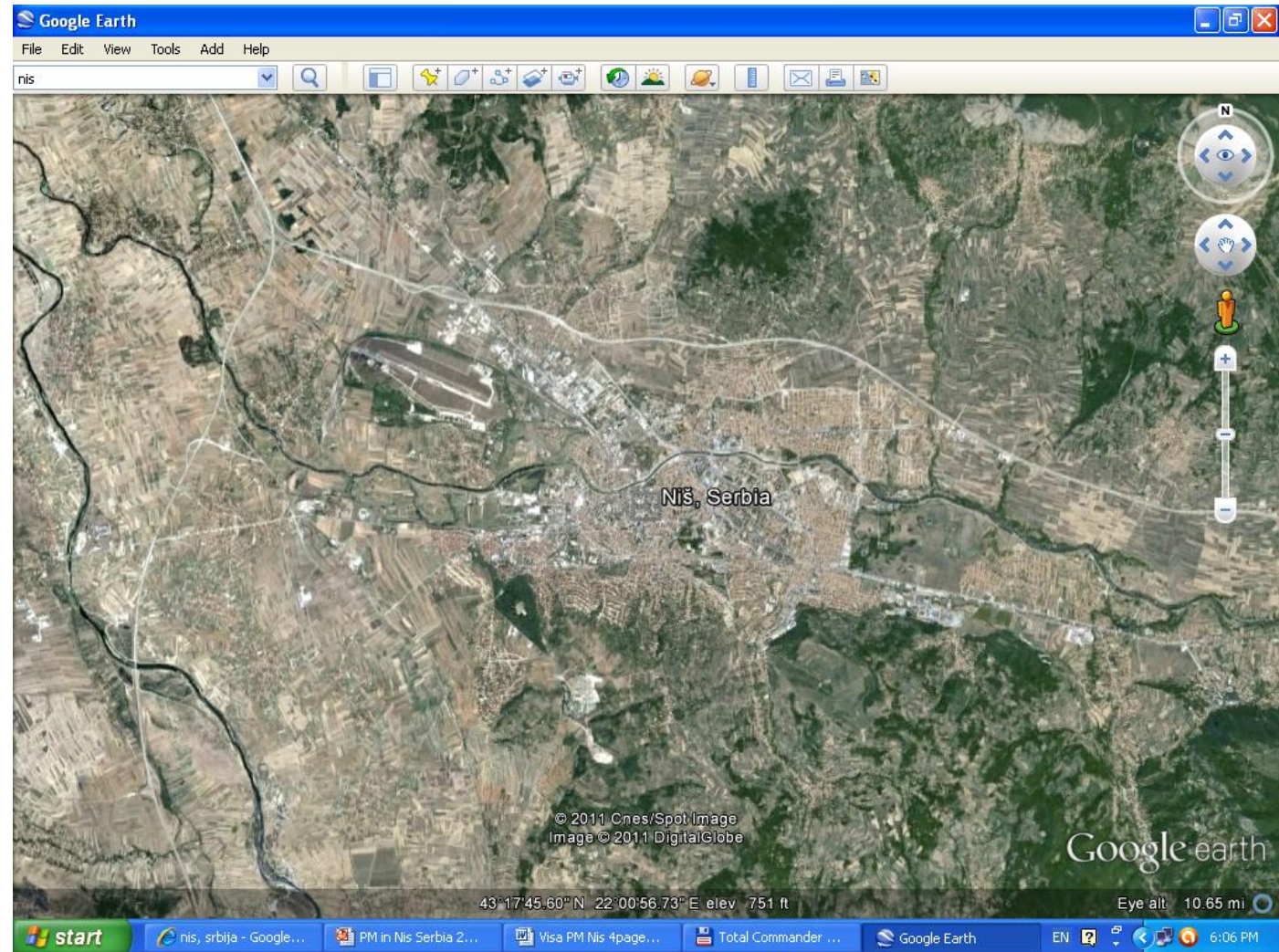
The city of Niš is the center of Southeastern Region of the Republic of Serbia and the second biggest city in the country.

This work presents the results of an ongoing study on schoolchildren exposure to PM in the city of Niš.

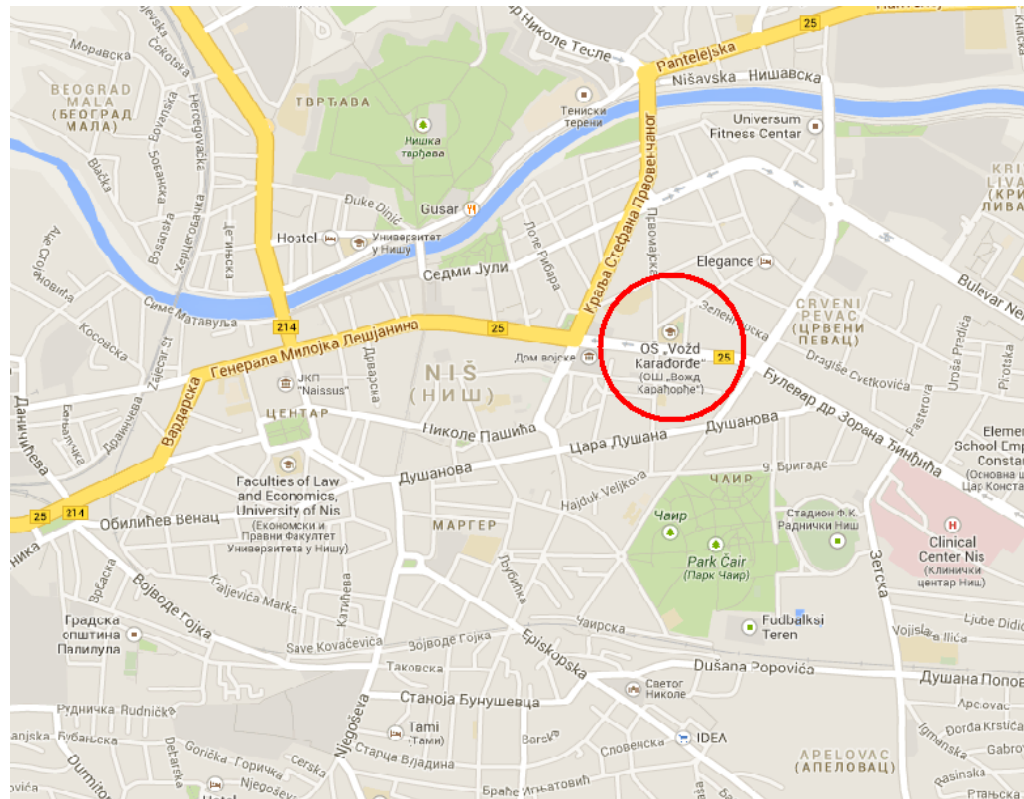


Study area

The city area is in the valley closed from three sides, at average height of 200 m above the sea level. Niš has continental climate with average annual temperature of about 11.2°C.



Measurement period and location



PM mass concentrations were measured during winter period, from 20 March to 4 April 2013, at primary school VK located in the Niš city center.

Measurement period and location



Primary school VK located on a busy street in the Niš city center.

Measuring equipment

- The European reference low volume samplers, Sven/Leckel LVS3, with size-selective inlets for PM10 and PM2.5 fractions, were used to collect particulate matter in indoor and in ambient air.
- GRIMM EDM 180 dust monitor, based on the optical light scattering technology is used for simultaneous real-time measurement of ambient PM (PM10 and PM2.5) levels



Measuring equipment

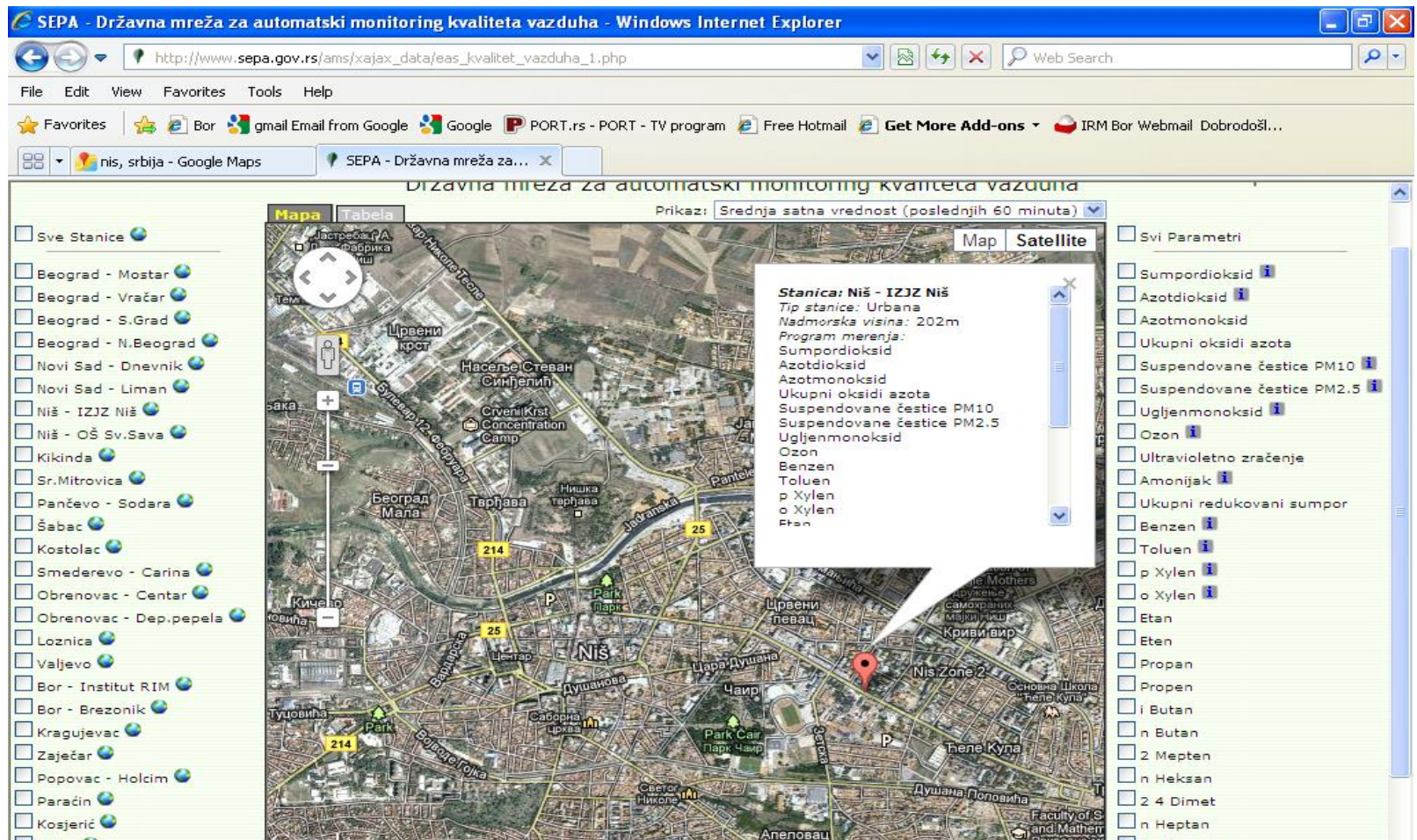
In accordance with the Air Protection Law authority over the national network for air quality monitoring in the Republic of Serbia has the Serbian Environmental Protection Agency (SEPA).

SEPA nowadays operates the network with 40 automatic monitoring stations (AMS) included. Two of them (AMS Nis Traffic, and AMS Nis Urban) are installed in the city of Niš.

The AMS Nis Traffic is situated in the city center, in a residential area, near a major avenue with heavy-traffic.

This AMS contains GRIMM EDM 180 dust monitor, for real-time monitoring of PM10 and PM2.5 concentrations.

Measuring equipment



The AMS Nis Traffic is situated in the city center, in a residential area, near a major avenue with heavy-traffic.

Results and discussion

Date	PM10 IN $\mu\text{g}/\text{m}^3$	PM10 OUT $\mu\text{g}/\text{m}^3$	PM10 IN/OUT $\mu\text{g}/\text{m}^3$
20.03.	66.4	47.1	1.41
21.03.	35.5	21.6	1.64
22.03.	54.1	36.4	1.49
23.03.	61.5	67.0	0.92
24.03.	48.8	57.9	0.84
25.03.	42.4	20.0	2.12
26.03.	41.5	28.6	1.45
27.03.	41.8	35.9	1.16
28.03.	56.7	46.5	1.22
29.03.	39.8	29.1	1.37
30.03.	55.4	86.0	0.64
31.03.	26.1	29.4	0.89
01.04.	68.0	57.4	1.19
02.04.	58.6	44.5	1.32
03.04.	49.4	31.5	1.57
04.04.	91.9	87.7	1.05
05.04.	90.0	88.0	1.02

The daily mean PM10 level in the school was $54.6 \mu\text{g}/\text{m}^3$.

The daily mean PM10 level in the ambient air was $47.9 \mu\text{g}/\text{m}^3$.

Results and discussion

Average annual concentrations of PM10 in the Republic of Serbia (SEPA annual report 2010)

AMS Nis
Traffic

АМСКВ, Мерно место	PM10 ($\mu\text{g}/\text{m}^3$)			Извор података	Метод мерења	Расположивост (%)
	средња вредност	број дана >ГВ	макс. днев. вредност			
Смедерево_Радицац	60	161	269	1	A	67
Панчево Старчево	60	149	252	3	A	88
Смедерево_Раља	60	109	204	1	A	51
Лазаревац	53	115	226	2	A	82
Ниш_ИЈЗ Ниш	51	123	197	1	A	94
Београд_Панч.мост	48	115	178	1	A	92
Београд_Зелено брдо	47	103	232	1	A	87
Земун Ј Копитара	42	74	385	2	A	80
Београд_Мостар	41	86	162	1	A	95
Панчево Војловица	40	79	313	3	A	99
Смедерево_Центар	38	49	182	1	A	70
Београд БД Стефана 54а	37	66	192	2	A	97
Београд_Стари град	37	52	156	1	A	84
Београд О бригада	37	57	769	2	A	95
Нови Сад_Дневник	36	62	113	1	A	94
Београд_Н.Београд	35	44	167	1	A	83
Бор_Градски парк	31	36	80	1	A	83
Обреновац М. Милан. 3	29	29	224	2	A	57
Беоцин центар	24	16	175	1	A	59

Results and discussion

Average annual concentrations of PM₁₀ in the Republic of Serbia (SEPA annual report 2014)

AMS Nis Traffic

PM ₁₀		средња годишња вредност	број дана са > 50 µg/m ³	максимална дневна вредност
Ваљево	T	76	162	448
Ужице	T	67	146	382
Београд_Врачар	T	43	89	198
Крагујевац	T	42	90	221
Ниш_ИЗЈЗ Ниш		38	73	196
Зајача	T	37	68	146
Косјерић		35	80	163
Зрењанин_АПВ		31	79	258
Београд_Мостар		29	48	115
Београд_Н.Београд		27	46	96
Нови Сад_СПЕНС		21	21	84
Смедерево_Центар		57	133	218
Сремска Митровица_Завод		43	51	410
Беоцин_Центар		30	45	176
Каменички Вис	T	17	0	48

Results and discussion

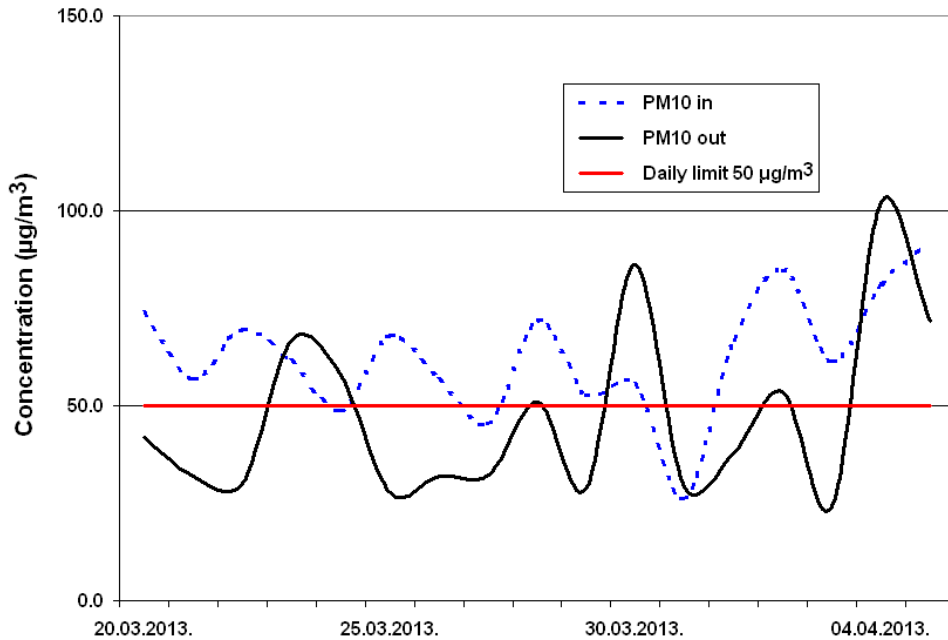
Date	PM2.5 IN $\mu\text{g}/\text{m}^3$	PM2.5 OUT $\mu\text{g}/\text{m}^3$	PM2.5 IN/OUT $\mu\text{g}/\text{m}^3$
20.03.	37.4	32.1	1.16
21.03.	22.3	18.2	1.22
22.03.	36.6	32.4	1.13
23.03.	49.3	59.7	0.83
24.03.	38.7	52.8	0.73
25.03.	25.4	20.3	1.25
26.03.	26.7	28.2	0.95
27.03.	34.9	36.8	0.95
28.03.	42.1	42.3	1.00
29.03.	31.1	24.4	1.27
30.03.	40.9	56.4	0.72
31.03.	15.3	18.8	0.81
01.04.	47.0	46.0	1.02
02.04.	43.2	39.7	1.09
03.04.	30.2	24.6	1.22
04.04.	68.6	107.5	0.64
05.04.	64.1	66.8	0.96

The daily mean PM2.5 level in the school was $38.5 \mu\text{g}/\text{m}^3$.
The daily mean PM2.5 level in the ambient air was $41.4 \mu\text{g}/\text{m}^3$.

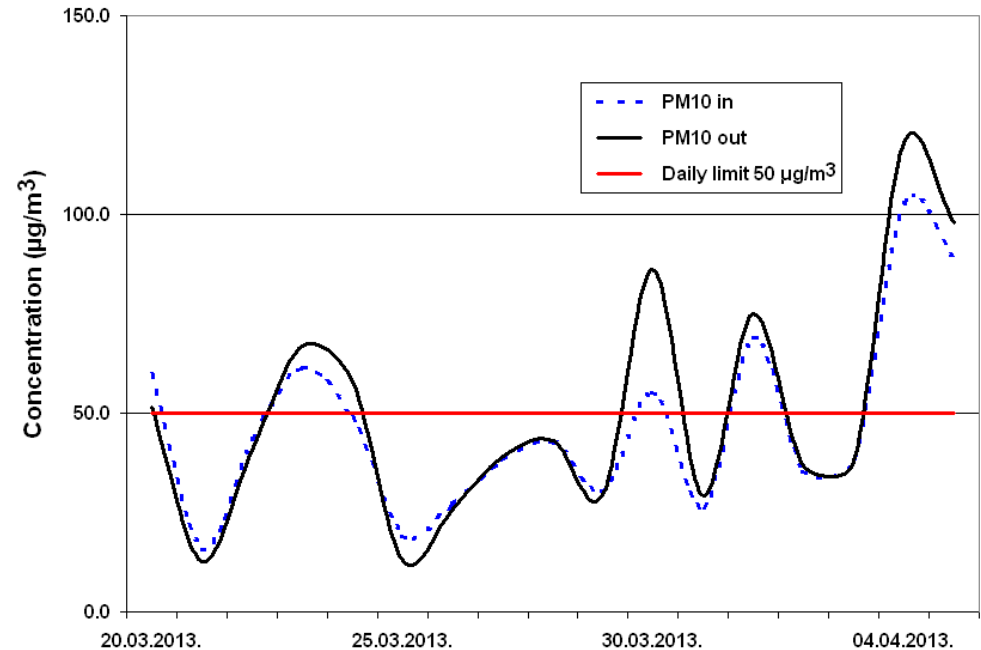
Results and discussion

- **The exceeding of daily limit value for PM10 in ambient air occurred during 35% days.**
- **The exceeding of daily limit value for PM10 in the school occurred during 59% of days.**
- **The exceeding of daily limit value for PM2.5 in ambient air occurred during 71% of days.**
- **The exceeding of daily limit value for PM2.5 in the school occurred during 88% of days.**

Results and discussion



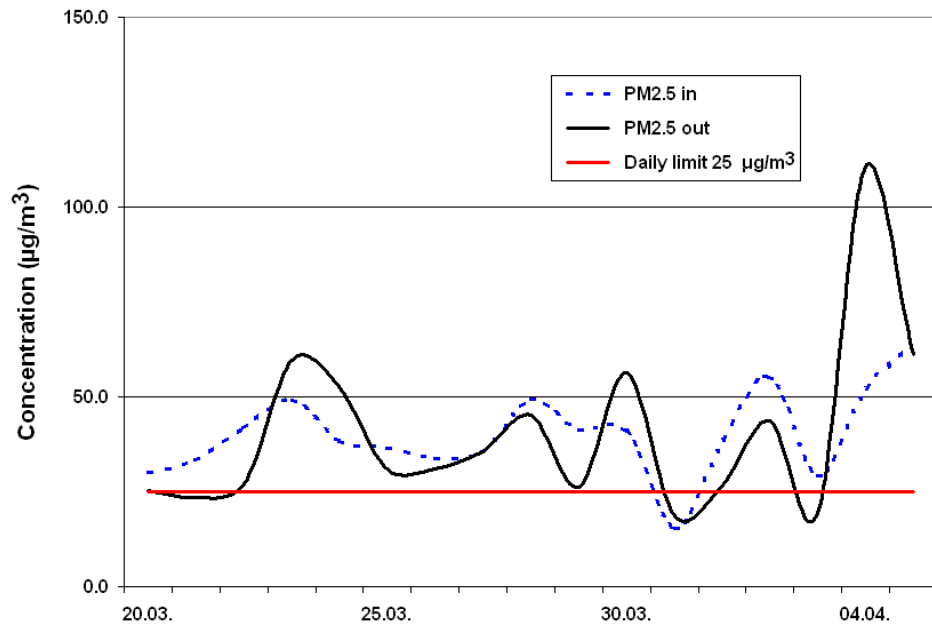
Teaching hours



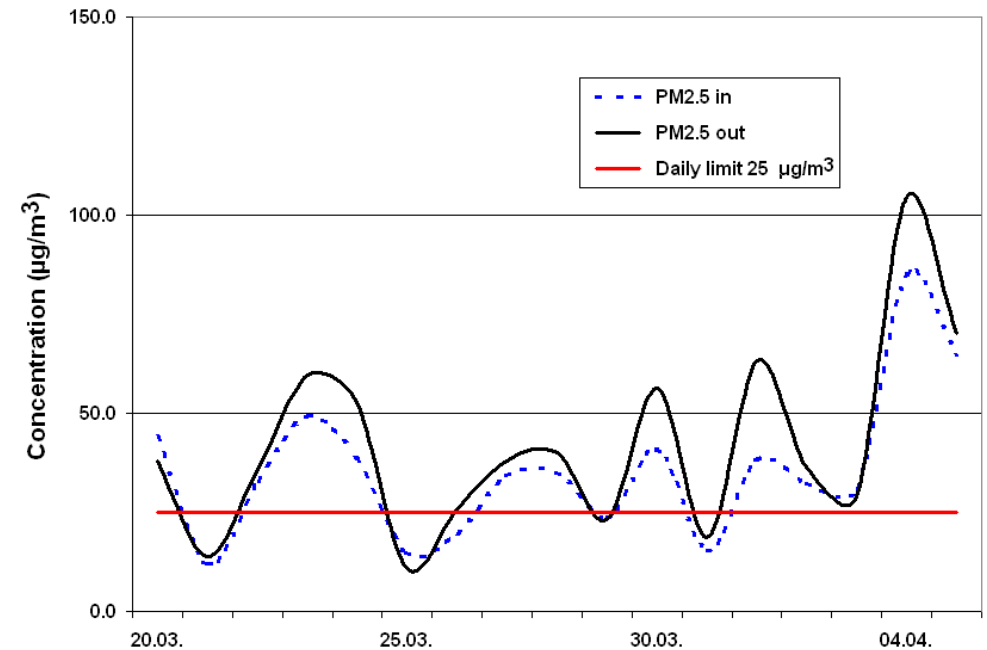
No teaching hours

The average PM10 I/O ratio was 1.57 during teaching hours, and 1.00 during no teaching hours. Strong correlations between indoor and outdoor PM10 concentrations during no teaching hours ($r>0.8$) was observed.

Results and discussion



Teaching hours



No teaching hours

The average PM2.5 I/O ratio was 1.11 during teaching hours and 0.90 during no teaching hours. Strong correlations between indoor and outdoor PM2.5 concentrations during no teaching hours ($r>0.8$) was observed.

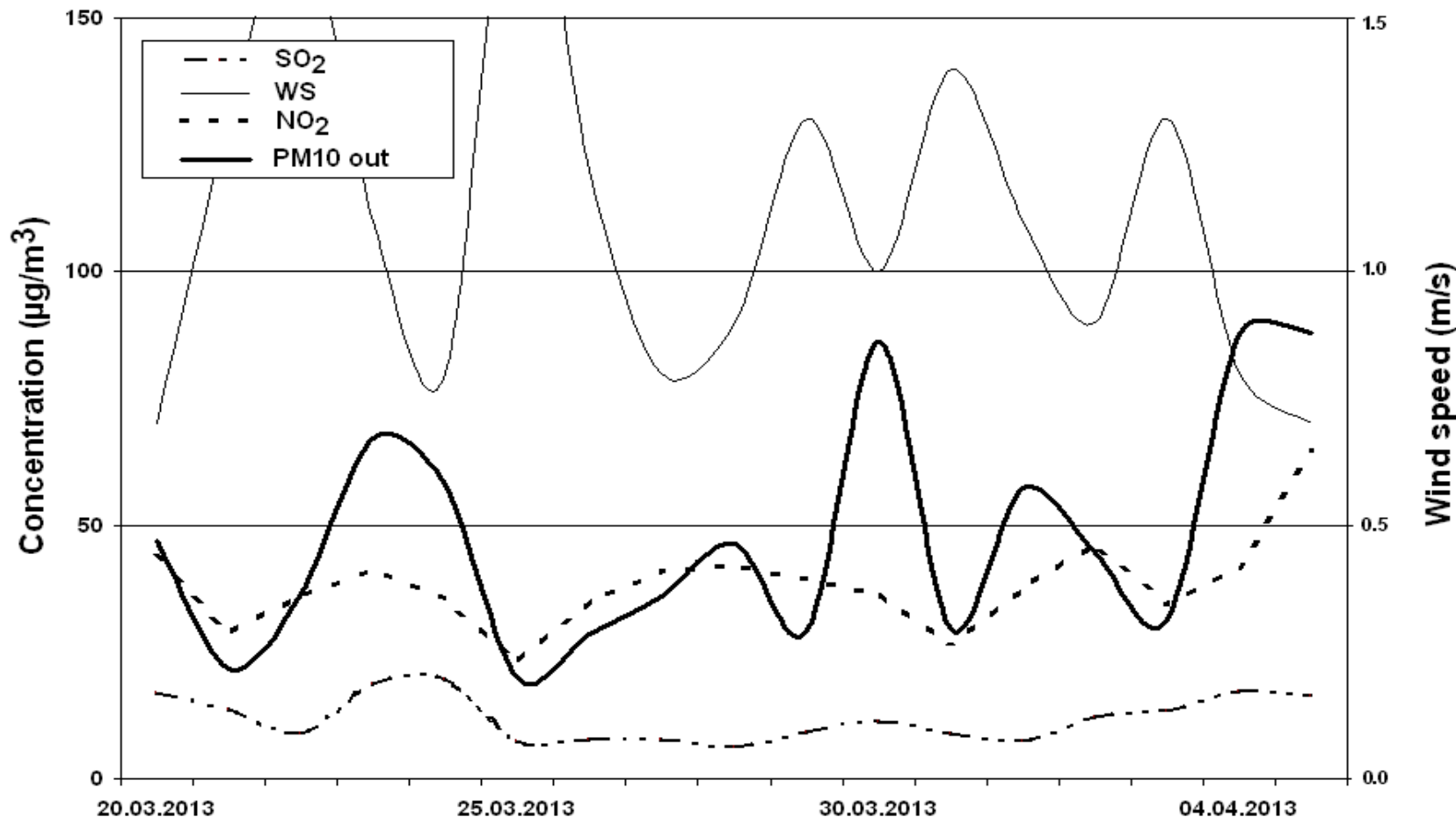
Results and discussion

Strong correlations between indoor and outdoor PM concentrations during no teaching hours ($r>0.8$) were observed in the school.

That points to considerable influence of air pollution with PM from the outdoor air.

School		PM ₁₀	PM _{2.5}	PM ₁₀	PM _{2.5}
		OUTDOOR	OUTDOOR	INDOOR	INDOOR
Teaching hours	PM ₁₀ OUTDOOR	1			
	PM _{2.5} OUTDOOR	0.65	1		
	PM ₁₀ INDOOR	0.82	0.43	1	
	PM _{2.5} INDOOR	0.61	0.66	0.79	1
No teaching hours	PM ₁₀ OUTDOOR	1			
	PM _{2.5} OUTDOOR	0.97	1		
	PM ₁₀ INDOOR	0.99	0.96	1	
	PM _{2.5} INDOOR	0.93	0.96	0.97	1

Results and discussion



Outdoor PM_{10} concentrations, together with the wind speed (WS), SO_2 and NO_2 concentrations at the AMS Nis Traffic (daily averages)

CONCLUSIONS

This work presents one of the first attempts to examine the impact of PM concentrations from ambient air to PM concentrations inside the school buildings in the Niš city center.

The most likely sources of PM in the Niš city center during the winter are traffic and fossil fuels combustion.

High PM concentrations together with a large number of days with PM concentrations over limits were observed in both the indoor and outdoor environments.

High outdoor PM concentrations, limited ventilation, and resuspension of particles are the most possible reasons for the elevated indoor PM concentrations found in the study.

CONCLUSIONS

The observed school environment in the Niš city center offer low protection against the combustion-related particles originated from the outdoor air.

The appropriate measures should be prescribed with the aim to provide better air quality inside the school.

Further research should be continued in the summer period in order to determine seasonal changes in the concentrations of PM.



**Thank you for your
patience!**