Sustainable mobility in Slovakia: Exhaust particles from traffic

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A few words about myself … freelancer

- Teaching at the Technical University of Denmark for 20 years in the two air pollution courses at master level.
- Work as senior advisor in Green Transition Denmark with key focus on air pollution and climate change.
- Work mainly on international projects – most within the EU but as well in Mexico, Greenland, Africa etc.
- On a UN, EU, national … and even … on a local level.
- Engineer work (e.g. air pollution measurements), economic analysis and communication regarding air quality.

Or said with pictures …

Health effects in Slovakia

- Air pollution causes significant morbidity and around 5,000-7,500 premature deaths in Slovakia every year i.e. 9-14 percent of all deaths in Slovakia.
- Air pollution costs 5,000-7,500 million USD in Slovakia every year i.e. 3-4.5 percent of GNP, and is thereby a huge economic burden for the Slovak society.
- Air pollution is one of the main health risk factors for the Slovak population.
- Air quality limits of the EU do not protect public health.

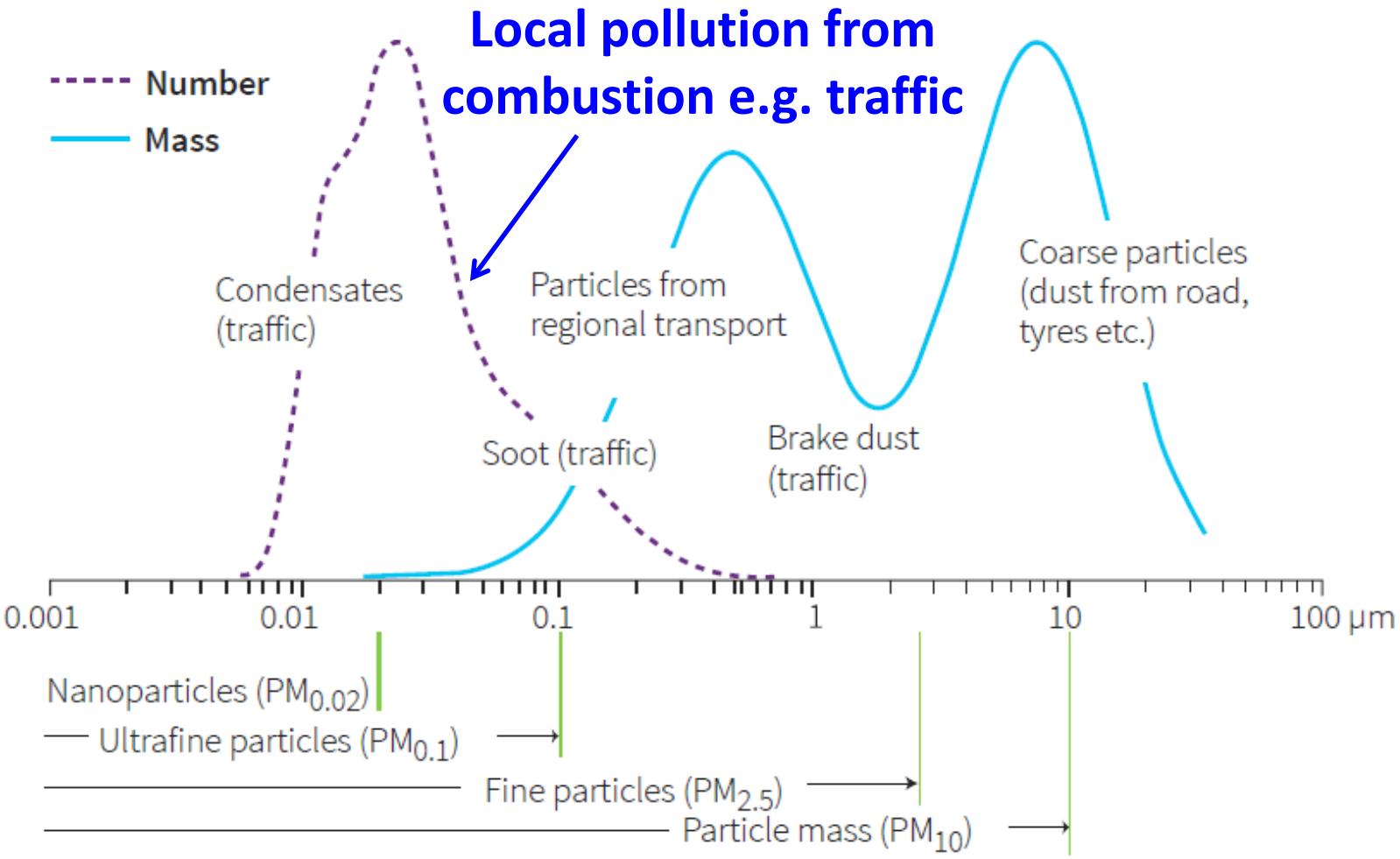
Particles in air

	Diameter in micrometers	Units
Particle mass (PM_{10})	< 10	$\mu g/m^3$
Coarse particles ($PM_{2.5-10}$)	2.5 - 10	$\mu g/m^3$
Fine particles ($PM_{2.5}$)	< 2.5	$\mu g/m^3$
Ultrafine particles ($PM_{0.1}$)	< 0.1	number/cm^3
Nanoparticles ($PM_{0.02}$)	< 0.02	number/cm^3

Coarse/Fine particles dominate the particle mass.

Ultrafine/Nanoparticles dominate the particle number.

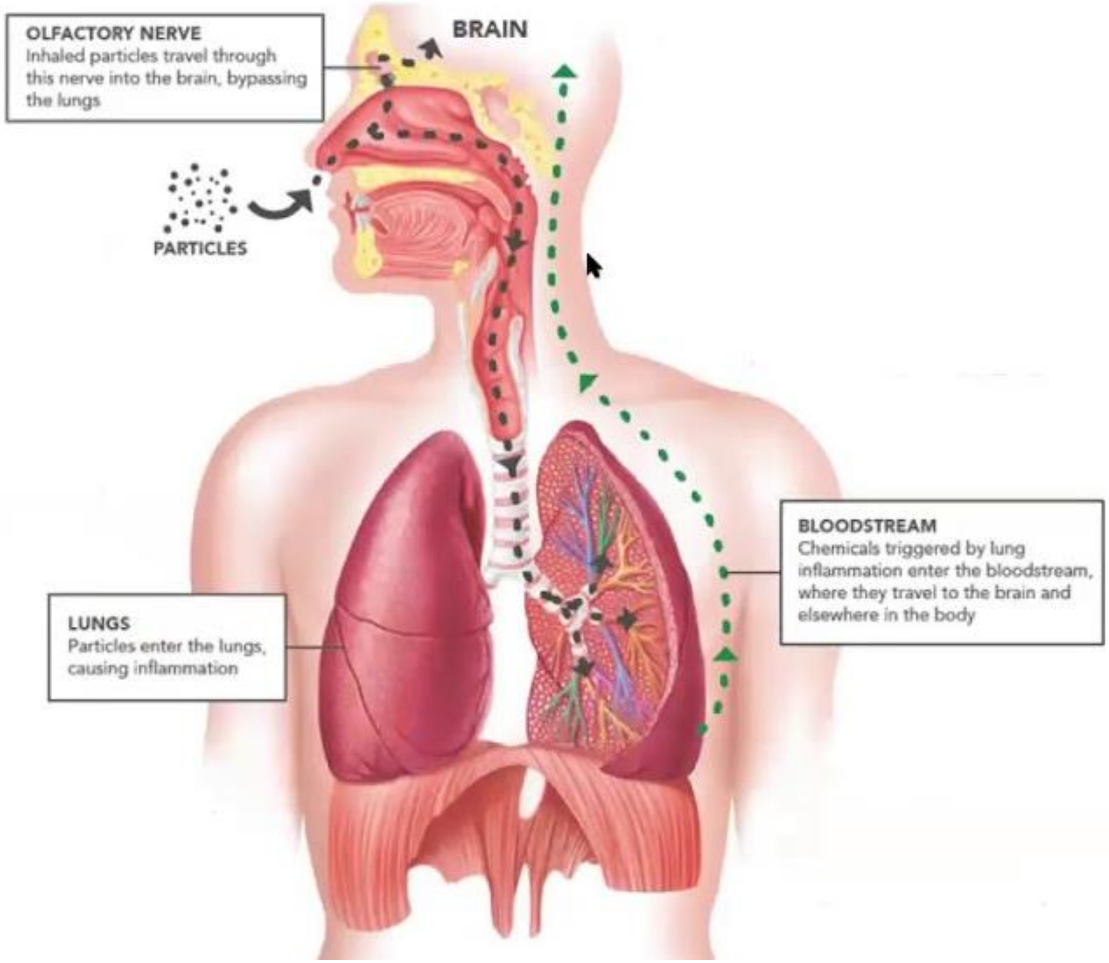
Particle size distribution



Ultrafine particles (UFPs)

- UFPs origin from local combustion.
- UFPs have a high content of toxic soot. Their huge surfaces are coated with PAHs & heavy metals.
- UFPs are deposited in the finest parts of the lungs and transferred into the blood.
- Thereby UFPs are a dangerous cocktail of toxic properties and a size allowing them to reach the most sensitive parts of the human organism.

Uptake of UFPs in air

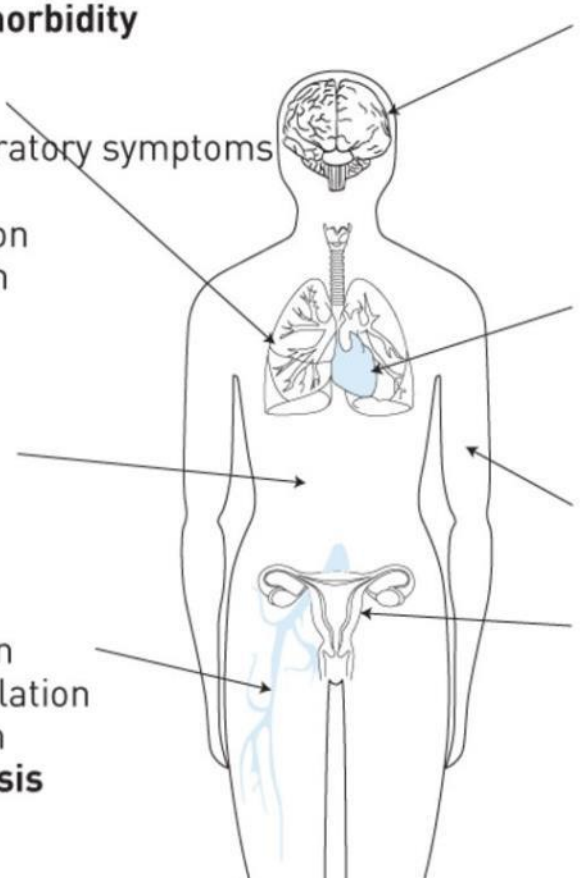


Same effects as tobacco smoking

Respiratory disease mortality
Respiratory disease morbidity
Lung cancer
Pneumonia
Upper and lower respiratory symptoms
Airway inflammation
Decreased lung function
Decreased lung growth

Insulin resistance
Type 2 diabetes
Type 1 diabetes
Bone metabolism

High blood pressure
Endothelial dysfunction
Increased blood coagulation
Systemic inflammation
Deep venous thrombosis



Stroke
Neurological development
Mental health
Neurodegenerative diseases

Cardiovascular disease mortality
Cardiovascular disease morbidity
Myocardial infarction
Arrhythmia
Congestive heart failure
Changes in heart rate variability
ST-segment depression

Skin ageing

Premature birth
Decreased birthweight
Decreased fetal growth
Intrauterine growth retardation
Decreased sperm quality
Pre-eclampsia

Aggregated UFPs look like this

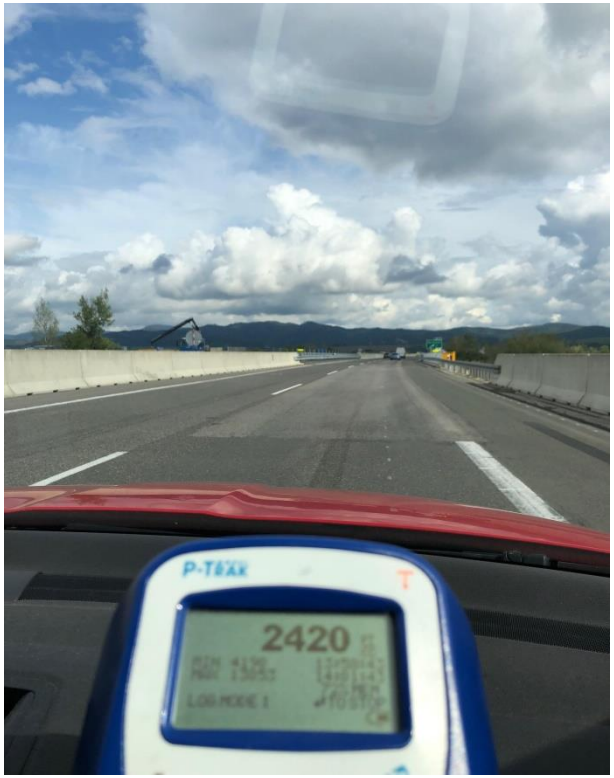
Measurements of UFPs in air

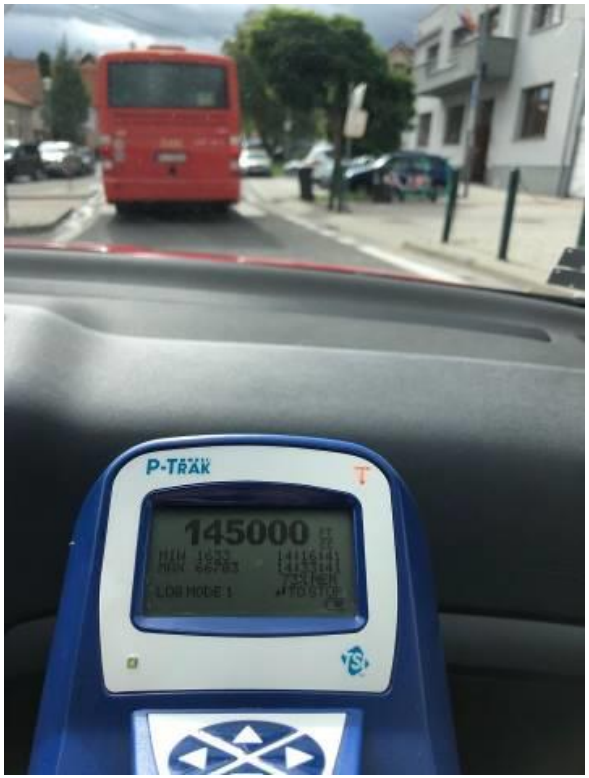
- There are many devices for measuring UFPs – or just "particle number" depending on the size interval.
- We use P-Trak's (particle size interval 20-1,000 nm) to avoid the smallest particles and include soot particles.
- P-Tracks from TSI are very stable at 0-45°C and humidity 20-90 %, easy to use, transportable, and can be carried as hand luggage.

- Cheap: 7,000 euro + 1,500 euro/year (calibration etc.).

Significant differences in Slovakia

Significant differences in Slovakia



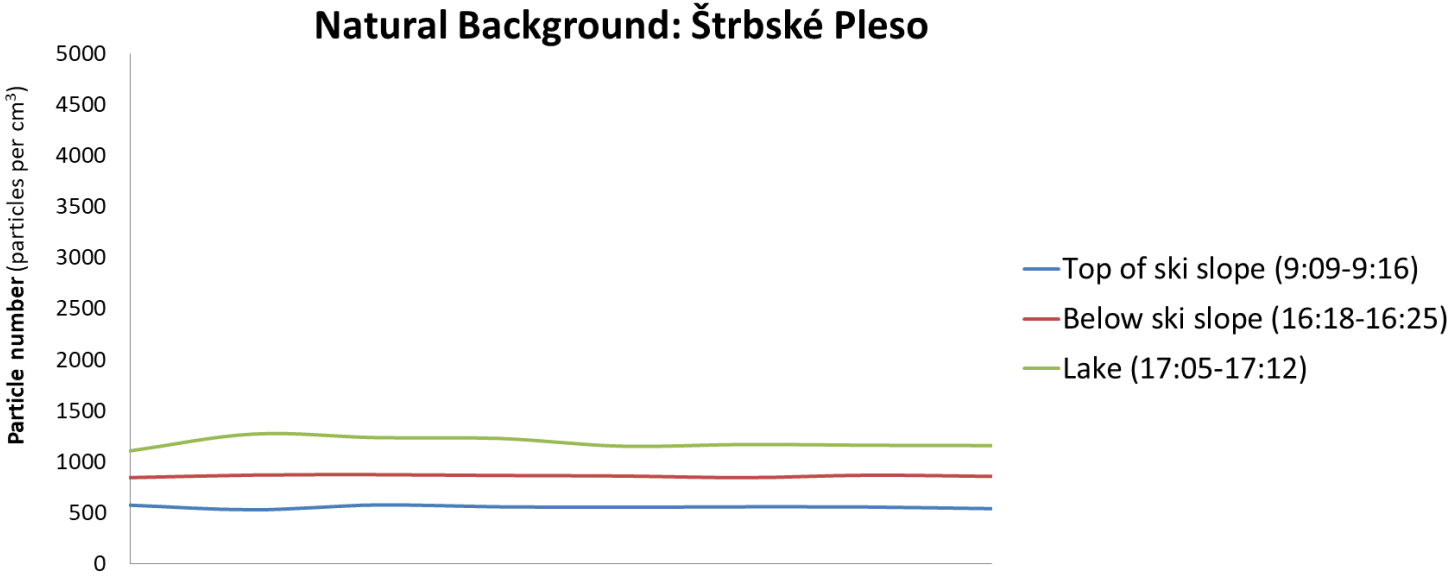


Traffic measurements

1) Nature background in the mountains in 2020.
2) City background in park areas in 2022.
3) Alongside larger streets in 2022.
4) Inside a car in 2022.

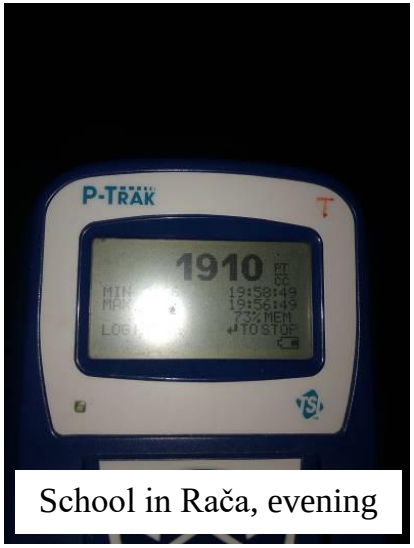
All measurements are based upon second measurements (60 measurements per minute) but minute averages are used in diagrams to keep data amount low (this reduces peaks from fluctuating pollution sources).

Nature background in 2020



- Very stable concentrations.

City background



School in Rača, evening

Park Medická záhrada

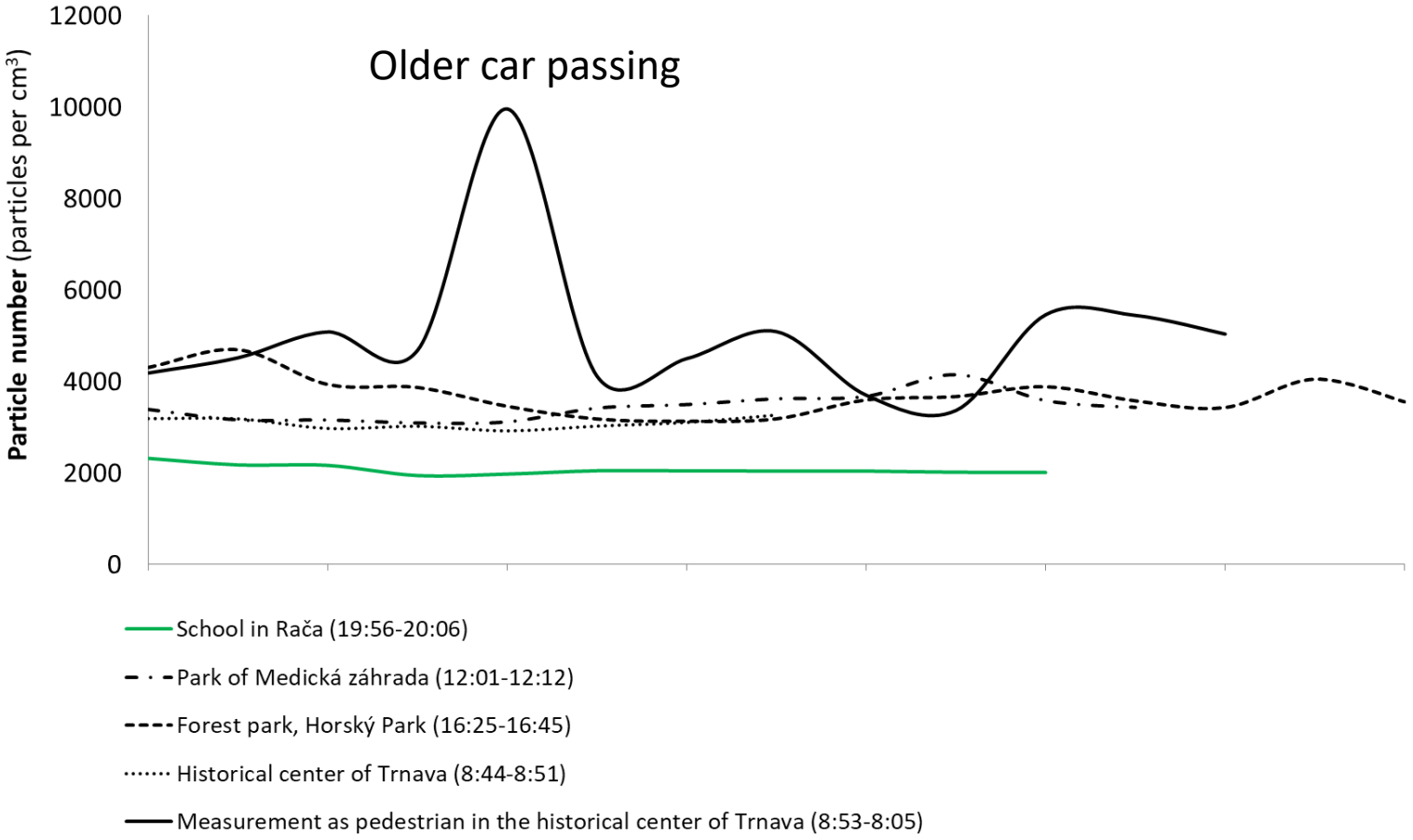
Horský Park

Center of Trnava

City center of Trenčín

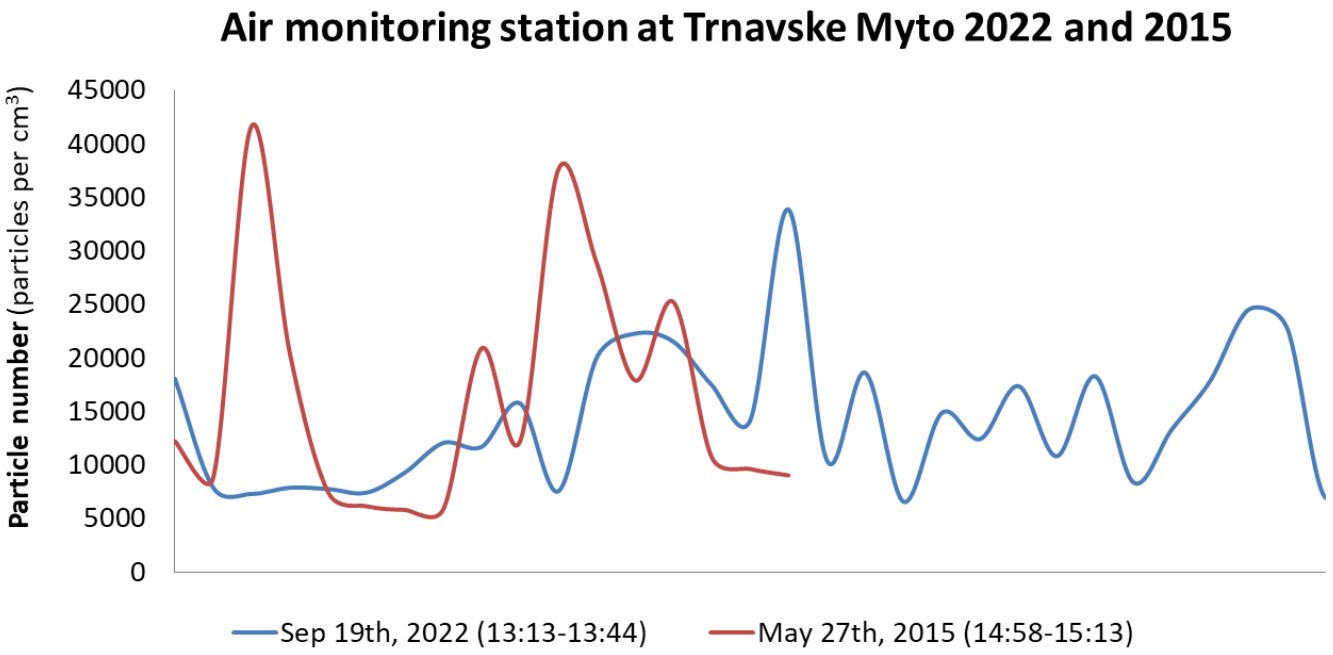
Park M. R. Štefánika

City background



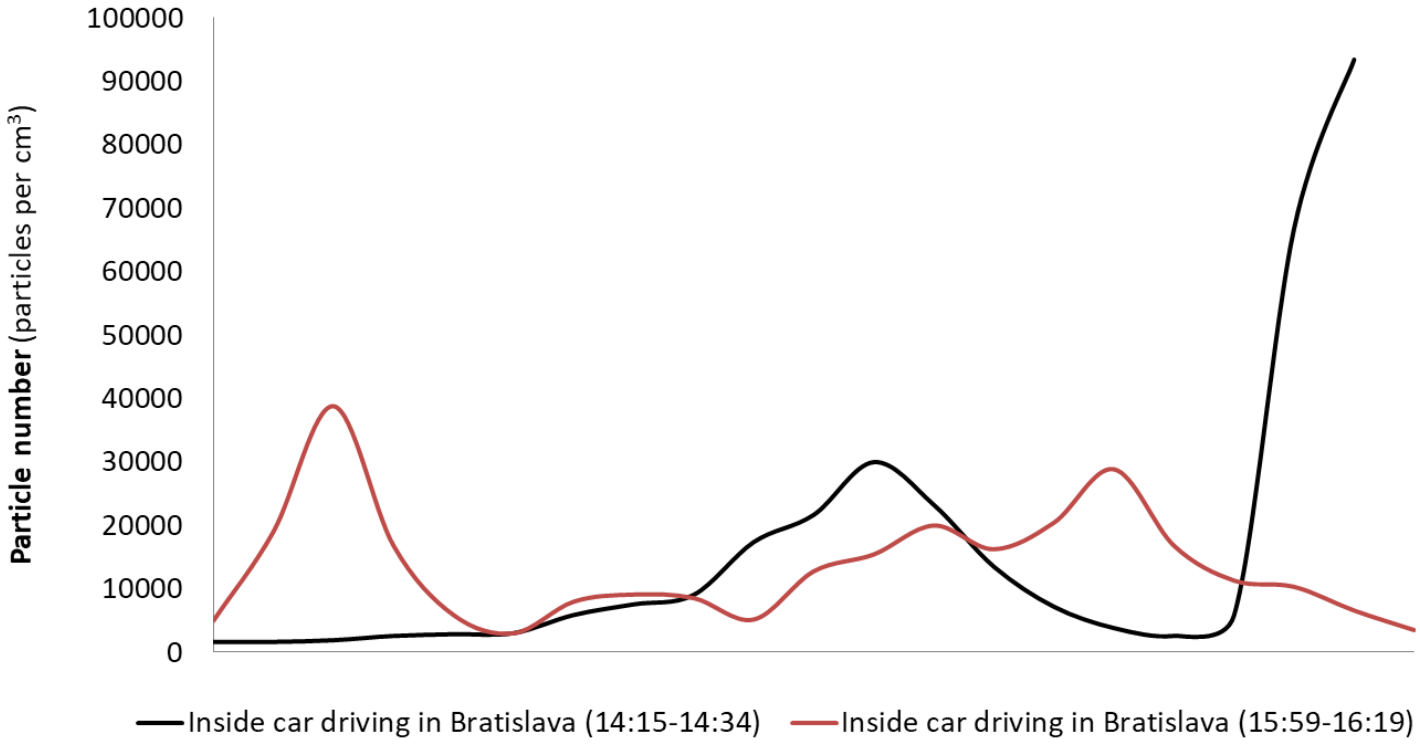
- Quite stable concentrations.

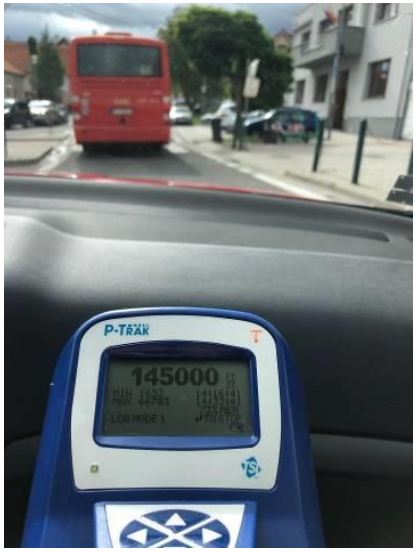
Large cross-road in Bratislava



- Very fluctuating concentrations.

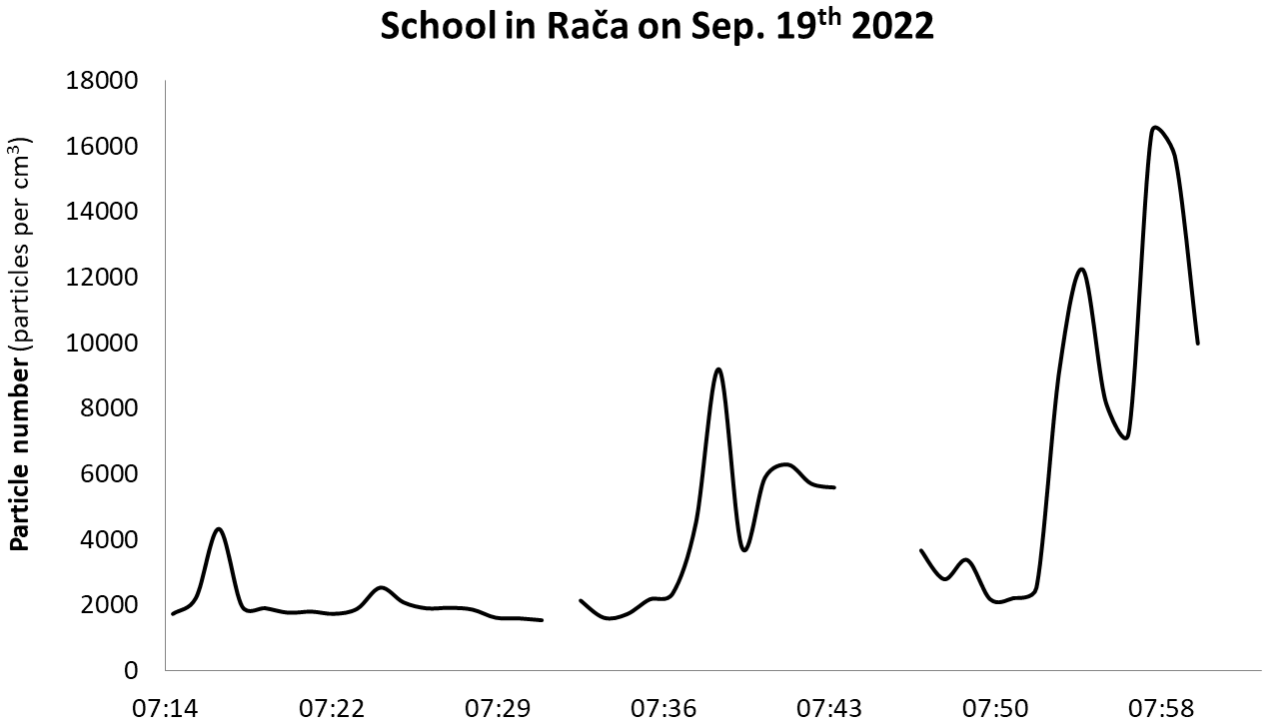
Inside a car in Bratislava





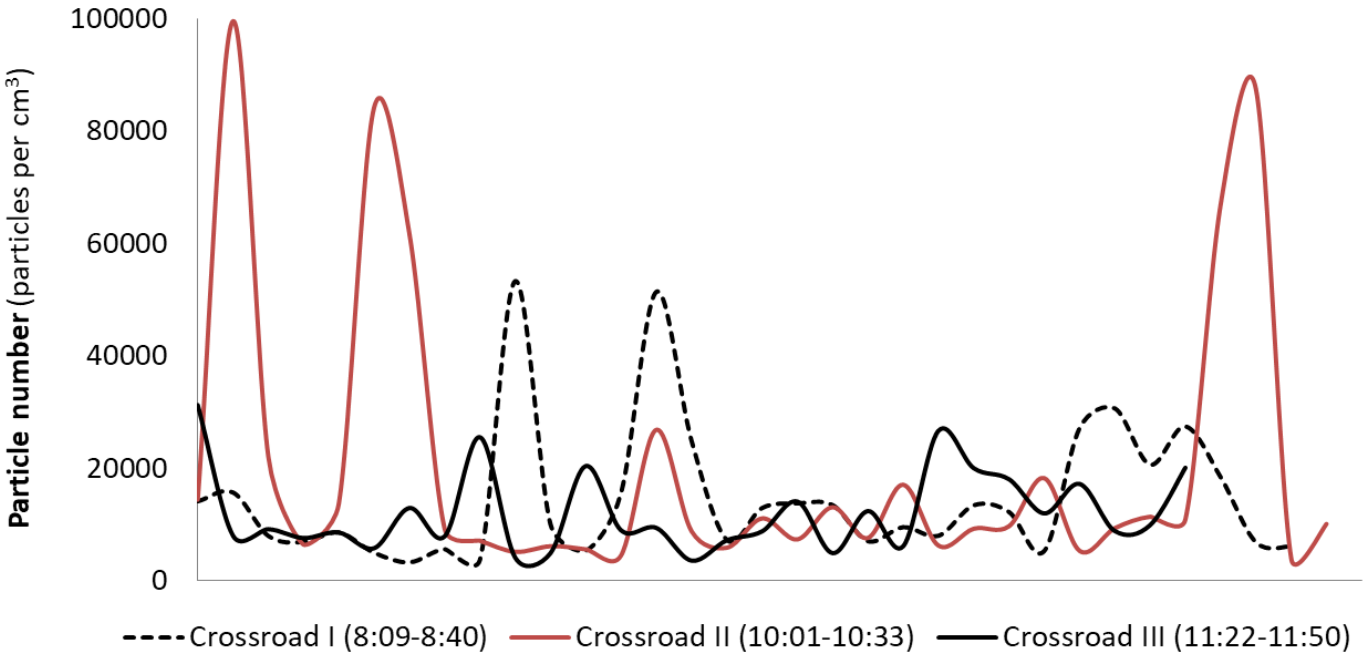
- Concentrations depend on the vehicle in front of you.

Pollution increases with more traffic



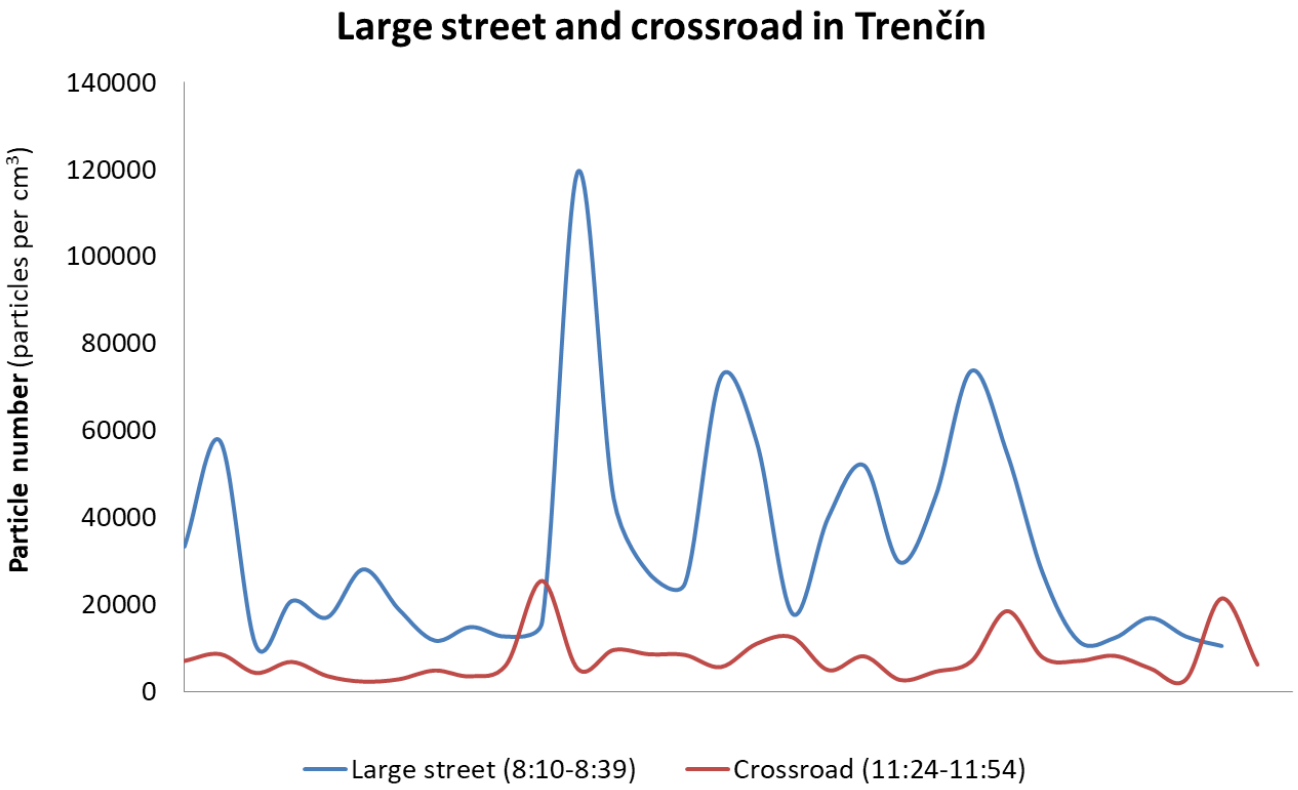
- Pollution increases with more traffic closer to 8.00.

Large cross-road in Trnava



- Very fluctuating concentrations: https://www.dropbox.com/s/0fw0cyoe3cs8fhn/IMG_9384%20%281%29.MOV?dl=0

Traffic in Trenčín

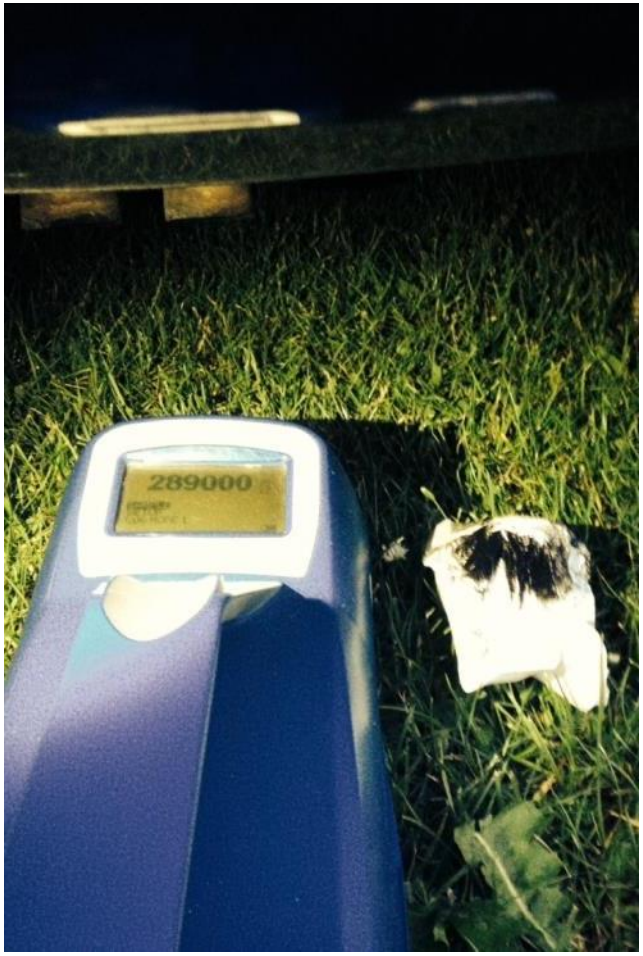


- Very fluctuating concentrations.

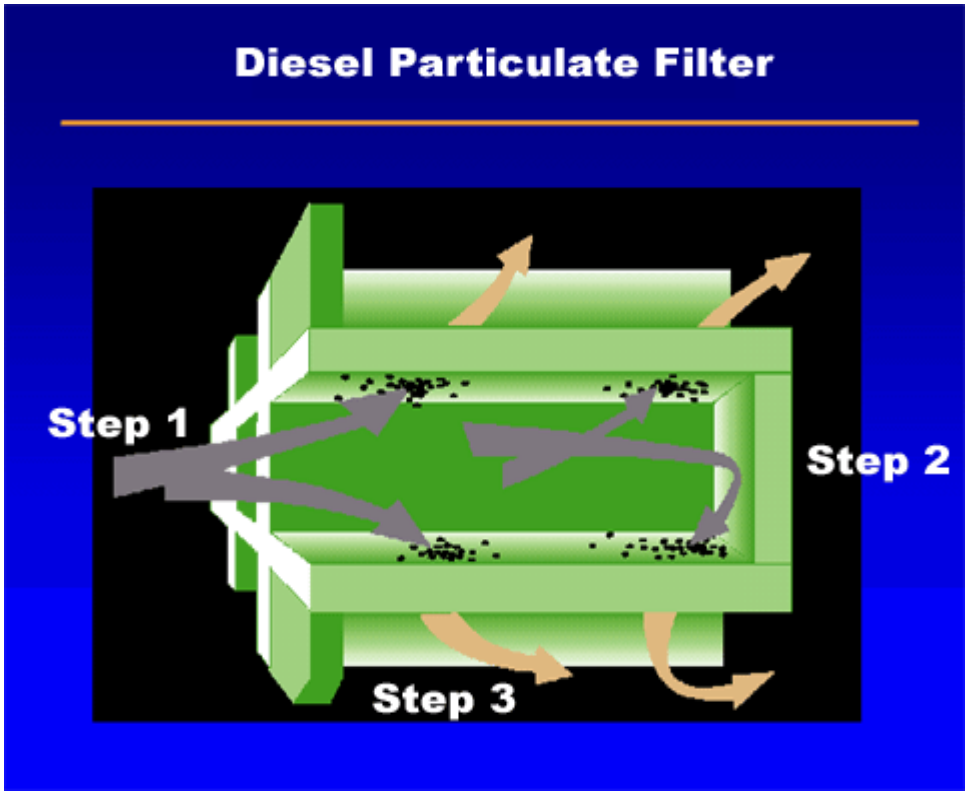
Pollution from traffic in Slovakia

	Location	Number of measurements	Pollution average (particles per cm^3)
Average typical nature background			**750**
Average typical city background			**3,250**
Bratislava	School in Rača (7:47-7:59)	780	**7,350**
	Crossroad with much traffic	1,920	**16,750**
	Crossroad with little traffic	1,920	**7,275**
	Air monitoring station 2022	1,920	**14,375**
	Air monitoring station 2015	1,020	**16,500**
	Inside car in Bratislava I	1,200	**16,075**
	Inside car in Bratislava II	1,280	**13,400**
Trnava	Larger street close to school	1,080	**10,800**
	Crossroad I	1,920	**14,775**
	Crossroad II	1,980	**20,825**
	Crossroad III	1,740	**12,250**
	Street in front of hospital	1,680	**8,500**
	Regional office (little traffic)	840	**5,050**
Highway	From Trnava to Trenčín	2,880	**7,375**
Trenčín	Small school street	2,040	**12,400**
	Large street (rush hour)	1,800	**33,050**
	Crossroad (limited traffic)	1,860	**7,775**

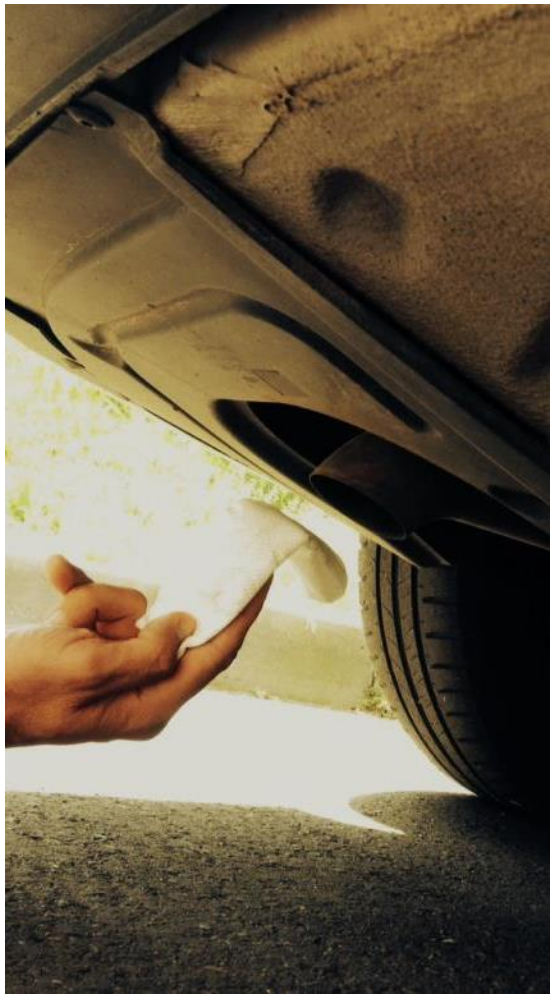
Problem with old diesel cars … no filter



Solution: Wall-flow particulate filters



New cars with filters are clean



Solution: Much more bicycle traffic

https://www.youtube.com/watch?v=996Hg2GeUvo

Solutions

Recommendations to reduce pollution from traffic in Slovakia		
Very efficient	Low emission zones in larger cities	Vehicles (cars/vans from before 2011 and trucks/busses from before 2014) are banned in larger cities.
	More bicycle traffic	Bicycle traffic is enhanced significantly by building safe separate bicycle lanes on all larger city streets.
	Green registration taxes	The state introduces registration taxes on new vehicles so polluting vehicles become expensive.
Efficient	Congestion charge	Vehicles need to pay a charge for driving in larger cities (highest charge in rush hours and for most polluting cars).
	Filter control during vehicle inspection	Introduce particle number counting when controlling filter efficiency at periodic vehicle inspection.
	Differentiated parking fees	The most polluting vehicles should pay much more to park in cities than the least polluting vehicles.
	Avoid chip-tuning/modification	Prohibit sale of chip-tuning devices and get the police to control if cars are chip-tuned or modified.
Less efficient	Green public procurement	Public institutions should buy transport service provided only by euro 6/VI or gas/electric vehicles.
	Retrofitting public diesel busses	Old diesel busses (euro V and earlier) in cities should be retrofitted with wall-flow filters and city-SCR.
Inefficient	Scrapping payment	The state pays e.g. 1,000 euro to people replacing an old diesel car with a newer and less polluting.

Supported by the European Union

Exhaust particles from traffic in Slovakia

Natural background

City background

Traffic pollution peaks

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