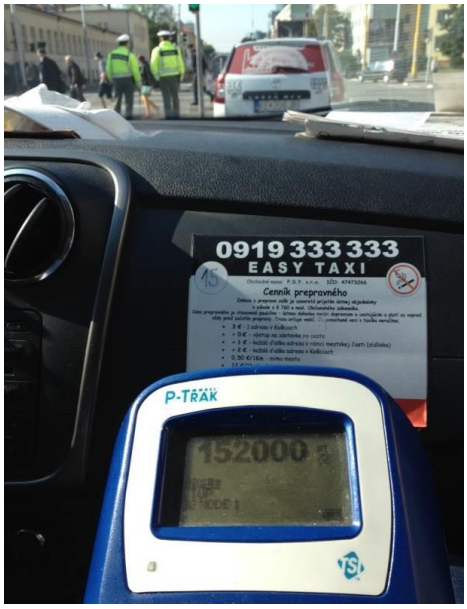
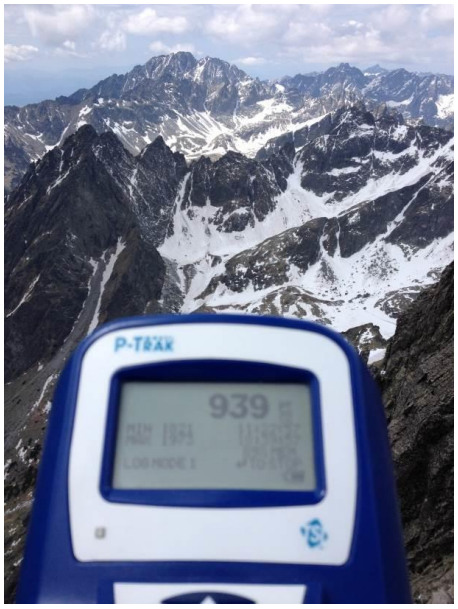
Measurements of ultrafine particles from traffic and wood burning in Slovakia





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Background

Exhaust particles from diesel engines are mainly ultrafine particles ($PM_{0.1}$) i.e. particles with a diameter less than 0.1 micro meter (100 nano meter). These particles are measured in numbers of particles per cm^3. Smoke from wood burning contains fine as well as ultrafine particles. Particles from diesel vehicles and wood burning cause serious health problems by increasing the risk of heart and airway diseases, cancer and premature death. Furthermore, a significant share of the particles are soot particles (black carbon) contributing to global warming as well. Diesel particles can efficiently be removed by particle filters required in low-emission zones implemented in modern European cities. These zones provide people with longer and healthier lives. The particle emission from wood burning can be reduced by better insulation reducing the amount of wood burned and by replacing old wood stoves and boilers with new units.

Measurements

Ultrafine particles were measured with a P-Trak (Model 8525 Ultrafine Particle Counter).
One measurement was taken every second but minute averages were used in data treatment i.e. one minute represents 60 measuring points and 10 minutes represents 600 measuring points.
Local wind speed, humidity and temperature were measured with a WindMate-300.
Measurements were performed all over Slovakia in May-June 2015. The key focuses were:

1) Pollution from street traffic alongside streets and at bus stops.
2) Pollution inside trains (electrical and diesel trains, first versus second class).
3) Pollution inside cars and busses in the rush-hour traffic.
4) Pollution in basement parking under shopping centers.
5) Pollution inside rooms using wood stoves (new and traditional stoves).
6) Background pollution in parks, city squares, rural areas and in the mountains.

Results

Temperature (6-35°C) and humidity (30-60%) during measurements indicated fine measuring conditions and have not affected the measurements. However, some days were measured high local wind speed (up to 3-5 m/s). Wind of this magnitude will cause a quick replacement of air alongside streets and thereby significantly reduce local air pollution. Below, will be mentioned if (and how) wind speed is believed to have affected the measurements.

Figure 1 shows measurements from Bratislava. It was very windy during these measurements. Hence, air pollution levels at the monitoring station and at the bus stop would be much higher during quiet wind conditions. From the figure is seen that the pollution levels are lower and much more stable at the city square and outside the city compared to levels at the bus stop and the monitoring station close to the local traffic. The two peaks at the bus stop were caused by diesel busses at the bus stop (no local car traffic was close to the bus stop). The low pollution level at the city square was caused by relatively strong wind. The high pollution levels at the monitoring station, even during relatively powerful wind speeds, clearly underline that diesel traffic is an important local pollution source in Bratislava.

Figure 1

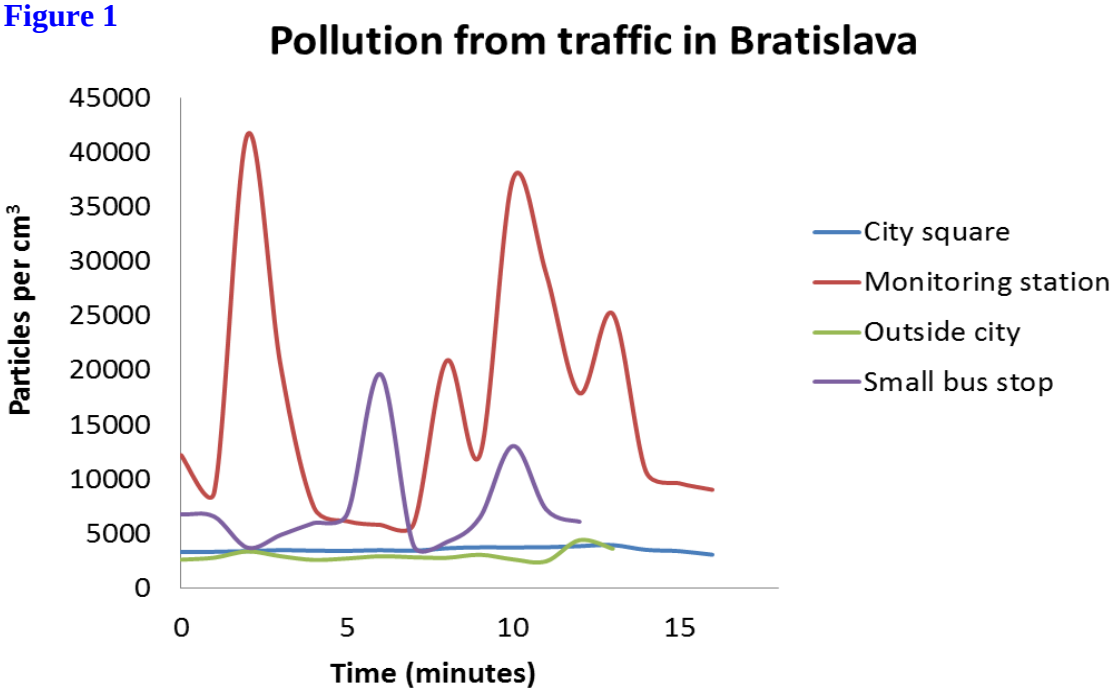
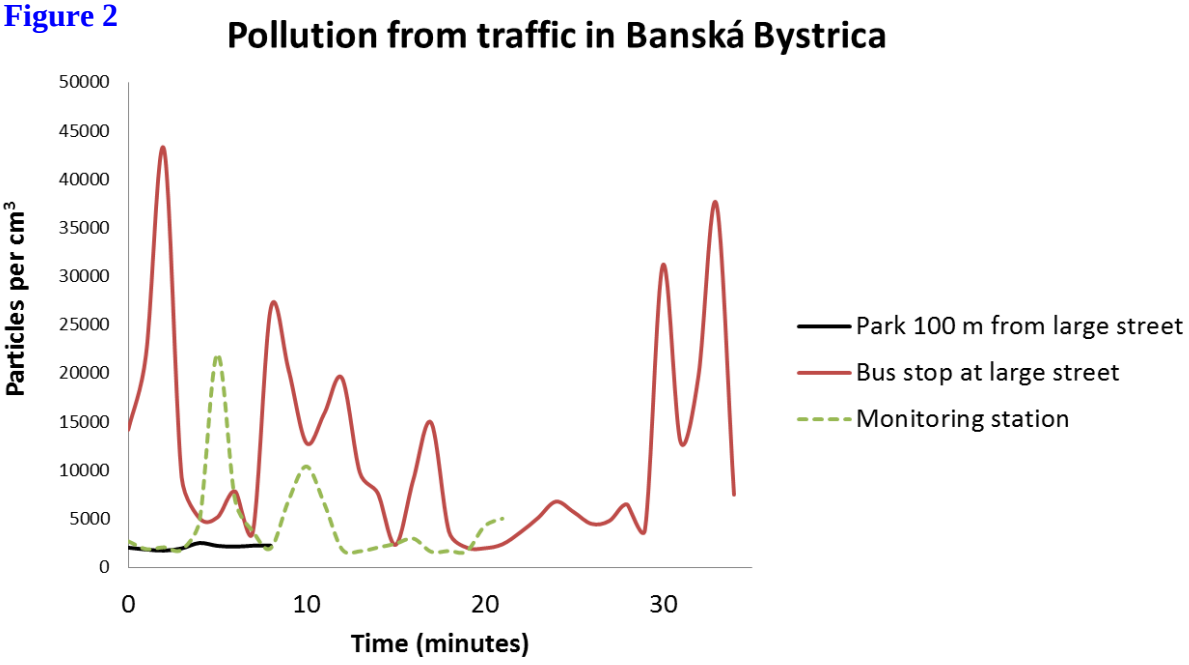


Figure 2 shows measurements from Banská Bystrica. It was windy under these measurements. Hence, air pollution levels at the bus stop and the monitoring station would be higher during quiet wind conditions. From the figure is seen that the pollution level is lower and much more stable in the park compared to the fluctuating levels at the bus stop and the monitoring station close to the large street. Some of the peaks at the bus stop were caused by diesel busses at the bus stop. CNG busses at the bus stop did not cause a significant pollution. The high pollution levels at the bus stop, even during relatively high wind speeds, clearly underline that diesel traffic is a key source to pollution in Banská Bystrica. The same was observed in other cities: Kosice, Trenčín, underlining that diesel traffic is a key source to pollution in Slovakian cities.

Figure 2



During the measurements in Slovakia was made simple “napkin tests” to show the difference between diesel cars with and without particle filters. The two pictures to the left show the test on a euro 4 diesel car without filter. The two pictures to the right show the test on a euro 5 passenger diesel car with filter. The high emission of soot particles from cars without filters is quite clear. Measurements directly in the exhaust showed above 400000 particles per cm^3 for diesel cars without filters and below 4000 particles per cm^3 for diesel cars with filters.

Figure 3 shows measurements from electrical and diesel trains in rural areas. In diesel train was measured pollution levels in first and second class since first class carriages (just behind the locomotive) might drive below the main plume of smoke from the locomotive and thereby contain lower pollution levels than second class carriages. From the figure is seen that the pollution inside the diesel train is much higher than inside the electrical train indicating that the diesel exhaust from the diesel locomotive is ventilated directly into the carriages through open windows and maybe by the mechanical ventilation system. Furthermore, it is seen that the pollution levels at second class are much higher than first class supporting the hypothesis that first class carriages might drive below the main plume of smoke from the locomotive. However, even in first class carriages were measured very high pollution levels. Tunnels did not seem to affect pollution levels. The pollution in diesel trains constitutes a health risk to daily commuters and train staff spending a significant part of their life time in the train.

Figure 3

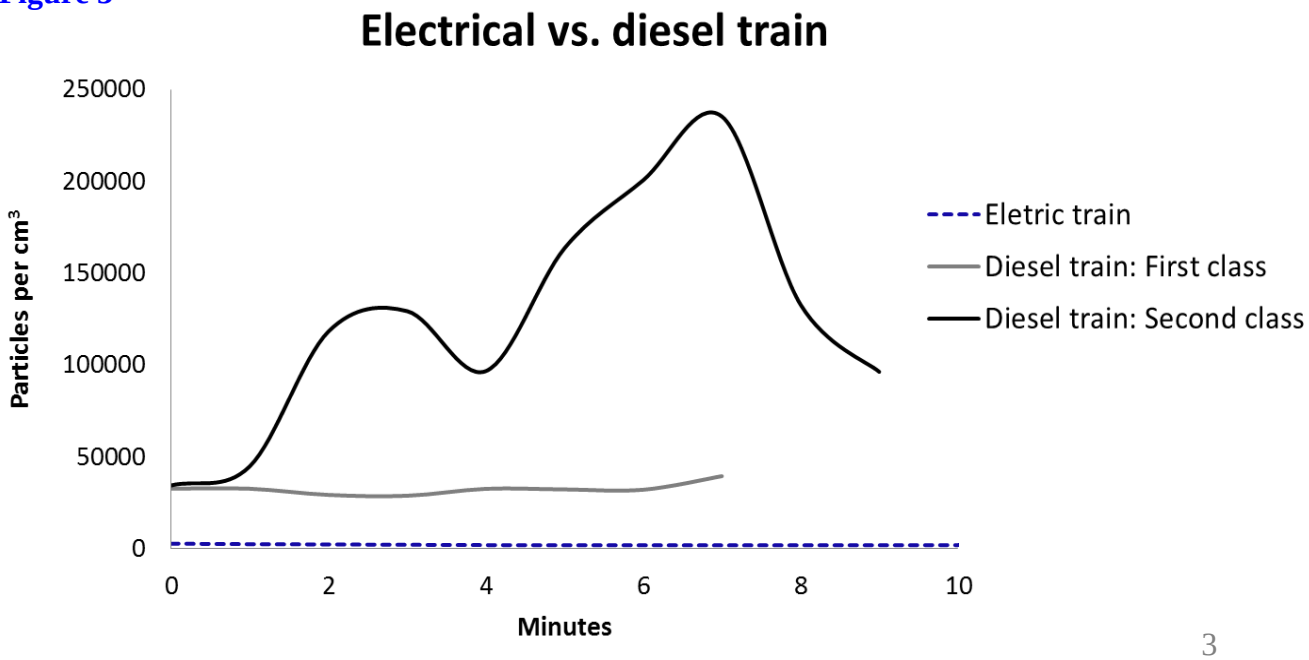


Figure 4 shows measurements from inside a car and a Euro III bus in the rush hour in Kosice. To comparison is shown city background pollution (measured in quiet areas of the city centre). From the figure is seen that the pollution levels inside the car and bus are relatively high. Hence, the pollution is ventilated from the street air into the car and bus thereby exposing the passengers to high levels of health damaging air pollution. The pollution inside cars and busses can thereby constitutes a health risk to daily commuters and bus drivers spending a significant part of their life time inside cars and busses in the rush hour traffic. The lowest levels of pollution inside the car (around 20000 particles per cm^3) was observed when the car left the larger streets and drove at smaller streets with less traffic. The steep increase inside the car after 8 minutes was due to driving behind an older diesel van.

Figure 4

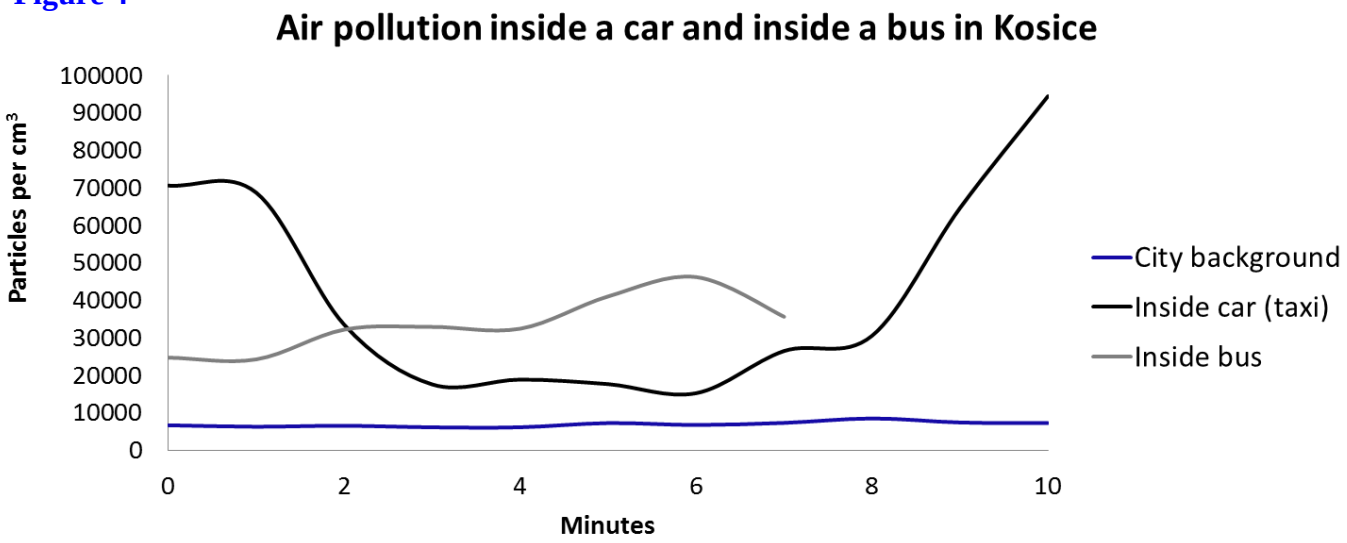


Figure 5 shows measurements from two basement parkings under different shopping centers compared to background pollution (measured in quiet areas of the city centre). From the figure is seen that the pollution in the basement parkings is very high indicating that the ventilation systems is insufficient. Pollution with diesel particles inside basement parkings constitutes a health risk to staff working in the basement. Children or pregnant woman should not be left waiting in the basement. Furthermore, the measurements indicate that the pollution seems to spread to the shopping area through escalators from the basement.

Figure 5

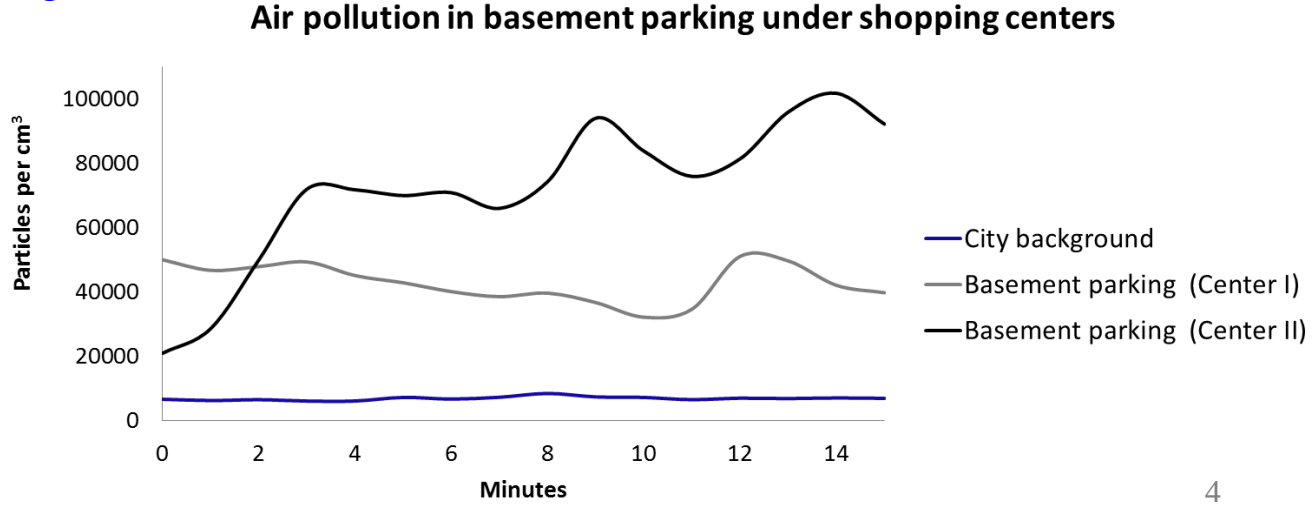


Figure 6 shows measurements walking from the city square (time 0) in Trenčín to the tower of Trenčín Castle (time 40-47). On the way up (walking) we were passed by a passenger diesel car two times. From the figure is seen that the car causes significant pollution (no other local pollution sources were present). Furthermore, it is seen that the pollution at the top of the tower is about half of the city square since the pollution from the city is diluted when rising.

Figure 6

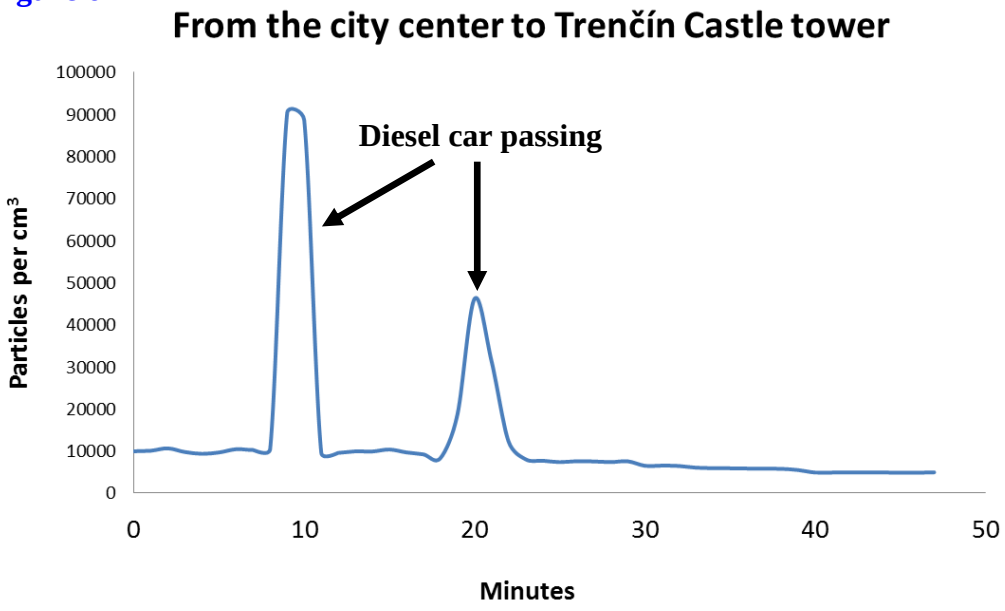


Figure 7 shows indoor measurements from wood burning in a house with a traditional stove (see picture). To comparison are shown the pollution levels inside the room before igniting the wood stove. At time 22 minutes was made full ventilation and the stove was ignited again at time 24 minutes. From the figure is seen that just after ignition the pollution quickly becomes 100 times higher than the initial pollution levels. This seems to happen as well after second ignition. Traditional stoves can thereby create extremely high indoor pollution when people are in the house (stoves are used when people are at home). Indoor and outdoor pollution from stoves might be a pollution problem causing significant health impact in Slovakia.

Figure 7

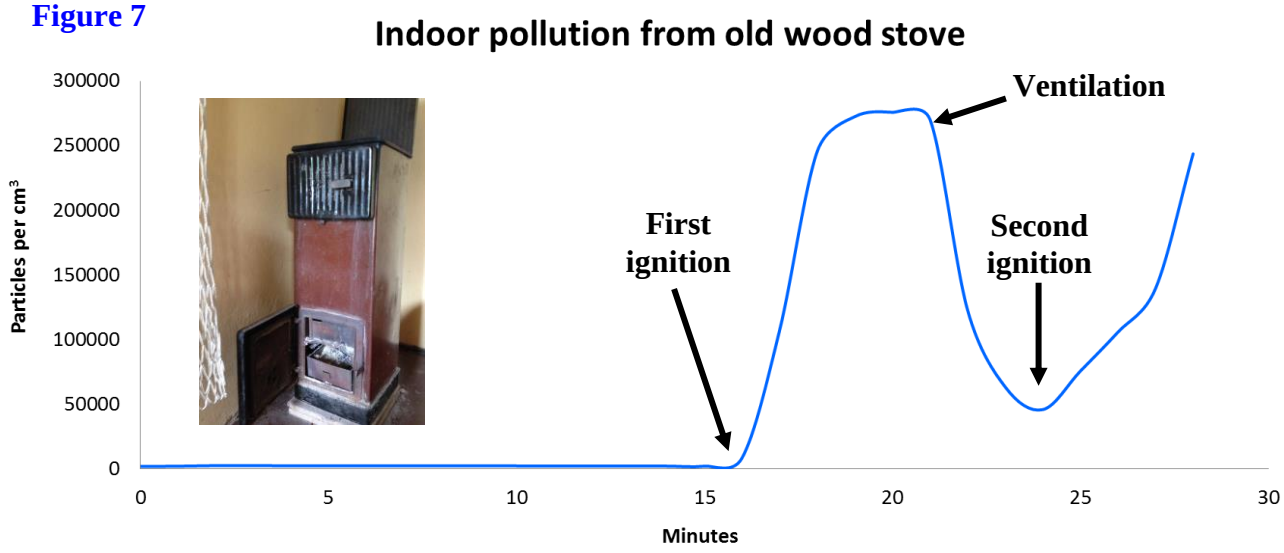


Figure 8 shows indoor measurements from wood burning in a modern stove in a hotel room under optimal conditions i.e. ignited by ethanol briquettes and heat dried wood (see picture). To comparison are shown the pollution levels inside the room before igniting the wood stove. From the figure is seen that the pollution inside becomes almost a factor 100 higher than the initial pollution levels inside the room. In a similar hotel room two doors away was not seen a significant pollution increase. However, the pollution increases slower compared to the old stove (figure 7 above). Hence, even new stoves under optimal conditions can create extremely high indoor (and outdoor) pollution and cause a significant health impact.

Figure 8

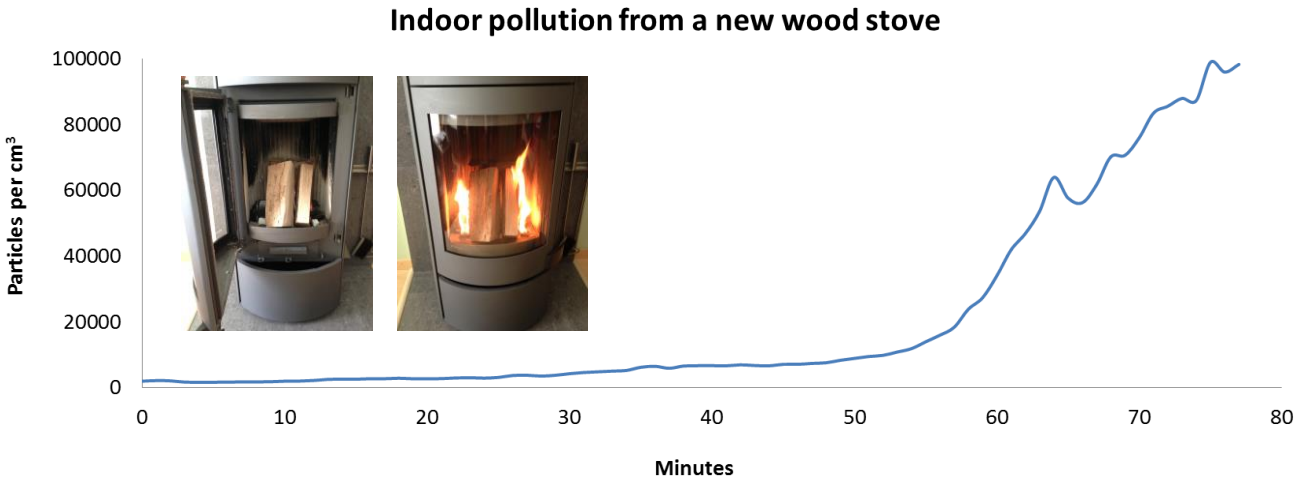


Table 1 summarizes some of the kay data from the measurements in Slovakia.

Table 1: Measurements from Slovakia

City/Place	Particles per cm^3	Measuring time: Comments
Tatra mountains (lake)	1,300	May 31st (10.04-10.36): Stable concentration
Lomnicky peak	1,400	May 30th (10.39-11.34): Stable concentration
Bratislava / city boarder	2,950	May 27th (15.47-16.00): Stable concentration
Rural crossing border point	3,250	May 31st (17.11-17.29): Stable concentration
Kosice / large street	22,350	May 29th (14.14-14.45): Fluctuating concentration
Street crossing	37,300	June 1st (11.44-12.01): Fluctuating concentration
Electrical train	2,900	May 28th (20.41-21.23): Stable concentration
Diesel train at first class	32,100	May 28th (18.33-18.43): Stable concentration
Diesel train at second class	117,550	May 28th (18.22-18.32): Fluctuating concentration
Kosice / inside diesel bus	33,550	May 29th (14.47-14.55): Fluctuating concentration
Kosice / inside car (taxi)	40,200	May 29th (7.59-8.10): Fluctuating concentration
Basement parking	42,900	May 29th (15.13-15.29): Stable concentration
Basement parking	59,200	June 1st (15.06-15.29): Fluctuating concentration
Indoor using wood stove	100-400,000	May 28th and May 31st: Rising concentrations

From table 1 is seen that the air pollution alongside larger streets in Slovakian cities is about 20 times higher than in the mountains and about 10 times higher than the pollution at the city boarder and in rural areas. This was confirmed by many measurements in several Slovakian cities (only some key data included). This underlines that local diesel traffic is a dominating pollution source inside cities. Furthermore, it is seen that passengers inside diesel trains are heavily exposed to diesel particles from the locomotive. Passengers in cars and busses are exposed to high levels of diesel particles from the surrounding traffic. Or in other words: Many commuters are exposed to hazardous air pollution from diesel traffic without particle filters. In two basement parkings were measured high pollution levels due to insufficient ventilation. Finally, wood burning could be an overlooked and significant pollution source causing a serious health impact in Slovakia by increasing indoor and outdoor air pollution.

Conclusion

People living in Slovakian cities are heavily exposed to ultrafine diesel particles when waiting for the bus or tram, walking alongside or driving on the large streets in cars or busses. Inside diesel trains was observed high pollution levels as well. Furthermore, wood burning seems to be a key source to indoor and outdoor air pollution in residential areas.

Recommendations

I. Introduce low-emission zones in cities with filter requirements for old diesel vehicles.

II. Replace old busses with new EURO VI busses with particle filters or CNG busses.

III. Replace diesel trains with electrical trains or retrofit diesel trains with particle filters.

IV. Make better requirements for - and control of - air exchange in basement parkings.

V. Build cycle lanes to make more people bike to reduce traffic congestion as well as air pollution and to improve public health and free mobility.

VI. Inform about indoor air pollution related to wood burning.

VII. Reduce the particle emission from wood burning by better insulation (reducing the amount of wood burned) and by replacing old wood stoves and boilers with new units.

These screening measurements should be followed by more detailed investigations covering longer measuring intervals. Especially more investigations of pollution in basement parkings spreading to shopping areas and in diesel trains and busses should be carried out.

Further information

Centre for Sustainable Alternatives: **www.cepta.sk/index.php/sk**
Danish Ecological Council: **www.ecocouncil.dk/en/traffic-and-air**
www.winkas.dk/wkwebshop/varedetaljer.asp?shopid=851152&funique=244&kat=3&hkat=1

Funding

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