Measurement Report: Air Quality Monitoring During the Remeo Fire in Rusko, Tampere (November 6–9, 2024)

19.2.2025

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1. Fire at waste management facility in Rusko, Tampere – sequence of events

According to the rescue department's report, the fire that broke out at Remeo's waste management facility in Rusko, Tampere, in early November turned out to be a large and challenging incident, requiring several days of intensive firefighting efforts. The fire started on Tuesday, November 5, and continued to burn strongly for several days. The smoke generated was significant, leading to an emergency warning being issued for the Rusko area on the same day. Later, the warning was extended to include the Lintuhytti area as smoke spread further due to wind.

The rescue department quickly launched extensive extinguishing and clearing operations. The tightly packed waste piles at the facility slowed down the firefighting, as the fire pockets were deep inside the material. The only effective solution was to dismantle and spread the waste piles by breaking down structures so the fire pockets could be extinguished efficiently. Thanks to round-the-clock firefighting, smoke production was significantly reduced by Friday, November 8, and the situation was considered to be improving.

However, smoke and odors continued at a milder level for several days, and residents were advised to stay indoors and close ventilation if necessary. The rescue department also actively monitored weather conditions and smoke dispersion in real time from its command center, which coordinated the situation in cooperation with various authorities. Air quality and the harmful effects of smoke were continuously assessed, and residents were provided with guidance and support regarding potential health impacts.

Over the weekend, the situation improved considerably. The largest fires were extinguished, and smoke turned into light steam, which no longer posed significant health risks. On Saturday, November 9, the rescue department was able to reduce the number of units on site, and the emergency warning was lifted. Although mild odor nuisances could still occur depending on weather conditions, the situation was brought fully under control.

2. Measurements and Equipment

On the morning of Wednesday, November 6, the Aerosol Physics Laboratory at Tampere University received a request to participate in an air quality assessment coordinated by the City of Tampere. In response to this request, the measurement equipment was quickly assembled and installed in the ATMo-Lab mobile laboratory so that measurements could begin as soon as possible. Measurement activities started that afternoon at around 1:00 PM. The initial goal was to obtain an overview of the fire's impact on air quality and to map pollutant concentrations, particularly near the fire site.

Measurements were continuously adapted based on weather conditions and smoke dispersion. Between Wednesday and Friday, the mobile laboratory was strategically relocated to areas with the highest smoke risk, especially residential neighborhoods. Real-time data enabled effective monitoring of smoke movement and reporting of its potential environmental impacts.

On Friday, November 8, measurements indicated that smoke formation around the fire site had significantly decreased, and by Saturday, concentrations were already so low that smoke no longer had a significant effect on measured particle levels. Consequently, measurement activities were concluded on Saturday, November 9.

2.1. Measurement devices

Measurement devices used in real time measurements are presented in table 1.

Table 1. *Devices used*

Device	Manufacturer and model	Measured quantity
Condensation Particle Counter (CPC)	TSI model 3752	Particle number concentration (N)
Engine Exhaust Particle Sizer (EEPS) spectrometer	TSI model 3090	Particle size-distribution (particle sizes 5.6 – 560 nm)
Aerodynamic Particle Sizer (APS) spectrometer	TSI model 3221	Particle size-distribution (particle sizes 0.5 – 20 µm)
Aethalometer	Magee Scientific model AE33	Black carbon (BC) mass concentration
CO_2-analyzer	LI-COR Model LI-840A	Carbon dioxide concentration (CO2)
Miniature Diffusion Size Classifier	Matter Aerosol AG DiSCmini	Lung deposited surface area (LDSA)

Using the particle size distributions measured by EEPS and APS, it is possible to estimate the mass concentration of particles smaller than 2.5 µm (PM2.5). The DiSCmini was not used for continuous measurements like the other instruments; instead, it was operated in selected situations by walking with the device near the mobile laboratory. In addition to the instruments listed in Table 1, samples were collected on Friday on a carbon-coated copper grid for transmission electron microscopy (TEM).

Particle number concentration indicates how many particles are present in one cubic centimeter of sampled air. Mass concentration, on the other hand, describes the mass of particles in one cubic meter of air, expressed in micrograms. LDSA represents the surface area of particles deposited in the alveoli, measured in square micrometers per inhaled cubic centimeter of air.

2.2. Specific description of measurements

The measurements conducted on Wednesday 6.11. are described in table 2.

Table 2. *Measurements on Wednesday 6.11.*

Measurement	Start	End
Lintuhytti and the end of Ruskontie	13:20	13:37
North-East of Rusko	13:37	13:45
Close to the fire in Tauskonkatu	13:47	13:58
Fire site	13:58	15:07
North-East of Rusko and the end of Ruskontie	15:12	15:50
Lintuhytti and the end of Ruskontie	15:58	16:08
Saarenmaantie	16:08	16:18
Kaarina Maununtyttären tie (Kangasala)	16:18	16:33
Varsamäentie (Kangasala)	16:33	16:47
Drive back to Rusko (Saarenmaantie)	16:47	16:58
Lintuhytti and the end of Ruskontie	17:00	17:15
North-East of Rusko and a quick visit to fire site	17:16	17:22

The measurements conducted on Thursday 7.11. are described in table 3.

Table 3. *Measurements on Thursday 7.11.*

Measurement	Start	End
Lintuhytti and the end of Ruskontie	9:22	10:40
Lintuhytti and the end of Ruskontie	11:26	12:06
Houkanvuorentie	12:10	12:30
Lintuhytti, the end of Ruskontie and north-west of Rusko	12:35	13:15
Background measurement near Hervanta campus	13:20	13:25
The end of Lintuhytinkatu	15:50	8.11., 8:00

The measurements conducted on Friday 8.11. are described in table 3.

Table 4. *Measurement on Friday 8.11.*

Measurement	Start	End
Rusko, especially on the side of Ruskontie	9:30	9:52
Lintuhytti	9:52	9:55
Hirvikallio	9:59	10:04
Saarenmaantie	10:23	10:29
Hirvikallio and Juvankatu	10:31	10:48
Ruskontie	10:48	10:52
Hirvikallio	11:51	12:02
Eastside of Rusko	12:02	12:16
Hirvikallio and eastside of Annala	12:20	13:05
Eastside of Rusko and Lintuhytti	13:05	13:26
Polunmäenkatu (TEM-sample collection)	15:00	15:36
Eastside of Ruskon and south of Hirvikallio	15:36	16:15

2.2. Electron microscopy

TEM samples were collected in Rusko at Polunmäenkatu 40 on Friday, November 8, at 3:00 PM. This location is less than 300 meters from the fire site. Three samples were collected using flow-through-collector with different collection times: 10 seconds, 1 minute, and 10 minutes.

The analysis was performed using the Transmission Electron Microscope (TEM, JEOL JEM-F200) at Tampere University's Microscopy Center, equipped with an elemental analyzer (Energy

Dispersive Spectroscopy, EDS, JEOL Dual EDS). Qualitative elemental analyses were conducted by focusing the electron beam around individual particles.

The TEM grid naturally introduces some copper into the analysis results, and the analyzer introduces silicon; therefore, these elements were excluded from the analysis. Copper was unlikely to be present in the particles, but small amounts of silicon may have been present in some. The carbon-coated TEM grid contributes some carbon to the measurements, but in all analyses, the carbon signal was so significant that it can be concluded that carbon was present in all analyzed particles.

2.3. Weather during the measurement

Figure 1 presents wind directions as wind roses for the measurement days. The sector orientation indicates the direction from which the wind originated: 0° corresponds to north, 90° to east, 180° to south, and 270° to west. The wind data is open data from the Finnish Meteorological Institute, recorded at the Siilinkari station in Tampere. The data shown in the figures covers the entire period with a 10-minute time resolution. The assumed smoke dispersion direction is naturally opposite to the wind direction.

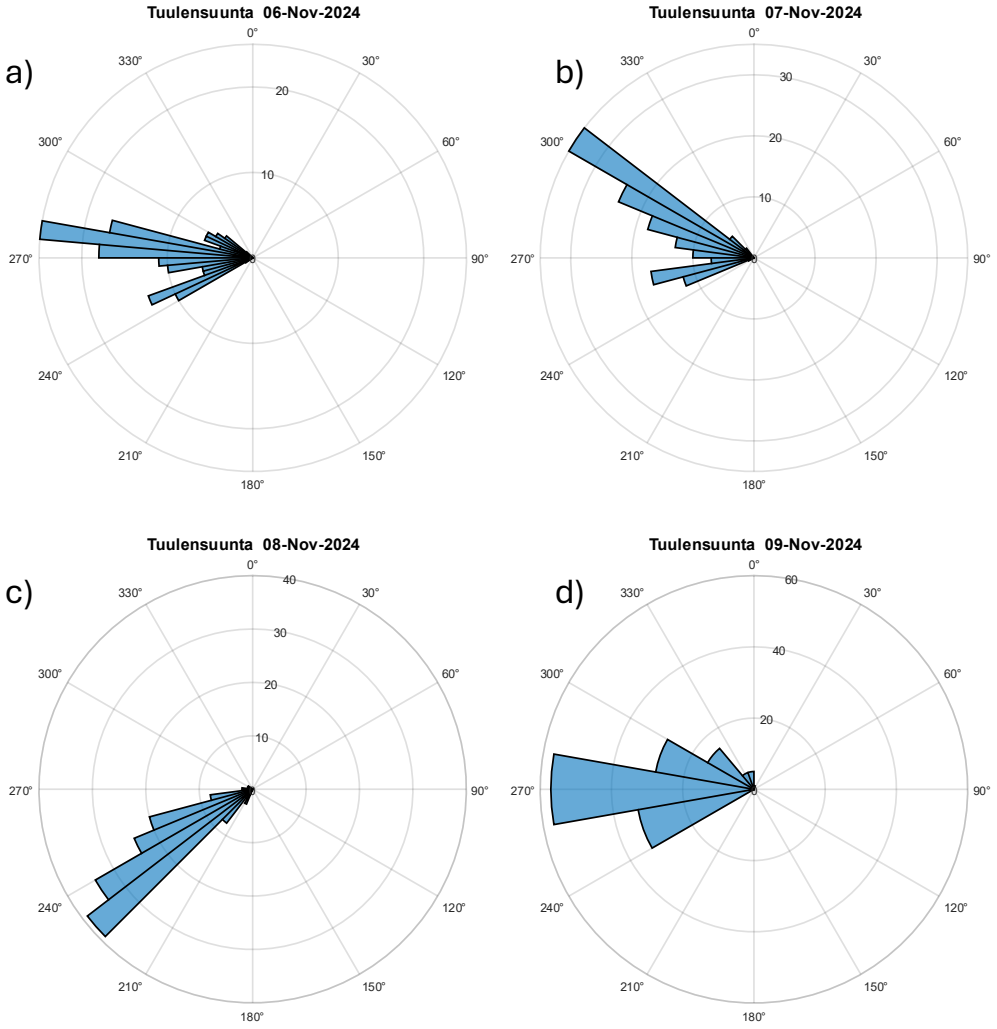


Figure 1. *Wind rose for (a) Wednesday 6.11., (b) Thursday 7.11., (c) Friday 8.11. ja (d) Saturday 9.11.*

3. Measurement results and conclusions

This section presents the measurement results, focusing mainly on particle number concentration, PM2.5 mass concentration, and black carbon mass concentration. These quantities have been plotted on maps for the measurement days, where the color of the circles represents the value of the parameter shown. The measurement results have been averaged so that all results from the same day measured within 10 meters of each other are combined into a single average.

Table 5 presents values for different parameters from Tampere city air quality monitoring stations to make it easier to understand the magnitude of the results in this report. The values are calculated based on one-minute averages. The results come from the Epilä, Pirkankatu, Kaleva, and bus station monitoring stations, except for LDSA, which is measured only at Epilä and Pirkankatu. The table averages are calculated from data from all stations, and the maximum value is from the station where it was recorded.

Table 5. *Mean and maximum values of particle number concentration, PM2.5, and LDSA at the City of Tampere air quality monitoring stations during the fire*

	N ($1/cm^3$)	PM2.5 ($\mu g/m^3$)	LDSA ($\mu m^2/cm^3$)
6.11. mean	4 900	2.0	5.0
6.11. maximum minute-average	61 000	11.7	53.5
7.11. mean	4 500	1.8	4.9
7.11. maximum minute-average	59 000	9.8	38.3
8.11. mean	2 800	1.7	3.9
8.11. maximum minute-average	30 000	11.6	29.8

Table 6 presents indicative threshold values for the measured parameters according to the air quality index prepared by the Helsinki Region Environmental Services Authority (HSY). The reported thresholds apply to hourly averages of the parameters.

Table 6. *HSY air quality index limits (HSY, 2025).*

Air quality	N (1/cm^3)	PM2.5 (µg/m^3)	BC (µg/m^3)	LDSA (µm^2/cm^3)
Very poor	≥101 000	≥76	≥12	≥120
Poor	61 000–100 000	51–75	7–12	80–120
Fair	31 000–60 000	26–50	3–7	40–80
Satisfactory	16 000–30 000	11–25	1–3	20–40
Good	<15 000	≤10	≤1	≤20

3.1. Results from the fire site

Measurements at the fire site were carried out very close to the source, approximately 50 meters from the fire. The measurement location is shown in Figure 2.

Figure 2. *The ATMo-Lab mobile laboratory measuring at the Rusko fire site. The fire was behind the waste pile visible in the picture.*

At the fire site, measurements were taken on Wednesday at the same location for about one hour. The results of these measurements are presented as time series in Figure 3. The LDSA measurement results from the fire site are presented in Section 3.3.

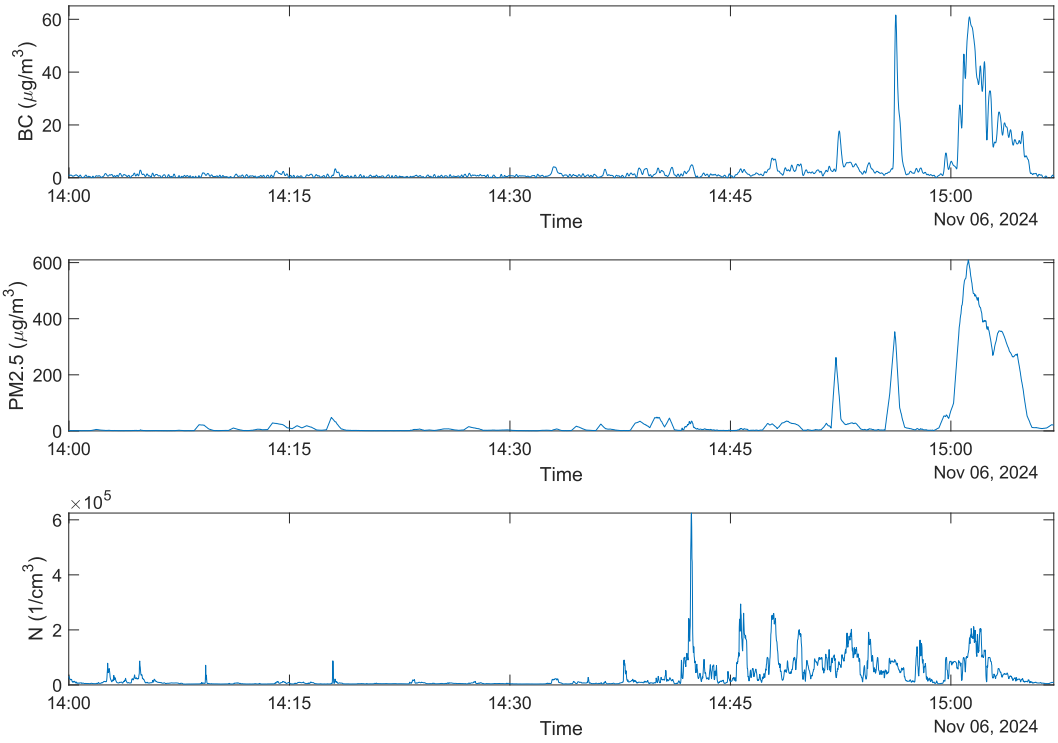


Figure 3. *Time series of black carbon (BC) mass, PM2.5, and particle number concentration (N) at the fire site on November 6.*

During the measurement period, pollutant concentrations varied significantly. At the beginning of the measurement period, smoke did not drift toward the mobile laboratory, which is clearly visible in the particle concentration time series. However, during the last half hour of the measurement—and especially in the final five minutes—smoke clearly moved toward the mobile laboratory, and elevated levels can be observed in the measurement results. It can also be noted that this smoke plume was clearly visible to the naked eye.

3.2. Smoke dispersion to nearby areas

3.2.1. Smoke Dispersion on Wednesday, November 6.

On Wednesday, it was observed that smoke drifted eastward from the fire site. The smoke crossed the road at the curve near the end of Ruskontie and moved north of the forest area located in the northeastern part of Lintuhytti. Based on these observations, measurements were mainly focused on the Rusko and Lintuhytti areas. Background concentrations on Wednesday

were approximately 2,200 particles/cm³ for particle number, about 3.2 µg/m³ for PM2.5, and about 0.2 µg/m³ for black carbon mass. These background concentrations were measured at Kaarina Maununtyttärentie.

Figures 4–6 show the mass concentrations of black carbon and PM2.5, as well as particle number concentration. Some data points are missing from the figures due to occasional GPS data gaps.

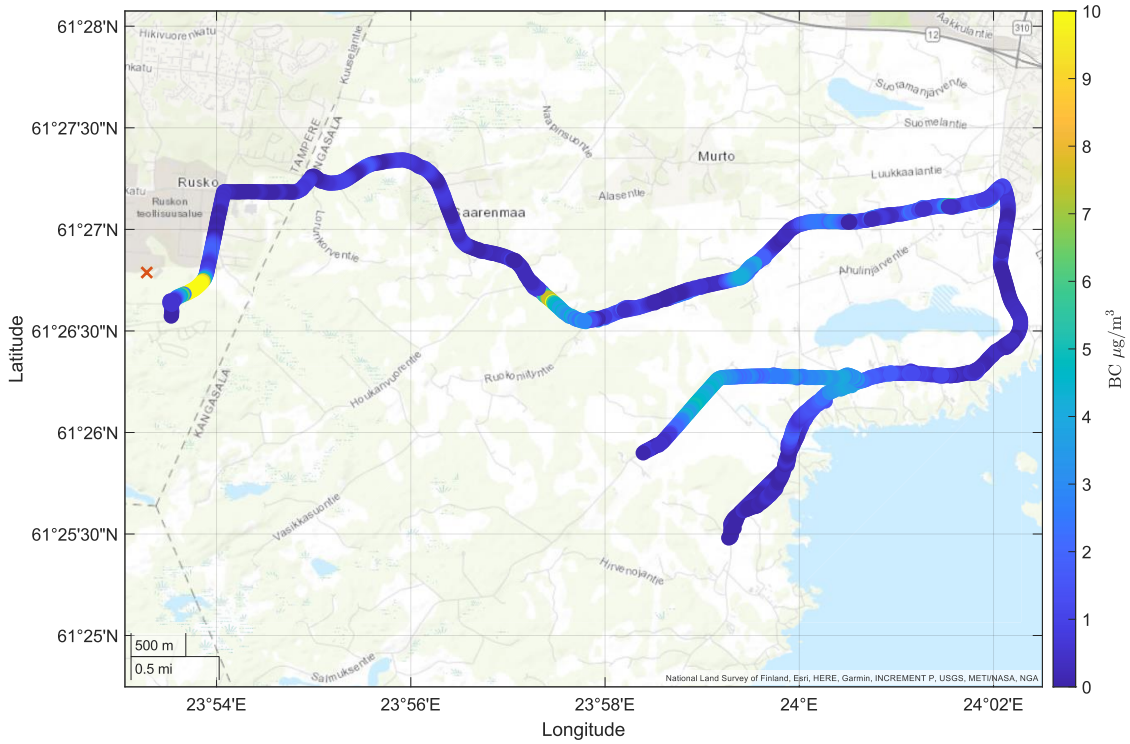


Figure 4. *Black carbon mass concentration on the map on Wednesday, November 6. The fire site is marked with an "x" symbol in this and all other map figures.*

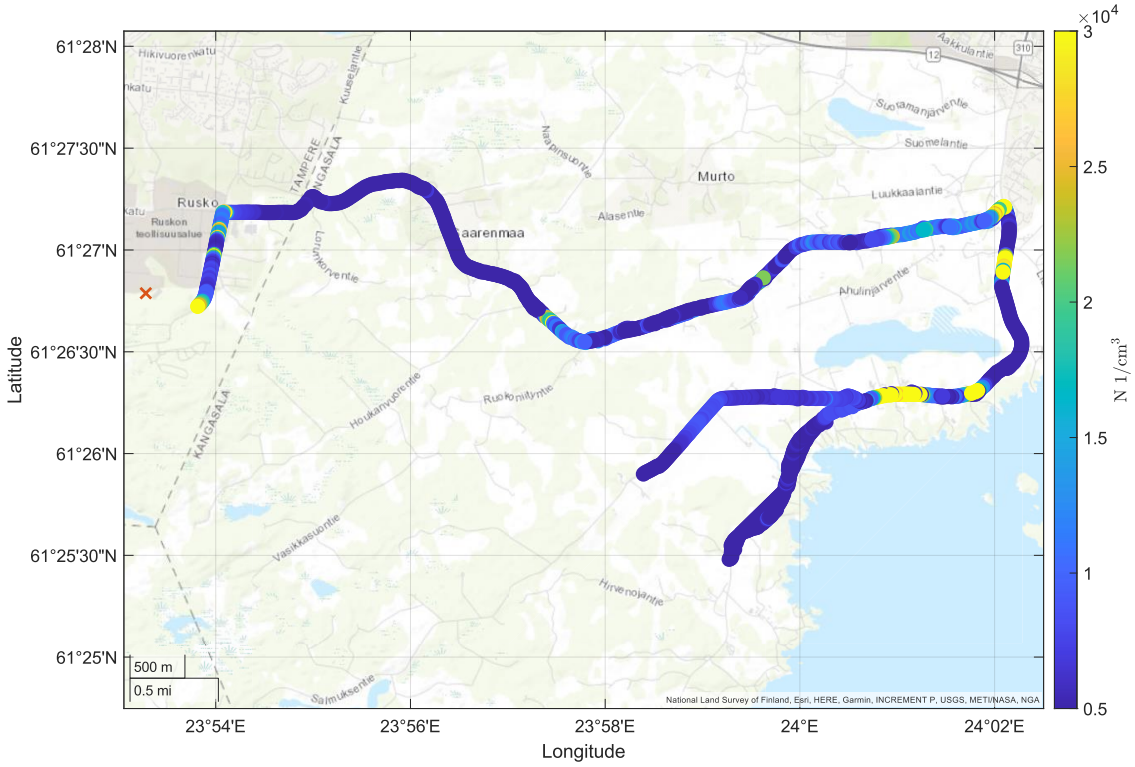


Figure 5. *Particle number concentration on the map on Wednesday, November 6.*

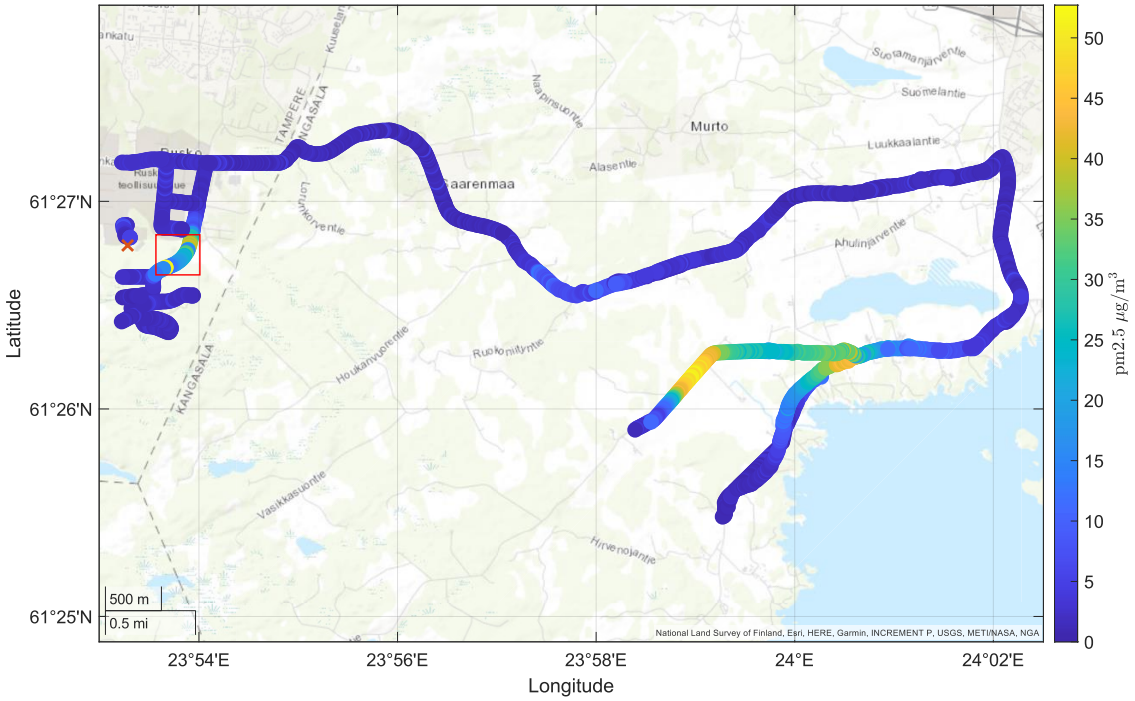


Figure 6. *PM2.5 concentration on the map on Wednesday, November 6.*

In general, the individual points with higher concentrations (circle symbols) in the figures are caused by emissions from vehicles passing the mobile laboratory. From Figure 6, it can be seen that smoke had not yet reached the Lintuhytti area on Wednesday. Smoke dispersion also appears to have been mostly limited south of Saarenmaantie, as only isolated measurement points with elevated concentrations were observed there for any parameter. Interestingly, on Varsamäentie in Kangasala—more than 5 km from the fire site—particle concentrations were clearly elevated. The smoke was also visible to the naked eye. The most pronounced difference is seen in PM2.5 results, which match background levels near nearby roads but exceed 50 µg/m³ in smoke at Varsamäentie. Table 5 shows that the daily average at Tampere air quality monitoring stations was 2 µg/m³, and the highest one-minute average was 11.7 µg/m³. Compared to these values, it is clear that fine particle mass concentration was significantly elevated even at such a distance from the fire.

Due to GPS issues, the data in the Ruskontie curve (red rectangle in Figure 6) is incomplete. As a result, PM2.5 concentrations appear higher on the Kangasala side than in Rusko. By reviewing the measurement log for times when the Ruskontie curve was driven, the following averages were calculated: particle number concentration—mean about 23,000 particles/cm³, median 20,000 particles/cm³, and maximum 145,000 particles/cm³; PM2.5 concentration—mean 84 µg/m³, median 67 µg/m³, and maximum 250 µg/m³; black carbon mass concentration—mean 9.3 µg/m³, median 7.5 µg/m³, and maximum 31 µg/m³.

3.2.2. Smoke Dispersion on Thursday, November 7.

On Thursday, the wind direction shifted compared to Wednesday, blowing more from the northwest, which caused smoke to drift southeast from the fire site, often toward Lintuhytti. For this reason, measurements focused particularly on the Lintuhytti area. Background concentrations in Rusko on Thursday were approximately 7,000 particles/cm³ for particle number, about 2.7 µg/m³ for PM2.5, and about 0 µg/m³ for black carbon mass. These background concentrations were measured at the western end of Huppionmäenkatu. Figures 7–9 present the mass concentrations of black carbon and PM2.5, as well as particle number concentration from Thursday’s measurements.

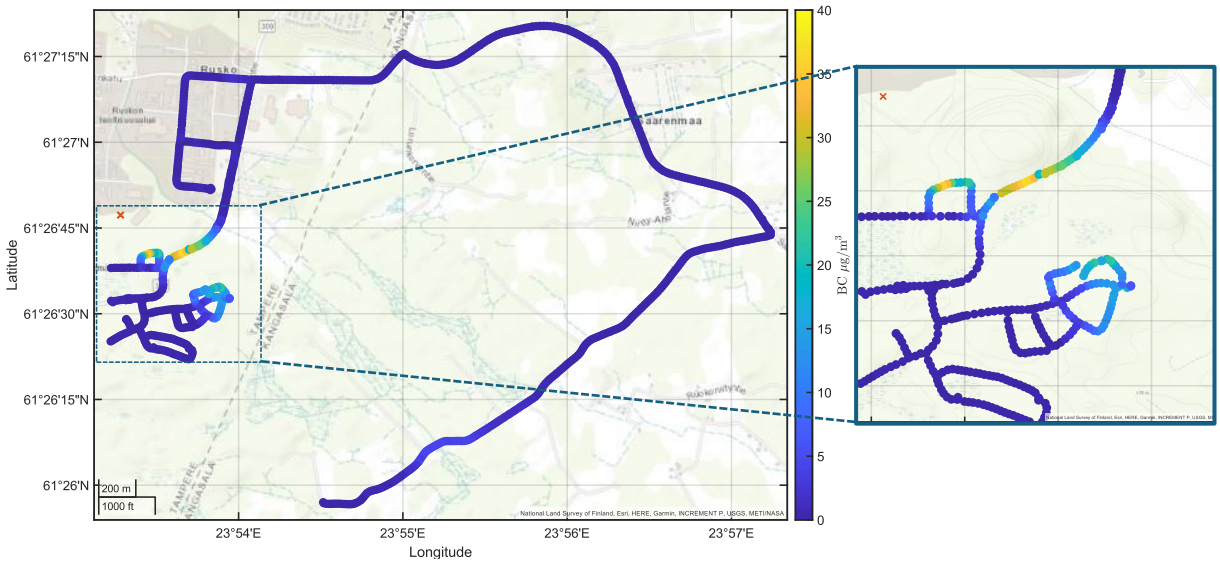


Figure 7. *Black carbon mass concentration on the map on Thursday, November 7.*

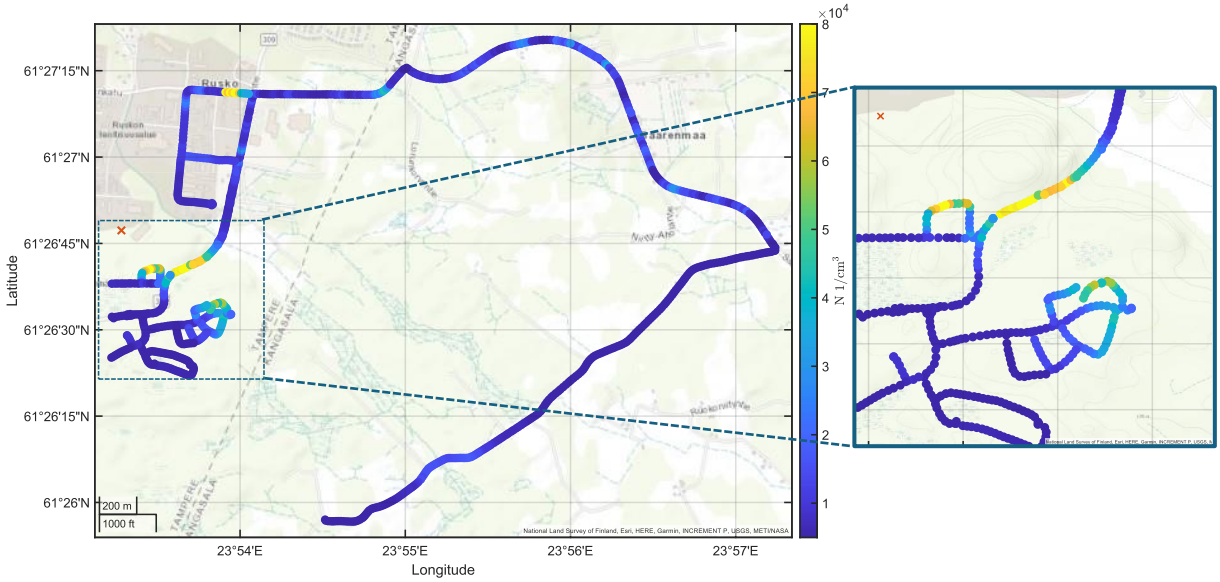


Figure 8. *Particle number concentration on the map on Thursday, November 7.*

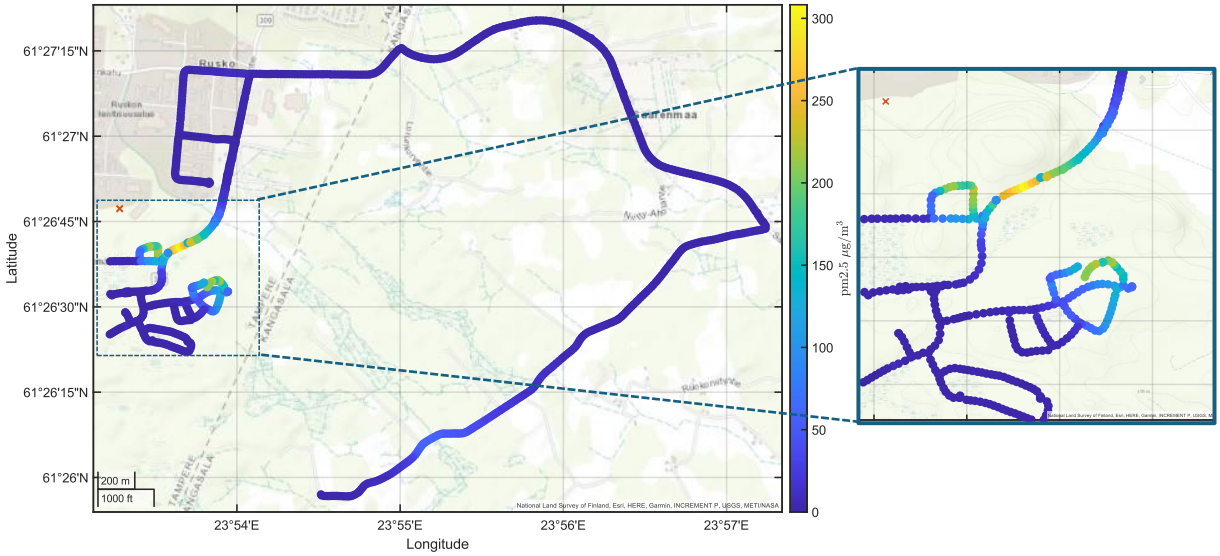


Figure 9. *PM2.5 concentration on the map on Thursday, November 7.*

The figures show that particle concentrations in the Ruskontie curve on Thursday were clearly higher than the maximum values mentioned for Wednesday in the previous section. It should be noted that the map points represent averages of all measurements taken within 10 meters of each other during the entire day.

In Lintuhytti on Thursday, the particle number concentration had a mean of 21,000 particles/cm³, a median of 13,000 particles/cm³, and a maximum of 90,000 particles/cm³. PM2.5 concentration had a mean of 65 µg/m³, a median of 33 µg/m³, and a maximum of 301 µg/m³. Black carbon mass concentration had a mean of 7.6 µg/m³, a median of 3.0 µg/m³, and a maximum of 59 µg/m³. These figures do not include nighttime measurements presented in the following figures. All of the above results are clearly higher than background levels. It is also noteworthy that the maximum value for each parameter was measured within 50 meters of the nighttime measurement location at the end of Lintuhytinkatu. Based on the mean values for PM2.5 and black carbon mass concentration, the indicative air quality index (Table 6) suggests that air quality in Lintuhytti was poor on Thursday. From the PM2.5 and black carbon maps, it can be seen that air quality in the northeastern part of Lintuhytti was very poor. Based on particle number concentration, air quality across Lintuhytti was moderate and poor in the northeastern part.
On Thursday afternoon, November 7, the mobile laboratory was moved to the parking area at the end of Lintuhytinkatu, where measurements continued overnight until morning. The particle number concentration from this measurement is shown in Figure 10.

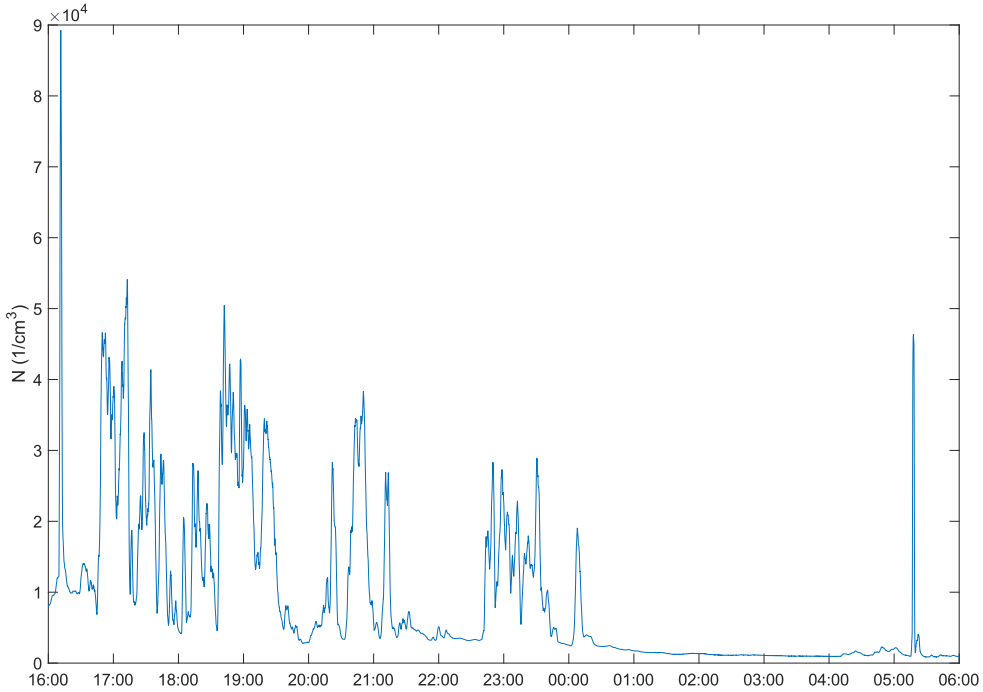


Figure 10. *Particle number concentration overnight, November 7–8.*

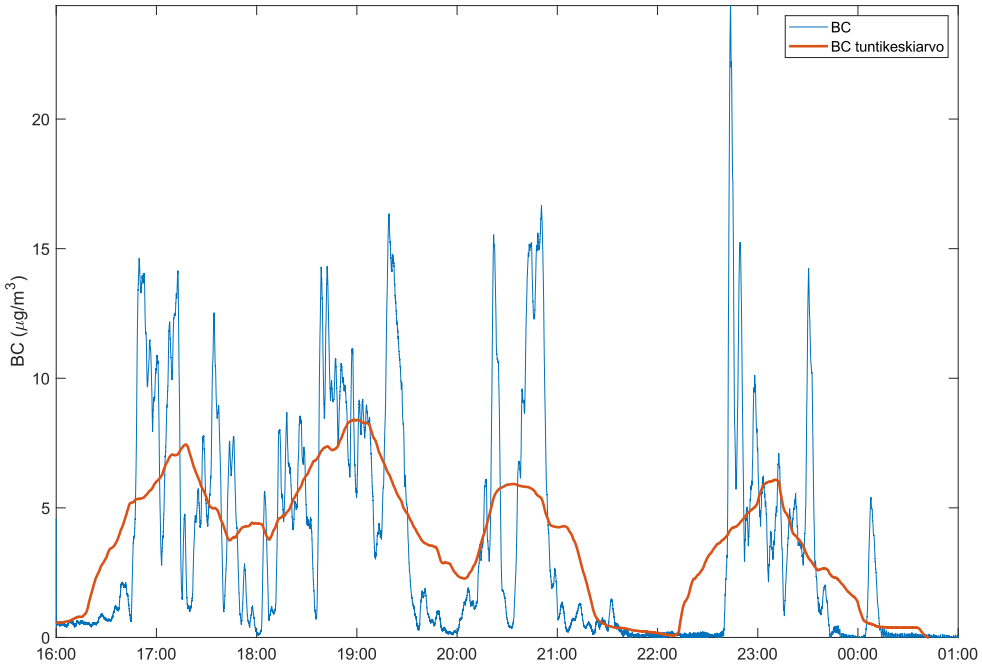


Figure 11. *Black carbon mass concentration and calculated continuous hourly average on the evening and night of November 7 in Lintuhytti.*

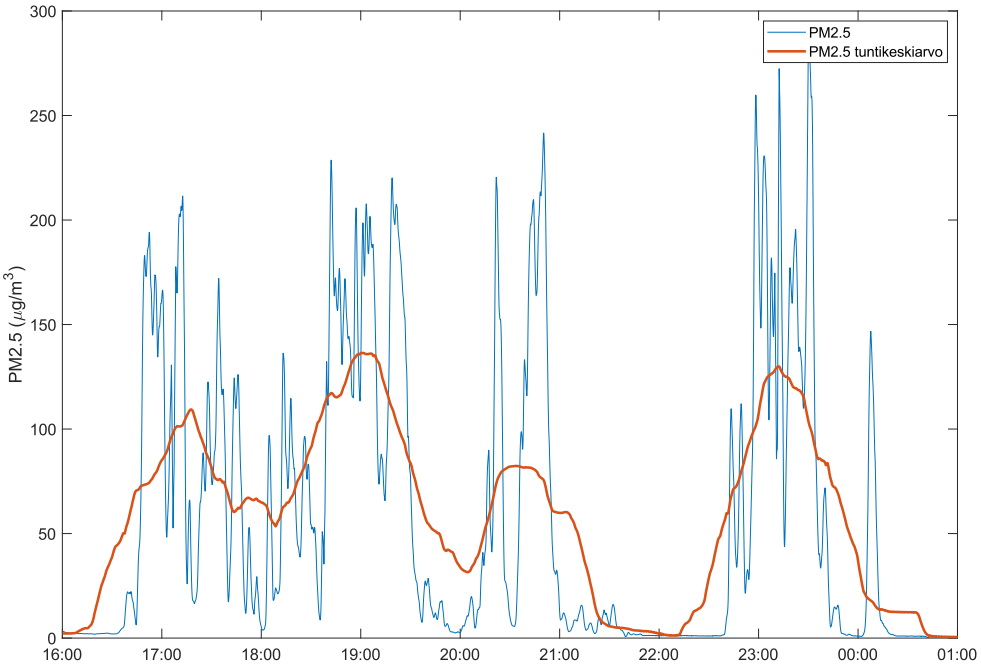


Figure 12. *PM2.5 concentration and its hourly average on the evening and night of November 7 in Lintuhytti.*

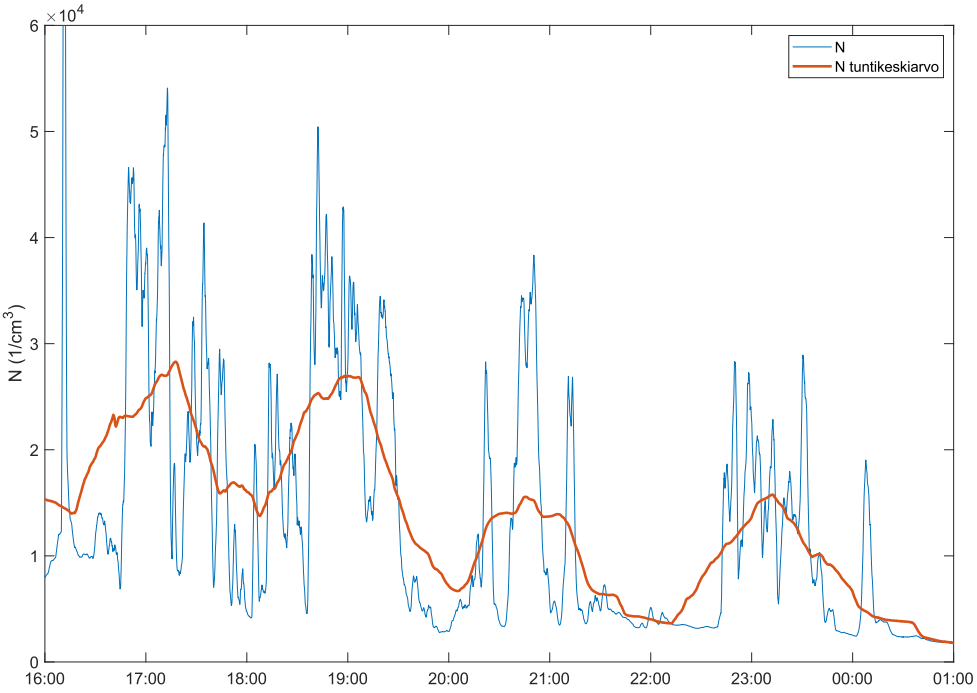


Figure 13. *Particle number concentration and its hourly average on the evening and night of November 7 in Lintuhytti. The first peak is truncated for height.*

Figures 11–13 show that, especially between 17:00 and 21:00, particle concentrations in Lintuhytti were clearly above background levels. Only particle number concentration recorded a higher single maximum value during the night than during the day, but these were isolated spikes around 16:10 and 05:15. Since these spikes in particle number concentration were brief and isolated, it is likely they were not caused by smoke from the fire. Overall, it can be said that air quality in Lintuhytti was significantly worse than background levels on Thursday evening due to smoke from the fire.

Based on PM2.5 measurements, air quality was poor or very poor during the afternoon and evening. Based on black carbon mass concentration, air quality was poor, and based on particle number concentration, it was satisfactory.

3.2.3. Smoke Dispersion on Friday, November 8

On Friday, November 8, smoke was observed drifting northeast and spreading across a much wider area in Rusko compared to previous days. Previously, smoke moved as a distinct plume, whereas on Friday, the entire eastern part of Rusko appeared to be somewhat covered by smoke. Based on these observations, measurements focused mainly on the residential areas of Rusko, Hirvikallio, and Annala. Background concentrations in Rusko on Friday were approximately 2,300 particles/cm³ for particle number, about 1.3 µg/m³ for PM2.5, and about 0.4 µg/m³ for black carbon mass. These background concentrations were measured at the western end of Huppionmäenkatu. Friday's measurement data is presented on maps in Figures 14, 15, and 16.

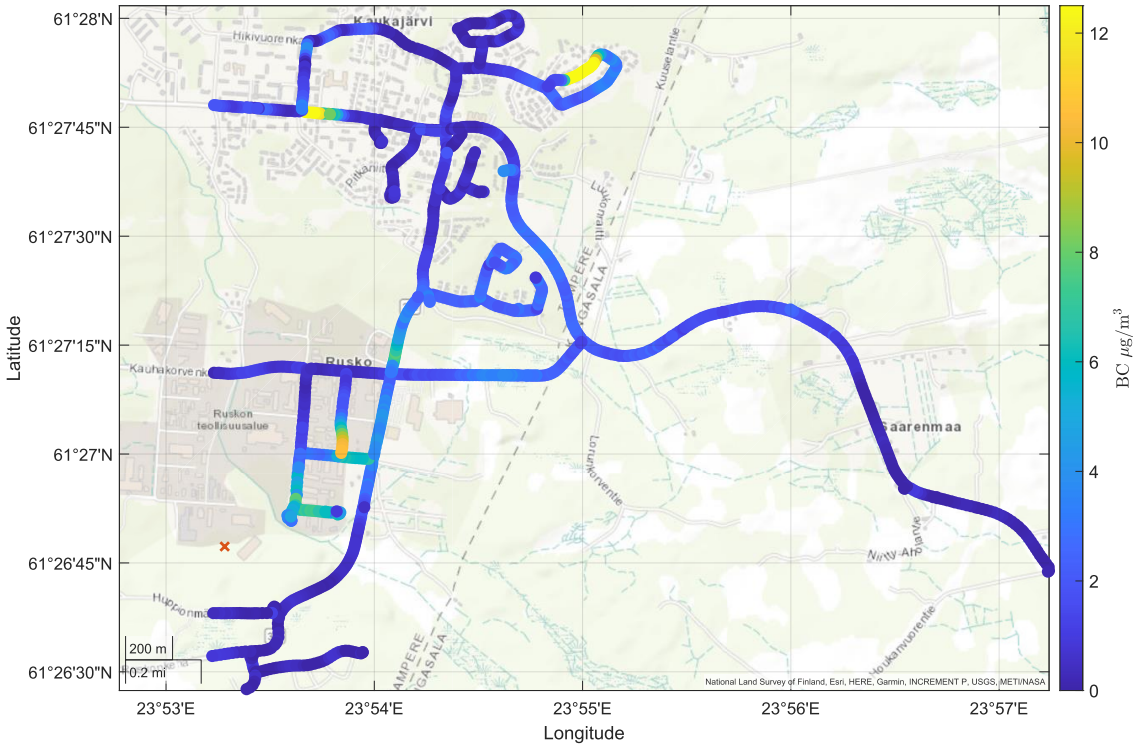


Figure 14. *Black carbon concentration on Friday, November 8.*

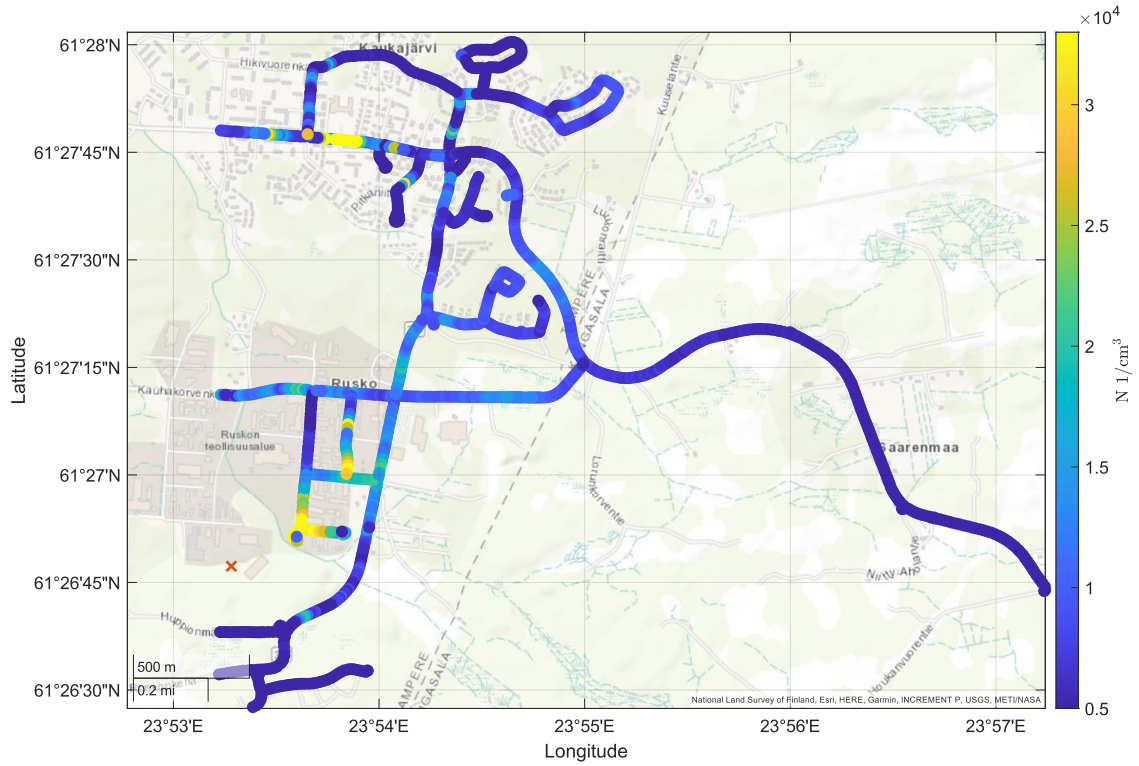


Figure 15. *Particle number concentration on Friday, November 8.*

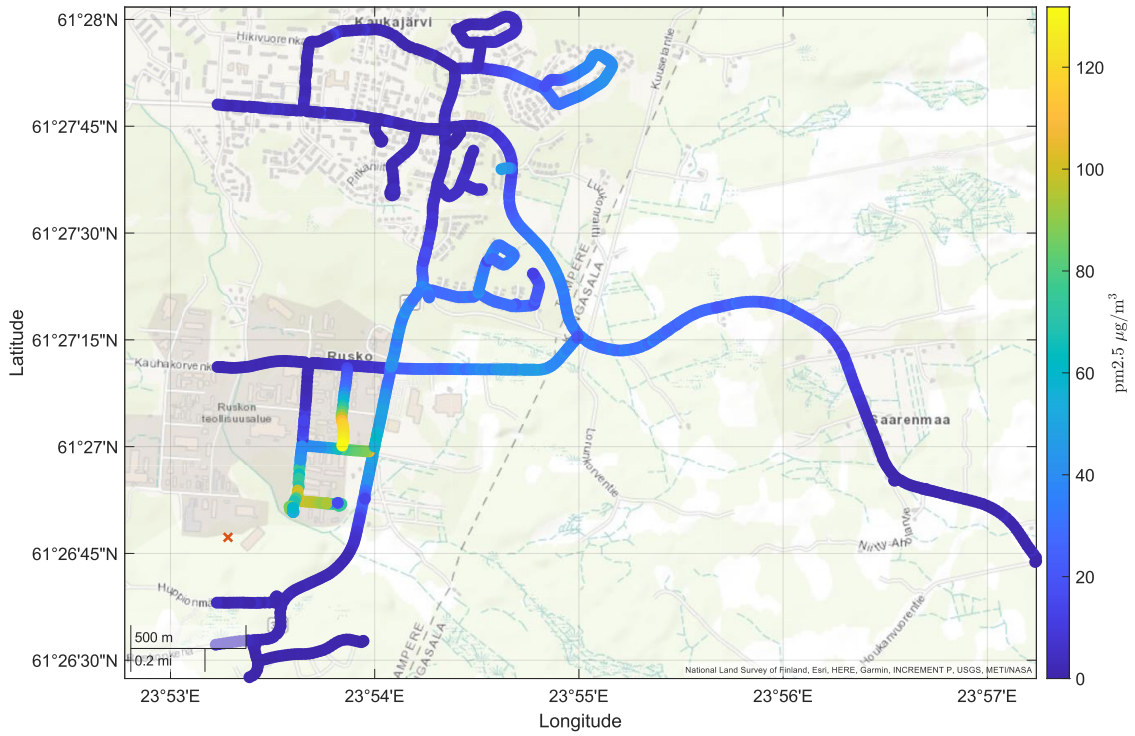


Figure 16. *PM2.5 concentration on Friday, November 8.*

The figures show that smoke spread in Rusko very differently compared to previous days. Elevated particle concentrations were also observed in Hirvikallio and the eastern parts of Annala. The spike in black carbon concentration visible on Meiramikatu in northeastern Annala (center north on the map) is likely due to emissions from small-scale combustion in a nearby house. It is also noteworthy that all measured values were clearly lower than those recorded on previous days. For example, the maximum PM2.5 average on Thursday was about 300 µg/m³ in the Ruskontie curve, whereas on Friday, the highest measured PM2.5 average was about 125 µg/m³. Nevertheless, PM2.5 remained elevated compared to the values presented in Table 5 and the background levels measured at Huppionmäenkatu.

In Hirvikallio on Friday, the particle number concentration had a mean of 7,900 particles/cm³, a median of 6,800 particles/cm³, and a maximum of 64,000 particles/cm³. PM2.5 concentration had a mean of 25 µg/m³, a median of 17 µg/m³, and a maximum of 85 µg/m³. Black carbon mass concentration had a mean of 2.1 µg/m³, a median of 1.3 µg/m³, and a maximum of 8.6 µg/m³. Thus, particle concentrations were clearly elevated compared to background levels.

Particle concentrations in Hirvikallio were mostly low in the morning and increased slightly in the afternoon. If similar values are calculated for measurements taken around 12:20–12:40, the mean particle number concentration in Hirvikallio was about 14,000 particles/cm³ and the median about 14,500 particles/cm³; PM2.5 concentration had a mean of about 65 µg/m³ and a median of 66

µg/m³; and black carbon mass concentration had both a mean and median of about 5.4 µg/m³. According to the indicative air quality index, air quality in Hirvikallio was satisfactory or good on average throughout the day, but during the aforementioned period, it was poor based on PM2.5 concentration and poor based on black carbon mass concentration.

3.3. LDSA results

The lung-deposited surface area (LDSA) of particles was measured using a portable DiSCmini device. The average measurement results and their locations are shown in Figure 17. It should be noted that the measurements were taken on different days.

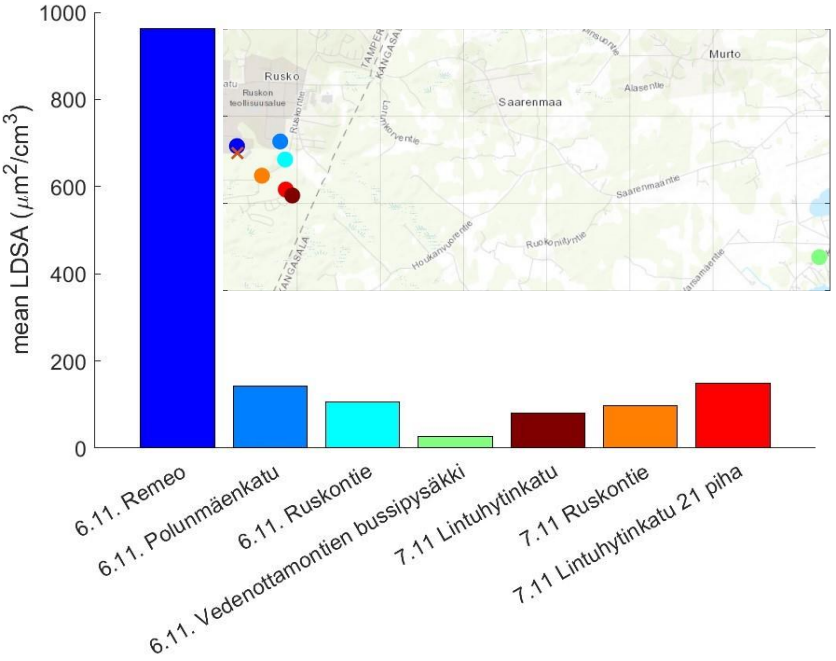


Figure 17. *LDSA concentrations at different measurement locations, with positions indicated below the bars.*

The figure shows that the LDSA average measured at the fire site is an order of magnitude higher than at other locations. The measurement was performed while walking at the fire site, and the wind carried smoke directly to the measurement point. In Figure 17, the bar for the fire site has been excluded to make comparison between other locations easier.

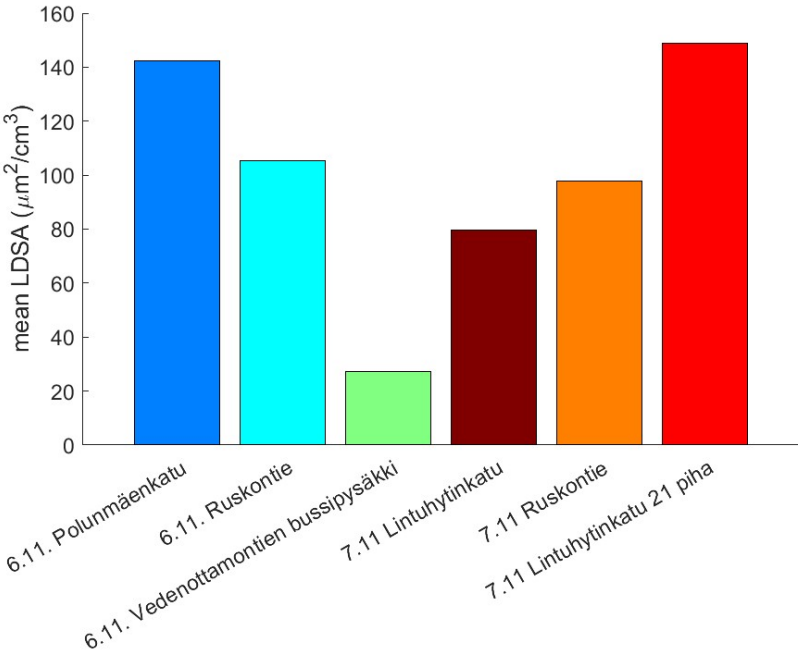


Figure 18. *LDSA concentrations at different measurement locations excluding the Remeo area.*

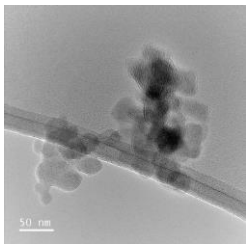
Figure 18 shows that the LDSA average at the Vedenottamo bus stop is significantly lower than at other locations, which is expected since it is much farther from the fire site. Other LDSA results are relatively close to each other, though all values are fairly high. The measurement results can be compared to Tampere city LDSA data from Epilä and Pirkankatu air quality stations based on Table 5. The average LDSA at these stations on Wednesday and Thursday was about 5 µm²/cm³. The highest one-minute averages recorded at the city stations were 53.5 µm²/cm³ and 38.3 µm²/cm³. Compared to these figures, it is clear that in Rusko and Lintuhytti on November 6 and 7, exposure to fine particles could have been several times higher than in a typical urban environment.

According to Table 6, air quality based on LDSA measurements was poor or very poor in Lintuhytti and Rusko on November 6–7. However, it should be noted that LDSA measurements were relatively short in duration—at most about 10 minutes—and therefore cannot be used to draw conclusions about air quality for the entire day.

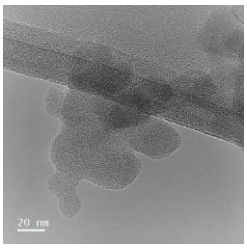
3.4. Electron microscopy results

The microscopy samples collected on Friday were analyzed using a transmission electron microscope (TEM) equipped with an elemental analyzer (EDS). This instrumentation allows imaging of the morphology of individual particles and identification of the elements they contain. The samples were collected about 300 meters from the fire site, in the yard at Polunmäenkatu

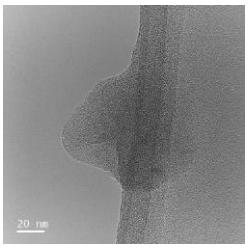
40. Sampling durations were 10 seconds, 1 minute, and 10 minutes. The samples were collected consecutively from the same location, so they mainly represent different subsets of the same situation. These results are shown in Figures 19–21.



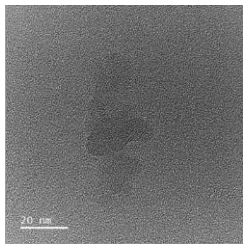
Kuva 1



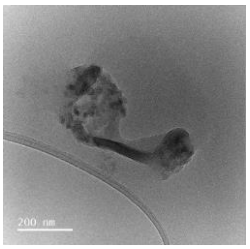
Kuva 2



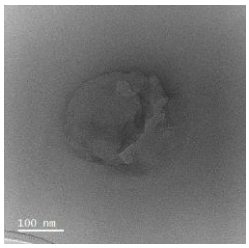
Kuva 3



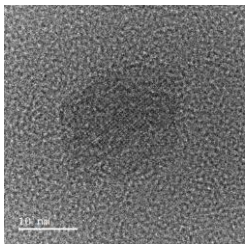
Kuva 4



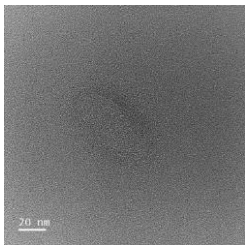
Kuva 5



Kuva 6



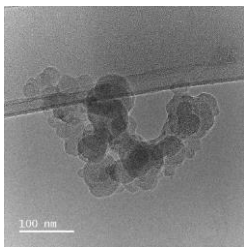
Kuva 7



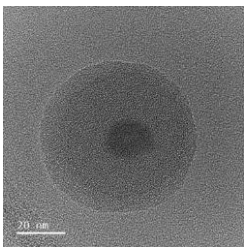
Kuva 8

	C	N	O	Zn	Na	P	S	Pb	Cl	K	Ca	Fe	Sb
Kuva 1	X		X				X		X				
Kuva 2	X		X										
Kuva 3	X	X	X	X	X		X	X	X	X			
Kuva 4	X		X			X							
Kuva 5	X	X	X			X	X						
Kuva 6	X	X	X										
Kuva 7	X		X	X		X					X	X	
Kuva 8	X		X										

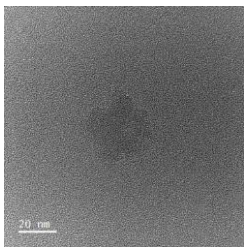
Figure 19. *TEM collection (shortest duration): images of individual particles and the elements they contain.*



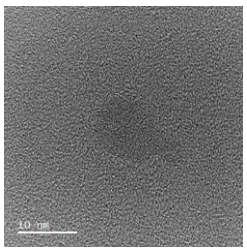
Kuva 1



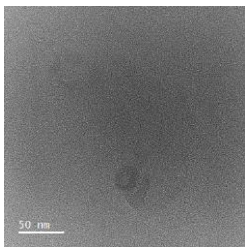
Kuva 2



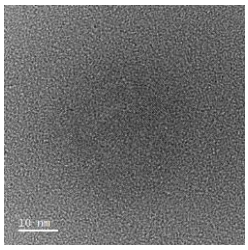
Kuva 3



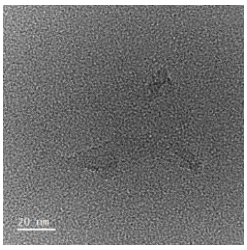
Kuva 4



Kuva 5



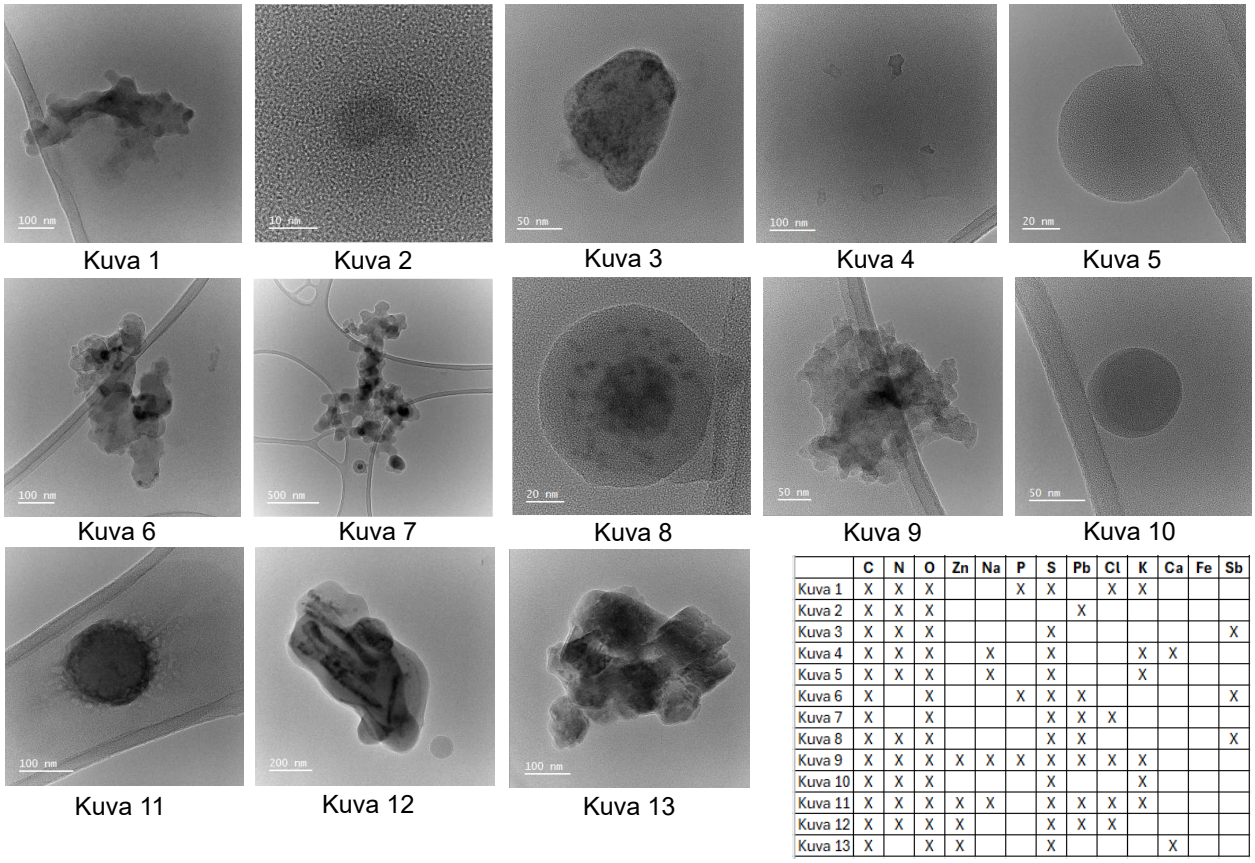
Kuva 6



Kuva 7

	C	N	O	Zn	Na	P	S	Pb	Cl	K	Ca	Fe	Sb
Kuva 1	X	X	X			X	X		X	X	X		
Kuva 2	X	X	X	X			X	X					
Kuva 3	X		X										
Kuva 4	X		X									X	
Kuva 5	X	X	X		X		X	X		X	X		
Kuva 6	X	X	X		X			X		X	X		
Kuva 7	X	X	X				X						

Figure 20. *TEM collection (medium duration): images of individual particles and the elements they contain.*



	C	N	O	Zn	Na	P	S	Pb	Cl	K	Ca	Fe	Sb
Kuva 1	X	X	X			X	X		X	X			
Kuva 2	X	X	X					X					
Kuva 3	X	X	X				X						X
Kuva 4	X	X	X		X		X			X	X		
Kuva 5	X	X	X		X		X			X			
Kuva 6	X		X			X	X	X					X
Kuva 7	X		X				X	X	X				
Kuva 8	X	X	X				X	X					X
Kuva 9	X	X	X	X	X	X	X	X	X	X			
Kuva 10	X	X	X				X			X			
Kuva 11	X	X	X	X	X		X	X	X	X			
Kuva 12	X	X	X	X			X	X	X				
Kuva 13	X		X	X			X				X		

Figure 21. *TEM collection (longest duration): images of individual particles and the elements they contain.*

Analyses of individual particles using TEM+EDS revealed that particle compositions and sizes varied considerably. The most common elements were carbon (C), nitrogen (N), oxygen (O), and sulfur (S), but individual particles in the samples also contained several other elements, such as phosphorus (P), sodium (Na), zinc (Zn), antimony (Sb), lead (Pb), calcium (Ca), and chlorine (Cl). This wide range suggests that the smoke originated from a variety of materials and that combustion conditions varied. The diversity of particle composition also indicates that aerosol formation mechanisms were complex. However, it is important to note that the collected samples represent only a specific moment and location during the fire.

4. Summary and conclusions

The effects of smoke on the environment and air quality were most evident in the immediate vicinity of the fire site, where particle and gas concentrations were highest. Peak levels reached 60 µg/m³ for black carbon and 500 µg/m³ for PM2.5, although average exposure during the measurement period was considerably lower. To minimize exposure, it is recommended to use personal protective equipment, such as particle and gas filters, especially for individuals working or staying in areas significantly affected by smoke.

The main direction of smoke dispersion varied daily:

- **Wednesday, Nov 6:** Smoke drifted east toward sparsely populated areas near Lake Roine**.**
- **Thursday, Nov 7:** Smoke primarily affected the northeastern part of Lintuhytti.
- **Friday, Nov 8:** Smoke spread toward Hirvikallio and Annala.
- **Saturday, Nov 9:** Measurements were discontinued as no elevated particle concentrations were detected.

Fine particle concentrations (PM2.5) were clearly elevated in areas affected by smoke. Although black carbon was abundant, it explained PM2.5 concentrations only partially. This suggests that the smoke contained significant amounts of other particle components, likely organic compounds typical of fires (Lovén et al., 2024). Particle number concentrations observed in the smoke plume were relatively low or comparable to those found in traffic environments. Therefore, mass concentration or black carbon concentration appear to be better indicators of smoke presence than particle number concentration.

Analyses of individual particles revealed substantial variation in particle composition and size. The most common elements were carbon (C), nitrogen (N), oxygen (O), and sulfur (S), but individual particles also contained phosphorus (P), sodium (Na), zinc (Zn), antimony (Sb), lead (Pb), calcium (Ca), and chlorine (Cl). This wide range indicates that the smoke originated from various materials and that combustion conditions and particle formation mechanisms varied.

The boundaries of smoke in the environment were distinct, and concentrations changed rapidly between smoky and clean air. This was evident as sudden changes in real-time particle concentration readings.

Sensory observations of the smoke:

1. **No odor or visible smoke:** Instruments detected no smoke-related particle concentrations.
2. **Smell of burning but no visible smoke:** Fine particle concentrations were generally very low, and smoke impact was barely detectable by instruments.
3. **Smoke odor and visible smoke:** Particle concentrations were clearly elevated, and exposure should be avoided. However, absolute concentration levels cannot be reliably estimated by sensory observation.

As a general observation, people can often detect the presence of smoke fairly reliably based on smell and visibility. This provides a rough indication of exposure risk, but sensory perception cannot determine exact concentration levels. Instrument-based measurements enable more accurate information on smoke composition and concentration levels, improving understanding of smoke dispersion and its impacts.

5. Sources

HSY. *What is the air quality index?* Available: https://www.hsy.fi/en/air-quality-and-climate/air-protection-and-health/what-is-the-air-quality-index/ (Read: 5.12.2025)

Lovén, K., Hagvall, L., Rex, J., Nilsson, C. A., Malmborg, V., Pagels, J., … Hedmer, M. (2024). Characterization of exposure to air pollutants for workers in and around fires. Journal of Occupational and Environmental Hygiene, 21(12), 878–894. https://doi.org/10.1080/15459624.2024.2406244.