National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Inter-laboratory comparison of **particulate matter filter weighing** 2025

RIVM report 2025-0086
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Colophon

DOI 10.21945/RIVM-2025-0086

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This study has been conducted on the own initiative of the participants in this comparison with the aim of checking the quality of reference measurements of particulate matter.

Published by:
National Institute for Public Health and the Environment, RIVM
PO Box 1 | 3720 BA Bilthoven
The Netherlands
www.rivm.nl/en

Synopsis

Inter-laboratory comparison of particulate matter filter weighing 2025

Measurements of particulate matter (PM_{10} and $PM_{2.5}$) in ambient air are performed by several air monitoring networks in Europe. These PM measurements are carried out using filters in a monitoring device with ambient air passing through it. Every filter is exposed to ambient air for 24 hours. The laboratories of the air monitoring networks determine the concentration of PM by using the weight of the filters before and after exposure.

In order to investigate whether this weighing procedure – when applied by different laboratories – leads to similar results, a comparison between the laboratories is carried out every two to four years. In general, the weighing results for 2025 were comparable to each other. This means there is a strong basis for comparing and exchanging PM measurements across the participating laboratories.

Nine laboratories in Europe participated in this round’s study. A total of 208 filters were compared. The results show relatively small differences between the participating laboratories, and these are well within the limit values for PM measurements. The filters have to be weighed exactly as described in a European standard (EN 12341). For example, the temperature and relative humidity in the weighing rooms must fall within specified value ranges. All participating laboratories matched the temperature requirements, and all but two complied with the relative humidity requirements. The deviating humidity conditions did not have a noticeable impact on the weighing results.

As a member of the European Network of National Air Quality Reference Laboratories, RIVM is responsible for the quality assurance of ambient air pollutant measurements in the Netherlands and performs the measurements together with several air monitoring networks throughout the European Union.

Keywords: particulate matter, PM, reference measurements,
filter weighing, inter-laboratory comparison

Publiekssamenvatting

Een vergelijking van de weging van fijnstoffilters door laboratoria in 2025

Verschillende luchtmeetnetten in Nederland en Europa meten de hoeveelheid fijnstof (PM_{10} en $PM_{2,5}$) in de buitenlucht. Dit wordt gedaan met filters in een apparaat dat continu buitenlucht aanzuigt. Elk filter wordt na 24 uur vervangen. De laboratoria van de meetnetten bepalen de concentratie fijnstof door het filter voor en na de plaatsing te wegen. Met onder andere het verschil in gewicht wordt de concentratie berekend.

Elke twee tot vier jaar vergelijkt het RIVM het weegproces bij een aantal laboratoria. Zo wordt gecontroleerd of de fijnstofconcentraties in de verschillende laboratoria overeenkomen. De resultaten van de wegingen waren in 2025 ongeveer hetzelfde. Dit betekent dat vrijwel alle fijnstofmetingen goed met elkaar overeenkomen en tussen de deelnemende meetnetten kunnen worden uitgewisseld.

Dit keer deden negen laboratoria uit Europa mee aan de vergelijking. In totaal zijn 208 filters gemeten. Er waren kleine verschillen te zien die ruim binnen de grenzen vallen die voor fijnstofmetingen zijn bepaald. De laboratoria moeten de metingen volgens een verplichte procedure doen (EN 12341) en zijn zelf verantwoordelijk voor de omstandigheden waarin ze meten. De weegkamers moeten bijvoorbeeld een bepaalde temperatuur en luchtvochtigheid hebben. Alle deelnemende laboratoria voldeden aan de eisen voor de temperatuur. Op twee laboratoria na voldeden ze ook aan de luchtvochtigheidseisen. De afwijkende luchtvochtigheid had geen zichtbare invloed op de resultaten.

Het RIVM meet fijnstof samen met andere meetnetten in de Europese Unie en controleert op nationaal niveau de kwaliteit ervan. Als referentielaboratorium voor luchtkwaliteitsmetingen in de buitenlucht van Nederland heeft het RIVM deze taak.

Kernwoorden: fijnstof, PM, referentie-metingen, filterweging, inter-laboratorium vergelijking

Contents

Summary

Reference measurements of particulate matter (PM_{10} and $PM_{2.5}$) in ambient air are performed by sampling an accurately known volume of air through a filter for 24 hours. By measuring the mass difference of the filter before and after sampling, the concentration of particulate matter can be determined. For this purpose, filters are weighed at least twice, both before and after sampling, under strict conditions of temperature and relative humidity, as described in European Standard EN 12341:2023.

In order to investigate whether application of this procedure – when applied by different laboratories – leads to comparable results, an inter-laboratory comparison has been conducted. For this purpose, one pilot laboratory has sent sets of 26 pre-weighed filters typically used for low-volume sampling (18 sampled, 8 blanks) to eight participating laboratories. After having been weighed by the participants, the filters have been reweighed by the pilot laboratory.

In addition, the temperature in the participants' weighing rooms has been monitored using portable temperature meters. The monitoring results show that all of the participants were able to ensure that the temperature in their weighing room complied with the requirements during filter weighing. Temperature and relative humidity values have also been reported by the participants themselves. Six out of the eight participants showed full compliance with the requirements, while two laboratories reported relative humidity values in their weighing room to be outside of the accepted range. The deviating humidity conditions did not have a discernible impact on the weighing results.

Evaluation of the results of the comparison shows that – when average results from the pilot laboratory are used as assigned reference values and E_n numbers are calculated using estimated weighing uncertainties – all but four results meet the criterion for E_n to range between -1 and 1.

From the results, the inter-laboratory (reproducibility) uncertainty of the weighing results has been calculated and has been found to be 0.044 mg for a confidence level of 95% for all filters. This corresponds to a relative uncertainty of 1.6% at the level of the current daily limit value for PM_{10} (50 µg/m^3) and 3.2% at the level of the future daily limit value for $PM_{2.5}$ (25 µg/m^3). The results indicate that there is a strong basis for comparing and exchanging PM measurements across the participating laboratories.

1 Introduction

Determination of filter masses is an essential part of the application of the European reference methods for the measurement of PM_{10} and $PM_{2.5}$ concentrations in ambient air. The procedures for filter weighing are described in European Standard EN 12341:2023 [1]. They comprise subsequent conditioning and weighing under prescribed temperature and relative humidity conditions at the weighing facilities. Such conditions are essential in order to avoid significant changes in filter masses due to (de)sorption of water vapour – both by filter materials and particulate matter (PM) – and evaporation of semi-volatile constituents of particulate matter.

In order to investigate the comparability of the mass determination of both loaded and blank filters, an inter-laboratory comparison was conducted from February to May 2025. Participating laboratories, including their abbreviations and locations, are:

- DCMR Rijnmond Environmental Service (DCMR; Schiedam, the Netherlands);
- National Centre for Scientific Research ‘Demokritos’ (NCSR; Athens, Greece);
- Flanders Environment Agency (VMM; Antwerp, Belgium);
- Public Health Service of Amsterdam (GGDA; Amsterdam, the Netherlands), pilot laboratory;
- Institute of Natural Products and Agrobiology from the Spanish Scientific Research Council (IPNA; Tenerife, Canary Islands, Spain);
- National Institute for Public Health and the Environment (RIVM; Bilthoven, the Netherlands);
- Scientific Institute of Public Service (ISSEP; Liège, Belgium);
- South Limburg Environmental Service (ODZL; Maastricht, the Netherlands);
- State Agency for Nature, Environment and Climate (LANUK; Essen, Germany).

GGD Amsterdam has acted as the pilot laboratory.

This report describes the used methods, results, and findings of this comparison.

2 Methods

The comparison is based on the weighing of filters typically used for low-volume sampling in accordance with EN 12341:2023 [1], with a diameter of 47 mm. In this study, two types of filters have been used, namely Whatman QMA quartz fibre filters and Pallflex Emfab glass fibre filters, to rule out any filter dependencies. A total of 144 sampled and 64 blank filters have been collected by the pilot laboratory (GGDA) and RIVM, specifically:

- 47 $PM_{2.5}$ Whatman QMA quartz fibre filters;
- 46 PM_{10} Whatman QMA quartz fibre;
- 25 $PM_{2.5}$ Pallflex Emfab glass fibre;
- 26 PM_{10} Pallflex Emfab glass fibre filters;
- 32 pre-conditioned blank Whatman QMA quartz fibre filters;
- 32 pre-conditioned blank Pallflex Emfab glass fibre filters.

All filters have been conditioned in the pilot laboratory's weighing facilities for a minimum of 48 hours at (20 ± 1) °C and (47.5 ± 2.5)% relative humidity (% RH). After conditioning, the filters have been subjected to four consecutive weighings, with a minimum interval of 24 hours between weighings (from 3 March 2025 onwards). When the results of the first and fourth weighings differ by less than 0.060 mg for loaded filters and 0.040 mg for blank filters, the mean results for all filters are used as the 'mass before dispatch'.

Subsequently, from the set of filters, eight subsets of 26 filters have been prepared, each containing twelve loaded QMA filters, six loaded Emfab filters, four blank QMA filters and four blank Emfab filters from the sources mentioned above, and dispatched to the other participants. In Appendix 1, an overview is given of the relevant information on the filters that were dispatched to the participants. This includes the ring test codes, (types of) PM loadings of the filters and site types of the stations where the filters have been situated in the field prior to this study.

All participants have stored, conditioned, and weighed the filters in their own facilities according to the procedure described in EN 12341:2023 [1] as follows; conditioning for a minimum of 48 hours followed by a first weighing, conditioning again for a minimum of 24 hours followed by a second weighing. If the two results differ by more than 0.040 mg for blank filters and 0.060 mg for sampled filters, the procedure for the second weighing is repeated for a third weighing and the average of the last two consecutive weighings are taken as the filter mass. If these requirements are not met, the filters are not taken into account in this study.

In addition, all participants have been supplied with portable temperature sensors to log readings every minute. Filters and sensors have been transported to the participants in cool boxes. The sensors have been used to record temperatures in the participants' weighing facilities over a period including the actual conditioning and weighing periods. Moreover, all participants reported temperature and relative humidity values during the weighing periods as measured by their own default instruments. Due to unavailability of sensors that log both temperature and relative humidity values, only temperature values could be measured with sensors at this time.

Following their return, filters and sensors have been placed in the pilot laboratory's weighing room. Filters have been reconditioned and reweighed three to four times following the prescribed conditions (from 11 April to 12 May 2025). When the results of the first and last weighings differ by less than 0.060 mg for loaded filters and 0.040 mg for blank filters, the mean results for all filters are used as the 'mass after return'.

The temperature sensors have been re-calibrated in the pilot laboratory's weighing room by comparing their readings to those of a calibrated dew point meter. The results of the calibrations have been used to correct the readings.

3 Results and evaluations

3.1 Results

3.1.1 General

The results of the weighings are presented in Appendix 2 as follows:

- The left-hand column contains filter codes;
- the second and third columns contain the weighing results from the pilot laboratory before and after dispatch to participants;
- the fourth column provides the mean of the weighing results before and after return, which is used as the reference value;
- the fifth and sixth columns contain the two weighing results from each participant;
- the seventh column presents the third weighing result from each participant in case this was needed;
- the eighth column contains the participants’ mean results;
- the ninth column shows the differences between the reference values and the participants’ mean results.

Comparing the results from the pilot laboratory to the participants’ results indicated a very high likeliness that results for filters G25 and G26 have been swapped by RIVM for both measurements, as was also noted by the pilot laboratory. This has been rectified prior to further analysis. Appendix 2 shows the results following this correction.

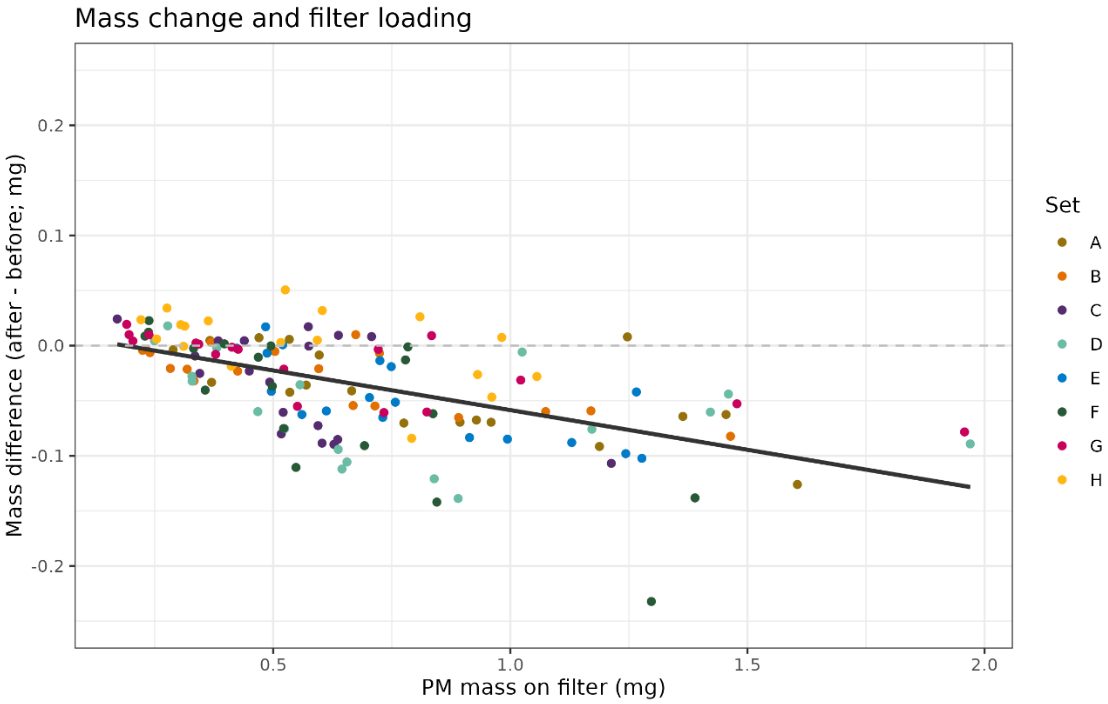
3.1.2 Results from the pilot laboratory

As a criterion for calculating the mean mass prior to dispatch for every filter, the first and fourth weighings had to differ by less than 0.060 mg for sampled filters and 0.040 mg for blank filters. For all filters, this criterion has been fulfilled. The same criterion applied to calculating the mean mass after return, for which all filters matched this criterion. However, for two filters (G10 and G11), a fifth weighing was needed in order to meet this criterion, so the entire set G was weighed five times post-return.

On the basis of the results of the weighings performed by the pilot laboratory before and after dispatch, it is observed that the mass after the return of the loaded filters averages out lower than it was prior to dispatch (a mean difference of -0.034 mg), whereas the mass for blank filters averages out slightly higher (a mean difference of 0.011 mg).

In Figure 1, the mass changes of the sampled filters are plotted against the masses of PM originally determined on the filters. The relation observed between the mass change and the filter loading suggests some proportionality between the mass loss and the mass of PM on the filter. This may be an indication for losses of (semi-)volatile constituents of the particulate matter.

Figure 1 Mass changes of sampled filters after return to the pilot laboratory.



3.1.3 *Results from the participants*

Differences between the mean participants' results and the reference values range from -0.171 to 0.06 mg, with an average of -0.004 mg.

Differences between the last two consecutive weighings by the participants all fall within the requirements of EN 12341:2023 (i.e. ≤0.040 mg for blank filters, ≤0.060 mg for sampled filters).

Corrected results of sensor measurements of temperatures in the participants' weighing facilities (one-hour average values) and mean relative humidity values as reported by the participant labs are presented graphically in Appendix 3. They reveal that for the weighing facilities of most participating laboratories, the temperature is stable. For IPNA, temperatures measured by the logger were below the minimum requirements at the start - and thus presumably during the conditioning period - and at the end of logging in their weighing room facility. But during the period in which the filter weighings where carried out, the temperatures fell within the accepted range. Following further consultation, IPNA reports to have two continuously operating temperature sensors that are calibrated according to EN 12341:2023. These two sensors reported weighing room temperatures remaining within the 19-20 °C range for the period in question, confirming compliance with the requirements.
It is observed that measurements in NCSR's weighing room exhibit fluctuations, but stay within the required temperature range. Reports by participants confirm this trend and show that all weighings for this study have been performed (within the inherent uncertainties of the loggers) at 19-21 °C.

The mean average relative humidity values for most labs are reported to fall within the requirements of 45-50% RH given in [1]. However, ISSEP has reported values just above the accepted relative humidity requirements (50.5 % RH on average) and NCSR reported an average of 42.8 % RH.

3.2 Evaluation of the weighing results

3.2.1 *Distribution of the weighing results*

The mean of the weighing results prior to dispatch to the participants and following return to the pilot lab is used as the reference value for comparing the results of the weighings performed by the participants. Figure 2 shows the distribution of the reference values next to the participants' results with a distinction between Emfab and QMA filters. The distribution is similar for all pairs of filter sets.

Figure 2 Distribution of reference values versus the weighing results from the participants, separated by filter type (top = Emfab, bottom = QMA). The grey boxes represent the reference values from the pilot lab for the corresponding sets of filters that were sent to the participants. The variously coloured boxes are the participants' values.

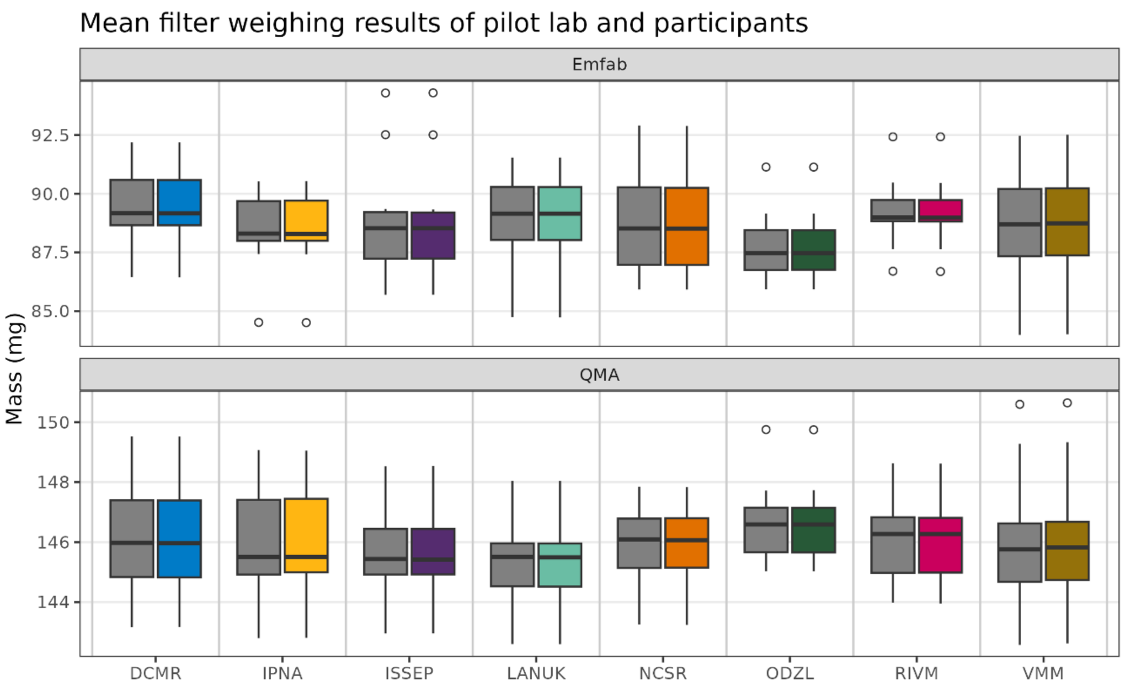
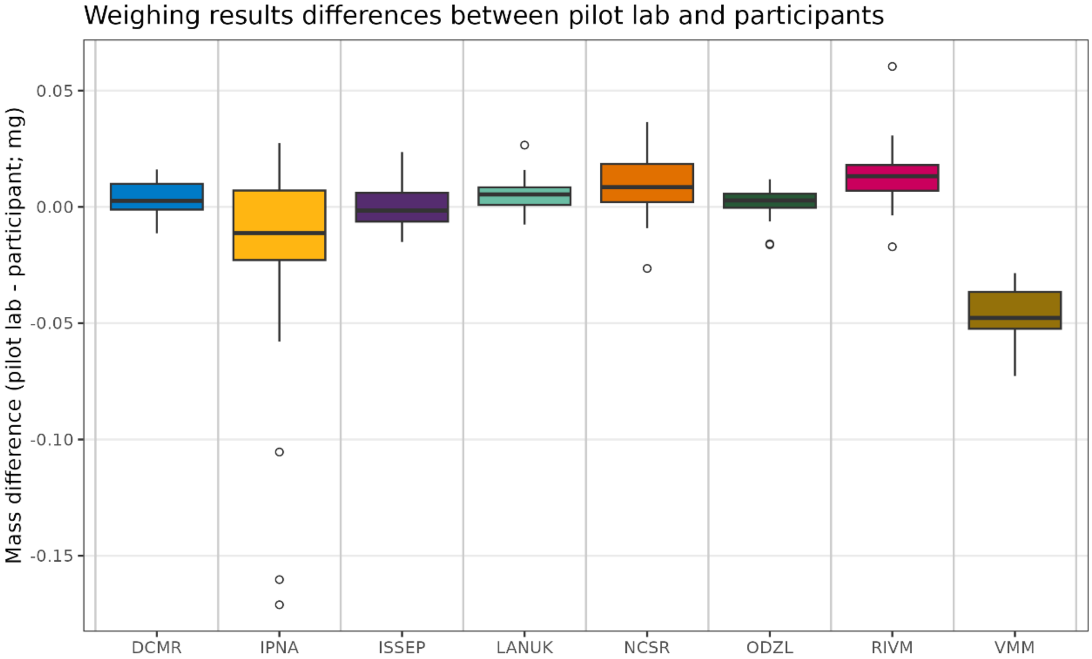


Figure 3 shows the distribution of the differences between the reference values and the participants' values. It is observed that most results are similar, although the results for VMM average out relatively high compared to the reference values, resulting in a negative mass difference value. For IPNA, some noticeable outliers are observed.

Figure 3 Distribution of differences in weighing results from the pilot lab and from the participants.



3.2.2 *Laboratory performance*

For the evaluation of the results of the comparison, the E_n number has been used. E_n is calculated according to ISO 13528 [2] as follows:

$$En = \frac{|x_p - x_{ref}|}{2 \cdot \sqrt{u_p^2 + u_{ref}^2}}$$

where

x_p is the participant's result;
x_{ref} is the reference value;
u_p is the measurement uncertainty of the participant's result;
u_{ref} is the measurement uncertainty of the reference value.

An E_n number ranging between -1 and 1 is an indication of comparability of the participant's result and the reference value at a 95% confidence level.

The mean results of the (last) two consecutive weighings of each filter performed by the participants have been taken as values of x_p; the mean results of the weighings before and after performed by the pilot laboratory have been taken as reference values.

The measurement uncertainty of the values of x_p has been estimated according to the approach described in EN 12341:2023 as follows:

$$u_{x,p}^2 = u_{cal}^2 + u_{zd}^2 + u_{buoy}^2 + u_{\Delta x,p}^2$$

where

- u_{cal} is the uncertainty in the calibration of the balance used for the weighings;
- u_{zd} is the uncertainty due to zero drift of the balance;
- u_{buoy} is the uncertainty due to differences in buoyancy;
- $u_{\Delta x,p}$ is the uncertainty due to the difference between the two weighing results from the participants.

The first three uncertainty contributions have been calculated from the maximum criteria and default values given in EN 12341:2014 [3], resulting in a value of 0.0084 mg. The uncertainty due to the difference between the participant's two weighing results has been calculated by assuming a uniform distribution as:

$$u_{\Delta x,p}^2 = \frac{\left(x_{p,2} - x_{p,1}\right)^2}{12}$$

where $x_{p,1}$ and $x_{p,2}$ are the participant's two weighing results.

The uncertainty of the reference values is estimated similarly as:

$$u_{x,ref}^2 = u_{cal}^2 + u_{zd}^2 + u_{buoy}^2 + u_{\Delta x,ref}^2$$

where $u_{\Delta x,ref}$ is the uncertainty due to the difference between the results from the pilot laboratory prior to dispatch and after return of the filters.

The uncertainty due to the difference between the two weighing results from the pilot laboratory has been calculated by assuming a uniform distribution as:

$$u_{\Delta x,ref}^2 = \frac{\left(x_{ref,2} - x_{ref,1}\right)^2}{12}$$

where $x_{ref,1}$ and $x_{ref,2}$ are the weighing results prior to dispatch and after return of the filters.

Because of potential differences in weighing room relative humidity values between the participants and the pilot laboratory, an additional (default) uncertainty contribution has been added, based on the maximum criteria for blank and loaded filter masses included in EN 12341:2014:

- 0.060/√3 mg for loaded filters;
- 0.040/√3 mg for blank filters.

The results of all calculations are presented in Appendix 4. These show that for all but four results, E_n numbers range between 0 and 1, indicating a correspondence with the reference values at 95%

probability. Out of the four results with $E_n > 1$, three are from IPNA and one is from RIVM.

3.2.3 *Method performance*

3.2.3.1 Uncertainty from differences

The uncertainty of the weighing method may be estimated from the differences in the results from participants and the pilot laboratory as follows:

$$u^2 = \frac{\sum_1^n \left(x_{i,p} - x_{i,ref}\right)^2}{2n}$$

where

$x_{i,p}$ is the participant's result for sample i;
$x_{i,ref}$ is the reference value for sample i;
n is the number of samples.

The resulting uncertainty is 0.045 mg.

When splitting the results between sampled and blank filters only, the uncertainty is 0.044 mg for sampled filters and 0.015 mg for blank filters.

Combining both uncertainties in quadrature may yield an indication of the uncertainty of a differential weighing. This results in an uncertainty of 0.046 mg and an expanded uncertainty (95% confidence, k = 2) of 0.093 mg.

3.2.3.2 ISO 5725 part 2 approach

The availability of normalised measurement results permits the evaluation of the method performance by application of the statistics of ISO 5725 part 2 [4] by treating normalised results for one laboratory as replicates. Normalised results are calculated as follows:

$$x_{i,n} = \frac{x_{i,p}}{x_{i,ref}}$$

where

$x_{i,p}$ is the participant's result for sample i;
$x_{i,ref}$ is the reference value for sample i.

Calculation of ISO 5725 part 2 statistical parameters for results of this study yields the relative standard deviations shown in Table 1 – with a differentiation between results for loaded filters, blank filters, and all filters combined. Using the mean mass of all filters, the absolute statistics may be estimated by multiplying the relative standard deviations by these mean masses. The results show that the weighing method used is quite robust.

Table 1 Relative standard deviations (RSD) and absolute standard deviations (SD) for loaded filters, blank filters, and all filters combined.

Relative standard deviations

	Loaded filters	Blank filters	All filters
Repeatability RSD	0.00005	0.00007	0.00006
Between-laboratory RSD	0.00009	0.00013	0.00012
Reproducibility RSD	0.00010	0.00015	0.00013

Absolute standard deviations

	Loaded filters	Blank filters	All filters
Repeatability SD (mg)	0.0061	0.0087	0.0078
Between-laboratory SD (mg)	0.0110	0.0155	0.0140
Reproducibility SD (mg)	0.0126	0.0178	0.0158

The relative standard deviations are comparable to those found in the previous comparison in 2022 [5], although previously, a sharper contrast was found between loaded and blank filters.

In addition, the results are submitted to Mandel's *h* and *k* tests for outliers of mean values and standard deviations, respectively, and to Grubbs' and Cochran's outlier tests. Mandel's *h* and *k* tests plots are shown in Figures 4 and 5.

Figure 4 Graph of Mandel's between-laboratory consistency statistic h, grouped by participants.

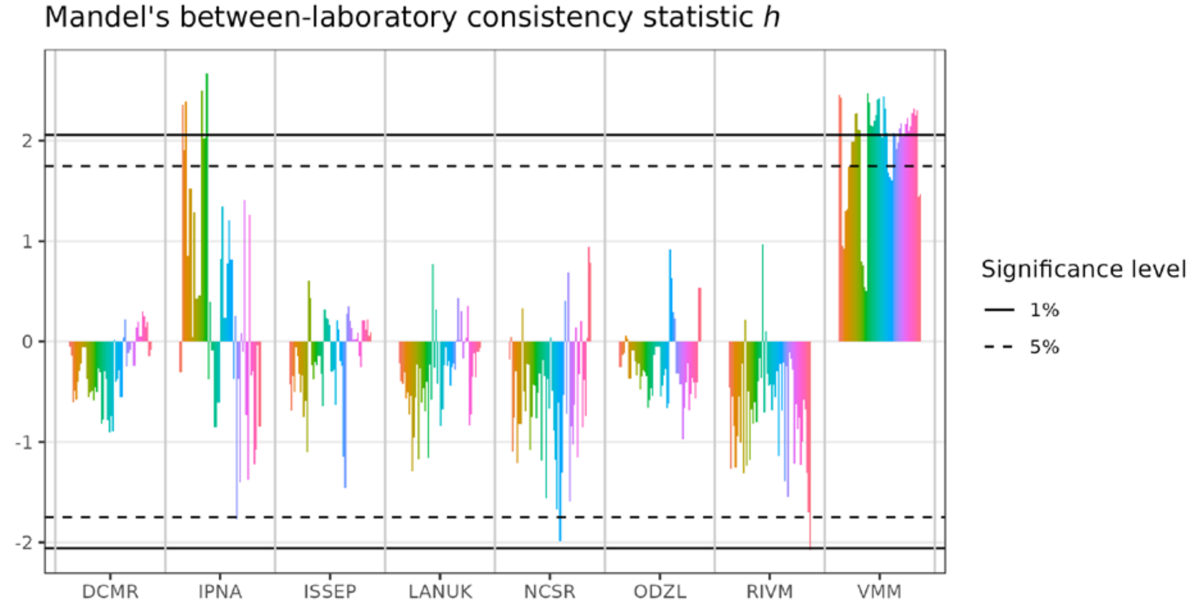
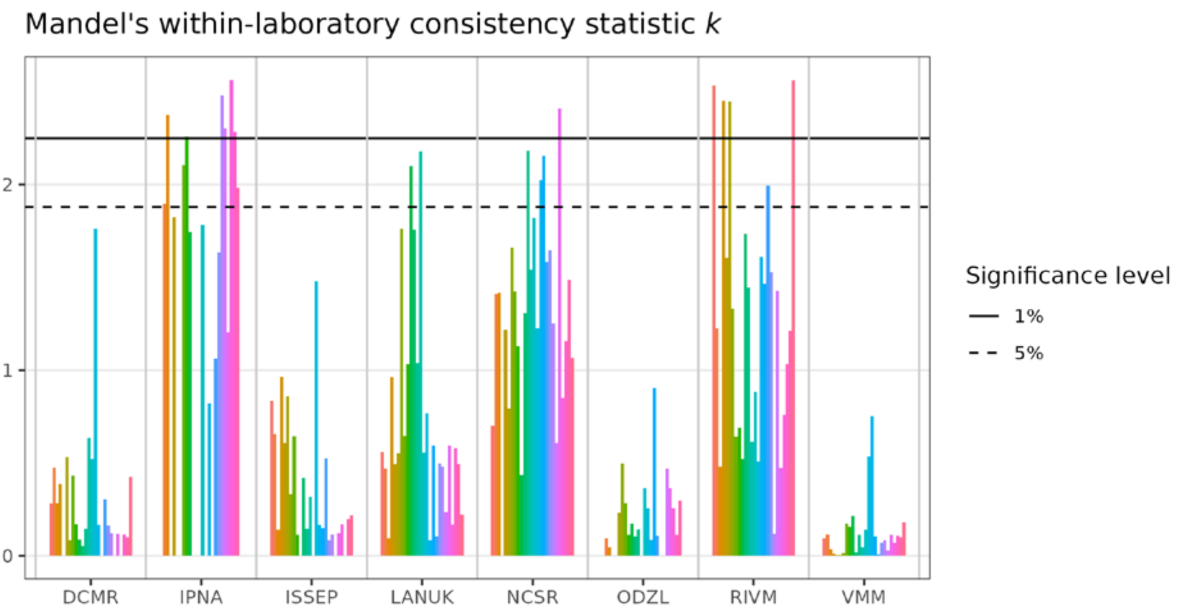


Figure 5 Graph of Mandel's within-laboratory consistency statistic k, grouped by participants.



Examination of the results of the ISO 5725 part 2 evaluation reveals that:

- For normalised data, the *h* graph shows that VMM obtained much higher normalised results than any other laboratory at all levels, except for some results from IPNA. More than half the results from VMM are marked as outliers of the mean (99% probability) as indicated by Mandel's *h* statistics. This implies that, compared to the results from the other participants, the weighing results from VMM in this ring test average out higher than the reference values from the pilot laboratory. This corresponds with the findings in Chapter 3.2.1.
- In addition, a couple of other results from several participants were also marked as outliers of the mean, both in a positive and in a negative direction. The specific outliers are all indicated with a superscript *h* in Appendix 2.
- For pooled normalised data, the *k* graph exhibits larger variability for IPNA, NCSR, and RIVM, and to a minor extent for LANUK. This might suggest a poorer repeatability for these laboratories than for the other participants. A total of 11 results are marked as outliers of precision (99% probability), as indicated by Mandel's *k* statistics, marked with a superscript *k* in Appendices 2 and 4. Six of these are from IPNA, four from RIVM and one from NCSR.
- Cochran's test did not reveal any stragglers or statistical outliers, indicating that the within-laboratory variances are homogeneous.
- Grubbs' tests for the largest and smallest observations did not reveal any statistical outliers, suggesting that between-laboratory variability is homogeneous.

Given that no outliers were found for multiple statistics and no technical explanation could be found for the observations from the *h* and *k* graphs, none of the results were discarded as outliers.
When using the reproducibility standard deviations as measures of the uncertainties of weighing results of loaded and blank filters, the method uncertainty may be calculated by combining both results in quadrature:

$$u_m^2 = s_{R,l}^2 + s_{R,b}^2$$

where $s_{R,l}$ and $s_{R,b}$ are the reproducibility standard deviations for loaded and blank filter weighings, respectively.

The combination results in an uncertainty value of 0.022 mg and an expanded uncertainty (95% confidence, k = 2) of 0.044 mg. This value is lower than the expanded uncertainty obtained from differences in results between the participants and the pilot laboratory (0.093 mg).

4 Conclusions

4.1 Organisation

This inter-laboratory comparison study involves the transport of filters to and from participating laboratories with filter weighings performed by the pilot laboratory before and after transports. It is observed that during this process, the average mass of loaded filters decreases very slightly, potentially due to losses of (semi)volatile constituents of particulate matter. Also, the fact that the filters have been preconditioned at high-relative humidity values may make losses of water an obvious cause of mass decrease. The minor mass changes are incorporated into the uncertainty budget used for the evaluation of laboratory performances.

Another thing to note is that there are deviations in the timing of the weighings, mostly because of differences in the distances between the pilot laboratory and the participants. For example, RIVM is located nearby Amsterdam and the filters can be transported between these two locations within a day, whereas for other participants, delivery and return might take up to a few weeks. In this round, the final weighing prior to dispatch to the participants took place on 13 March 2025 for all filters. However, the dates of weighing by the participants range from 30 March 2025 (for filter set A) to 14 April 2025 (set C) and the weighings post-return to the pilot laboratory range from 11 April 2025 (set G) to 12 May 2025 (set H).

In future rounds, it is recommended to try to enforce a shorter time span for the weighings to account for any potential effects of longer transport and storage durations. To accomplish this, the dates for weighing the filters could be specified, or the sets with suspected longer delivery times could be sent earlier than the ones with shorter distances from the pilot laboratory, so that the differences in timing become smaller.

4.2 Laboratory performance

Overall, the results of the laboratory performance evaluation are satisfactory. Evaluation using E_n numbers shows that for all but four results, the performance requirement of $-1 \leq E_n \leq 1$ is met.

The three results (H2, H8 and H9) from IPNA with $E_n > 1$ are all from sampled QMA filters from the same urban traffic site, the one from RIVM (G26) is from a blank QMA filter. The difference of masses prior to dispatch to the participants and following return to the pilot lab for these filters are on the higher side, i.e. the mass after return is slightly elevated compared to the mass prior to dispatch (ranging from 0.026 to 0.046 mg), possibly indicative of slight moisture absorption by the filter medium during transportation or in one of the weighing rooms. However, this is not a comprehensive explanation for the higher E_n scores, as there are some filters with higher mass differences pre-dispatch and post-return (up to 0.123 mg) with low E_n scores.

A study of the control of temperatures and relative humidity values in the participants' weighing facilities shows that all the laboratories conform to the temperature requirements in European Standard EN 12341:2023 [1] and all but two participant laboratories comply with the relative humidity requirements. The deviating humidity conditions did not have a noticeable impact on the weighing results.

4.3 Method performance

The method performance, expressed as the reproducibility standard deviation of weighing results calculated according to ISO 5725 part 2, is 0.0158 mg. When only results of loaded filters are used, the reproducibility standard deviation decreases slightly to 0.0126 mg.

By combining uncertainties for the weighing of loaded and blank filters expressed as reproducibility standard deviations, an uncertainty of 0.022 mg results, resulting in an expanded method uncertainty of 0.044 mg. When using this value to calculate the relative uncertainty contribution by the weighing process to the overall uncertainty of the measurement of PM, expressed at the limit values of PM_{10} and $PM_{2.5}$, the following values are obtained (95% confidence):

- PM_{10} at 50 µg/m^3 (current daily limit value according to the EU Directive [6]): 1.6%;
- PM_{10} at 45 µg/m^3 (daily limit value to be attained by 1 January 2030 (EU) and daily air quality guideline level recommended by WHO [7]): 1.8%.
- $PM_{2.5}$ at 25 µg/m^3 (daily limit value to be attained by 1 January 2030 (EU) [6]): 3.2%;
- $PM_{2.5}$ at 15 µg/m^3 (daily air quality guideline level recommended by WHO [7]): 5.3%.

These values suggest that the uncertainty contributions by the filter conditioning and weighing process as obtained in this study are relatively small, considering that the maximum allowed uncertainty for PM reference measurements is 25% [6].

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[5] RIVM (2022) Inter-laboratory comparison of particulate matter filter weighing 2022. RIVM report 2022-0117. Bilthoven: RIVM.

[6] European Parliament, Council of the European Union. Directive (EU) 2024/2881 of the European Parliament and of the Council of 23 October 2024 on ambient air quality and cleaner air for Europe (recast), Annex I. Official Journal of the European Union, L 123.

[7] World Health Organization (2021) WHO global air quality guidelines. Particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide, p. 74-97. Geneva: World Health Organization.

Appendix 1 Filters supplied to each laboratory

Participant	Filter code	Loading type	PM type	Filter type	PM mass (mg)	Site type
VMM	A1	sampled	$PM_{2.5}$	Emfab	0.960	S
VMM	A2	sampled	$PM_{2.5}$	QMA	0.929	S
VMM	A3	sampled	$PM_{2.5}$	QMA	0.367	S
VMM	A4	sampled	$PM_{2.5}$	QMA	0.535	S
VMM	A5	sampled	$PM_{2.5}$	QMA	0.289	I
VMM	A6	sampled	$PM_{2.5}$	QMA	0.370	I
VMM	A7	sampled	PM_{10}	QMA	0.894	R
VMM	A8	sampled	PM_{10}	QMA	1.364	R
VMM	A9	sampled	PM_{10}	QMA	1.188	R
VMM	A10	sampled	PM_{10}	QMA	0.666	R
VMM	A11	sampled	PM_{10}	QMA	1.247	S
VMM	A12	sampled	PM_{10}	QMA	0.534	S
VMM	A13	sampled	$PM_{2.5}$	Emfab	0.776	S
VMM	A14	sampled	$PM_{2.5}$	Emfab	0.570	S
VMM	A15	sampled	$PM_{2.5}$	Emfab	1.455	S
VMM	A16	sampled	PM_{10}	Emfab	1.606	S
VMM	A17	sampled	PM_{10}	Emfab	0.470	I
VMM	A18	sampled	PM_{10}	Emfab	0.597	I
VMM	A19	blank	$PM_{2.5}$	Emfab	-	UB
VMM	A20	blank	$PM_{2.5}$	Emfab	-	S
VMM	A21	blank	PM_{10}	Emfab	-	R
VMM	A22	blank	PM_{10}	Emfab	-	I
VMM	A23	blank	$PM_{2.5}$	QMA	-	S
VMM	A24	blank	$PM_{2.5}$	QMA	-	I
VMM	A25	blank	PM_{10}	QMA	-	R
VMM	A26	blank	PM_{10}	QMA	-	S
NCSR	B1	sampled	$PM_{2.5}$	QMA	0.225	S
NCSR	B2	sampled	$PM_{2.5}$	QMA	0.319	S
NCSR	B3	sampled	$PM_{2.5}$	QMA	0.669	S
NCSR	B4	sampled	$PM_{2.5}$	QMA	1.465	S
NCSR	B5	sampled	$PM_{2.5}$	QMA	0.283	I
NCSR	B6	sampled	$PM_{2.5}$	QMA	0.333	I
NCSR	B7	sampled	PM_{10}	QMA	0.504	R
NCSR	B8	sampled	PM_{10}	QMA	0.715	R
NCSR	B9	sampled	PM_{10}	QMA	0.425	R
NCSR	B10	sampled	PM_{10}	QMA	0.369	R
NCSR	B11	sampled	PM_{10}	QMA	0.596	S
NCSR	B12	sampled	PM_{10}	QMA	0.891	S
NCSR	B13	sampled	$PM_{2.5}$	Emfab	0.232	S
NCSR	B14	sampled	$PM_{2.5}$	Emfab	0.240	S

Participant	Filter code	Loading type	PM type	Filter type	PM mass (mg)	Site type
NCSR	B15	sampled	$PM_{2.5}$	Emfab	1.170	S
NCSR	B16	sampled	PM_{10}	Emfab	1.075	S
NCSR	B17	sampled	PM_{10}	Emfab	0.674	I
NCSR	B18	sampled	PM_{10}	Emfab	0.724	I
NCSR	B19	blank	$PM_{2.5}$	Emfab	-	UB
NCSR	B20	blank	$PM_{2.5}$	Emfab	-	S
NCSR	B21	blank	PM_{10}	Emfab	-	R
NCSR	B22	blank	PM_{10}	Emfab	-	I
NCSR	B23	blank	$PM_{2.5}$	QMA	-	S
NCSR	B24	blank	$PM_{2.5}$	QMA	-	I
NCSR	B25	blank	PM_{10}	QMA	-	R
NCSR	B26	blank	PM_{10}	QMA	-	R
ISSEP	C1	sampled	$PM_{2.5}$	QMA	0.517	S
ISSEP	C2	sampled	$PM_{2.5}$	QMA	0.595	S
ISSEP	C3	sampled	$PM_{2.5}$	QMA	0.171	S
ISSEP	C4	sampled	$PM_{2.5}$	QMA	0.345	S
ISSEP	C5	sampled	$PM_{2.5}$	QMA	0.636	I
ISSEP	C6	sampled	$PM_{2.5}$	QMA	0.603	I
ISSEP	C7	sampled	PM_{10}	QMA	0.638	R
ISSEP	C8	sampled	PM_{10}	QMA	0.493	R
ISSEP	C9	sampled	PM_{10}	QMA	0.574	R
ISSEP	C10	sampled	PM_{10}	QMA	0.708	R
ISSEP	C11	sampled	PM_{10}	QMA	0.521	S
ISSEP	C12	sampled	PM_{10}	QMA	0.384	S
ISSEP	C13	sampled	$PM_{2.5}$	Emfab	0.439	S
ISSEP	C14	sampled	$PM_{2.5}$	Emfab	0.335	S
ISSEP	C15	sampled	$PM_{2.5}$	Emfab	0.628	S
ISSEP	C16	sampled	PM_{10}	Emfab	0.575	S
ISSEP	C17	sampled	PM_{10}	Emfab	0.450	S
ISSEP	C18	sampled	PM_{10}	Emfab	1.213	I
ISSEP	C19	blank	$PM_{2.5}$	Emfab	-	UB
ISSEP	C20	blank	$PM_{2.5}$	Emfab	-	I
ISSEP	C21	blank	PM_{10}	Emfab	-	R
ISSEP	C22	blank	PM_{10}	Emfab	-	I
ISSEP	C23	blank	$PM_{2.5}$	QMA	-	S
ISSEP	C24	blank	$PM_{2.5}$	QMA	-	I
ISSEP	C25	blank	PM_{10}	QMA	-	S
ISSEP	C26	blank	PM_{10}	QMA	-	R
LANUK	D1	sampled	$PM_{2.5}$	QMA	0.278	S
LANUK	D2	sampled	$PM_{2.5}$	QMA	0.524	S
LANUK	D3	sampled	$PM_{2.5}$	QMA	0.329	S
LANUK	D4	sampled	$PM_{2.5}$	QMA	0.645	S
LANUK	D5	sampled	$PM_{2.5}$	QMA	1.172	I

Participant	Filter code	Loading type	PM type	Filter type	PM mass (mg)	Site type
LANUK	D6	sampled	$PM_{2.5}$	QMA	0.637	I
LANUK	D7	sampled	PM_{10}	QMA	0.656	R
LANUK	D8	sampled	PM_{10}	QMA	0.890	R
LANUK	D9	sampled	PM_{10}	QMA	0.468	S
LANUK	D10	sampled	PM_{10}	QMA	0.840	S
LANUK	D11	sampled	PM_{10}	Emfab	1.970	I
LANUK	D12	sampled	PM_{10}	Emfab	1.460	I
LANUK	D13	sampled	$PM_{2.5}$	Emfab	0.250	S
LANUK	D14	sampled	$PM_{2.5}$	Emfab	0.329	S
LANUK	D15	sampled	$PM_{2.5}$	Emfab	0.381	S
LANUK	D16	sampled	PM_{10}	Emfab	1.025	S
LANUK	D17	sampled	PM_{10}	Emfab	0.557	S
LANUK	D18	sampled	PM_{10}	Emfab	1.422	I
LANUK	D19	blank	$PM_{2.5}$	Emfab	-	UB
LANUK	D20	blank	$PM_{2.5}$	Emfab	-	I
LANUK	D21	blank	PM_{10}	Emfab	-	S
LANUK	D22	blank	PM_{10}	Emfab	-	I
LANUK	D23	blank	$PM_{2.5}$	QMA	-	S
LANUK	D24	blank	$PM_{2.5}$	QMA	-	I
LANUK	D25	blank	PM_{10}	QMA	-	S
LANUK	D26	blank	PM_{10}	QMA	-	I
DCMR	E1	sampled	$PM_{2.5}$	QMA	0.561	S
DCMR	E2	sampled	$PM_{2.5}$	QMA	1.130	S
DCMR	E3	sampled	$PM_{2.5}$	QMA	0.994	S
DCMR	E4	sampled	$PM_{2.5}$	QMA	0.496	I
DCMR	E5	sampled	$PM_{2.5}$	QMA	0.423	I
DCMR	E6	sampled	$PM_{2.5}$	QMA	0.612	I
DCMR	E7	sampled	PM_{10}	QMA	0.731	S
DCMR	E8	sampled	PM_{10}	QMA	1.278	S
DCMR	E9	sampled	PM_{10}	QMA	1.244	S
DCMR	E10	sampled	PM_{10}	QMA	0.484	S
DCMR	E11	sampled	PM_{10}	QMA	0.749	S
DCMR	E12	sampled	PM_{10}	QMA	0.725	S
DCMR	E13	sampled	$PM_{2.5}$	Emfab	0.758	S
DCMR	E14	sampled	$PM_{2.5}$	Emfab	0.914	S
DCMR	E15	sampled	$PM_{2.5}$	Emfab	0.487	S
DCMR	E16	sampled	PM_{10}	Emfab	0.520	S
DCMR	E17	sampled	PM_{10}	Emfab	0.703	S
DCMR	E18	sampled	PM_{10}	Emfab	1.266	I
DCMR	E19	blank	$PM_{2.5}$	Emfab	-	R
DCMR	E20	blank	$PM_{2.5}$	Emfab	-	I
DCMR	E21	blank	PM_{10}	Emfab	-	UB
DCMR	E22	blank	PM_{10}	Emfab	-	I

Participant	Filter code	Loading type	PM type	Filter type	PM mass (mg)	Site type
DCMR	E23	blank	$PM_{2.5}$	QMA	-	R
DCMR	E24	blank	$PM_{2.5}$	QMA	-	I
DCMR	E25	blank	PM_{10}	QMA	-	R
DCMR	E26	blank	PM_{10}	QMA	-	I
ODZL	F1	sampled	$PM_{2.5}$	QMA	0.357	S
ODZL	F2	sampled	$PM_{2.5}$	QMA	0.238	S
ODZL	F3	sampled	$PM_{2.5}$	QMA	0.548	S
ODZL	F4	sampled	$PM_{2.5}$	QMA	0.498	I
ODZL	F5	sampled	$PM_{2.5}$	QMA	0.237	I
ODZL	F6	sampled	$PM_{2.5}$	QMA	0.397	I
ODZL	F7	sampled	PM_{10}	QMA	0.693	S
ODZL	F8	sampled	PM_{10}	QMA	0.469	S
ODZL	F9	sampled	PM_{10}	QMA	0.845	S
ODZL	F10	sampled	PM_{10}	QMA	0.784	S
ODZL	F11	sampled	PM_{10}	QMA	0.779	S
ODZL	F12	sampled	PM_{10}	QMA	0.495	S
ODZL	F13	sampled	$PM_{2.5}$	Emfab	0.230	S
ODZL	F14	sampled	$PM_{2.5}$	Emfab	0.522	S
ODZL	F15	sampled	$PM_{2.5}$	Emfab	0.332	S
ODZL	F16	sampled	PM_{10}	Emfab	1.390	S
ODZL	F17	sampled	PM_{10}	Emfab	1.298	S
ODZL	F18	sampled	PM_{10}	Emfab	0.837	I
ODZL	F19	blank	$PM_{2.5}$	Emfab	-	UB
ODZL	F20	blank	$PM_{2.5}$	Emfab	-	UB
ODZL	F21	blank	PM_{10}	Emfab	-	R
ODZL	F22	blank	PM_{10}	Emfab	-	I
ODZL	F23	blank	$PM_{2.5}$	QMA	-	R
ODZL	F24	blank	$PM_{2.5}$	QMA	-	I
ODZL	F25	blank	PM_{10}	QMA	-	R
ODZL	F26	blank	PM_{10}	QMA	-	R
RIVM	G1	sampled	$PM_{2.5}$	QMA	0.379	S
RIVM	G2	sampled	$PM_{2.5}$	QMA	0.191	S
RIVM	G3	sampled	$PM_{2.5}$	QMA	0.343	S
RIVM	G4	sampled	$PM_{2.5}$	QMA	0.413	I
RIVM	G5	sampled	$PM_{2.5}$	QMA	0.337	I
RIVM	G6	sampled	$PM_{2.5}$	QMA	0.551	UB
RIVM	G7	sampled	PM_{10}	QMA	0.523	S
RIVM	G8	sampled	PM_{10}	QMA	0.426	S
RIVM	G9	sampled	PM_{10}	QMA	0.834	S
RIVM	G10	sampled	PM_{10}	QMA	1.478	S
RIVM	G11	sampled	PM_{10}	QMA	1.958	S
RIVM	G12	sampled	PM_{10}	QMA	1.022	S
RIVM	G13	sampled	$PM_{2.5}$	Emfab	0.238	S

Participant	Filter code	Loading type	PM type	Filter type	PM mass (mg)	Site type
RIVM	G14	sampled	$PM_{2.5}$	Emfab	0.196	S
RIVM	G15	sampled	$PM_{2.5}$	Emfab	0.204	S
RIVM	G16	sampled	PM_{10}	Emfab	0.722	S
RIVM	G17	sampled	PM_{10}	Emfab	0.734	S
RIVM	G18	sampled	PM_{10}	Emfab	0.824	I
RIVM	G19	blank	$PM_{2.5}$	Emfab	-	R
RIVM	G20	blank	$PM_{2.5}$	Emfab	-	nd
RIVM	G21	blank	PM_{10}	Emfab	-	S
RIVM	G22	blank	PM_{10}	Emfab	-	S
RIVM	G23	blank	$PM_{2.5}$	QMA	-	R
RIVM	G24	blank	$PM_{2.5}$	QMA	-	S
RIVM	G25	blank	PM_{10}	QMA	-	R
RIVM	G26	blank	PM_{10}	QMA	-	I
IPNA	H1	sampled	$PM_{2.5}$	QMA	0.311	S
IPNA	H2	sampled	$PM_{2.5}$	QMA	0.276	S
IPNA	H3	sampled	$PM_{2.5}$	QMA	0.314	S
IPNA	H4	sampled	$PM_{2.5}$	QMA	0.982	UB
IPNA	H5	sampled	$PM_{2.5}$	QMA	0.961	UB
IPNA	H6	sampled	$PM_{2.5}$	QMA	0.221	UB
IPNA	H7	sampled	PM_{10}	QMA	0.526	S
IPNA	H8	sampled	PM_{10}	QMA	0.604	S
IPNA	H9	sampled	PM_{10}	QMA	0.810	S
IPNA	H10	sampled	PM_{10}	QMA	1.056	S
IPNA	H11	sampled	PM_{10}	QMA	0.931	S
IPNA	H12	sampled	PM_{10}	QMA	0.792	UB
IPNA	H13	sampled	$PM_{2.5}$	Emfab	0.254	S
IPNA	H14	sampled	$PM_{2.5}$	Emfab	0.305	S
IPNA	H15	sampled	$PM_{2.5}$	Emfab	0.363	S
IPNA	H16	sampled	PM_{10}	Emfab	0.516	S
IPNA	H17	sampled	PM_{10}	Emfab	0.412	S
IPNA	H18	sampled	PM_{10}	Emfab	0.593	I
IPNA	H19	blank	$PM_{2.5}$	Emfab	-	UB
IPNA	H20	blank	$PM_{2.5}$	Emfab	-	UB
IPNA	H21	blank	PM_{10}	Emfab	-	S
IPNA	H22	blank	PM_{10}	Emfab	-	S
IPNA	H23	blank	$PM_{2.5}$	QMA	-	S
IPNA	H24	blank	$PM_{2.5}$	QMA	-	I
IPNA	H25	blank	PM_{10}	QMA	-	R
IPNA	H26	blank	PM_{10}	QMA	-	R

The abbreviations in the site type column are as follows:
R = rural background;
UB = urban background;
S = regional or urban traffic;
I = industrial;
nd = not determined / unclassified.

Appendix 2 Results of weighings in this study

Filter code	Pilot			Participant				Differ-ence
	Before	After	Mean	First	Second	Third	Mean	
A1	87.020	86.951	86.986	87.018[h]	87.018[h]	-	87.018	-0.033
A2	146.048	145.980	146.014	146.067	146.066	-	146.067	-0.053
A3	144.923	144.928	144.925	144.973	144.973	-	144.973	-0.048
A4	146.619	146.577	146.598	146.650	146.650	-	146.650	-0.052
A5	143.807	143.803	143.805	143.853	143.853	-	143.853	-0.048
A6	145.324	145.291	145.307	145.359[h]	145.359[h]	-	145.359	-0.051
A7	146.209	146.140	146.175	146.227[h]	146.226[h]	-	146.227	-0.052
A8	146.750	146.686	146.718	146.785	146.783	-	146.784	-0.066
A9	149.322	149.231	149.276	149.336	149.333	-	149.334	-0.058
A10	144.591	144.550	144.571	144.644[h]	144.642[h]	-	144.643	-0.073
A11	145.757	145.765	145.761	145.824[h]	145.824[h]	-	145.824	-0.063
A12	143.057	143.063	143.060	143.116[h]	143.117[h]	-	143.116	-0.057
A13	88.731	88.661	88.696	88.737[h]	88.737[h]	-	88.737	-0.041
A14	88.404	88.369	88.386	88.430[h]	88.429	-	88.429	-0.043
A15	92.498	92.436	92.467	92.510[h]	92.508[h]	-	92.509	-0.042
A16	86.115	85.989	86.052	86.101[h]	86.092	-	86.097	-0.044
A17	90.201	90.209	90.205	90.240	90.240	-	90.240	-0.035
A18	90.199	90.191	90.195	90.226[h]	90.226[h]	-	90.226	-0.031
A19	83.984	83.991	83.987	84.015	84.016	-	84.016	-0.028
A20	90.996	91.000	90.998	91.031[h]	91.031[h]	-	91.031	-0.033
A21	87.692	87.690	87.691	87.722[h]	87.722[h]	-	87.722	-0.031
A22	88.876	88.878	88.877	88.909[h]	88.910[h]	-	88.910	-0.033
A23	142.573	142.575	142.574	142.623[h]	142.624[h]	-	142.623	-0.049
A24	146.650	146.657	146.653	146.702[h]	146.703[h]	-	146.702	-0.049
A25	150.590	150.600	150.595	150.643[h]	150.644[h]	-	150.644	-0.049
A26	144.791	144.773	144.782	144.826	144.827	-	144.826	-0.045
B1	144.906	144.902	144.904	144.900	144.905	-	144.902	0.002
B2	146.138	146.117	146.127	146.135	146.090	146.105	146.098	0.030
B3	146.077	146.023	146.050	146.045	146.015	-	146.030	0.020
B4	147.890	147.808	147.849	147.830	147.830	-	147.830	0.019
B5	144.842	144.821	144.832	144.840	144.820	-	144.830	0.002
B6	143.263	143.231	143.247	143.235	143.245	-	143.240	0.007
B7	147.135	147.130	147.133	147.130	147.110	-	147.120	0.013
B8	146.597	146.542	146.569	146.540	146.560	-	146.550	0.019
B9	147.859	147.836	147.847	147.845	147.825	-	147.835	0.012
B10	146.171	146.174	146.172	146.170	146.175	-	146.173	0.000
B11	145.835	145.814	145.825	145.845	145.805	145.830	145.818	0.007
B12	145.343	145.278	145.311	145.305	145.275	-	145.290	0.021
B13	89.008	89.004	89.006	89.000	88.995	-	88.998	0.008

Filter code	Pilot			Participant				Differ-ence
	Before	After	Mean	First	Second	Third	Mean	
B14	86.299	86.293	86.296	86.300	86.290	-	86.295	0.001
B15	92.934	92.874	92.904	92.890	92.885	-	92.887	0.016
B16	90.777	90.717	90.747	90.710	90.735	-	90.723	0.024
B17	90.694	90.704	90.699	90.655	90.670	-	90.663	0.037
B18	88.650	88.643	88.646	88.635	88.650	-	88.643	0.004
B19	86.767	86.770	86.769	86.760	86.780	-	86.770	-0.001
B20	87.560	87.566	87.563	87.545	87.555	-	87.550	0.013
B21	85.921	85.925	85.923	85.915	85.920	-	85.917	0.005
B22	88.394	88.393	88.394	88.395	88.375	-	88.385[k]	0.009
B23	145.219	145.223	145.221	145.225	145.235	-	145.230	-0.009
B24	143.610	143.598	143.604	143.585	143.595	-	143.590	0.014
B25	147.531	147.540	147.536	147.525	147.540	-	147.533	0.003
B26	146.605	146.727	146.666	146.695	146.690	-	146.693	-0.026
C1	146.054	145.974	146.014	146.004	145.998	-	146.001	0.013
C2	147.241	147.169	147.205	147.201	147.194	-	147.198	0.007
C3	146.172	146.196	146.184	146.187	146.184	-	146.186	-0.002
C4	145.185	145.159	145.172	145.167	145.162	-	145.165	0.007
C5	145.234	145.148	145.191	145.183	145.173	-	145.178	0.013
C6	145.723	145.634	145.678	145.668	145.657	-	145.663	0.016
C7	147.463	147.473	147.468	147.485	147.481	-	147.483	-0.015
C8	146.011	145.978	145.994	145.997	145.988	-	145.993	0.002
C9	148.522	148.539	148.530	148.543	148.541	-	148.542	-0.012
C10	145.070	145.078	145.074	145.081	145.081	-	145.081	-0.007
C11	145.207	145.146	145.176	145.178	145.170	-	145.174	0.002
C12	144.208	144.213	144.210	144.221	144.219	-	144.220	-0.010
C13	86.654	86.658	86.656	86.660	86.659	-	86.660	-0.004
C14	87.890	87.881	87.885	87.883	87.883	-	87.883	0.002
C15	92.561	92.472	92.516	92.513	92.507	-	92.510	0.006
C16	88.679	88.678	88.679	88.686	88.684	-	88.685	-0.006
C17	88.391	88.368	88.380	88.375	88.374	-	88.375	0.005
C18	89.405	89.298	89.351	89.330	89.325	-	89.328	0.024
C19	87.006	87.019	87.012	87.018	87.019	-	87.019	-0.006
C20	94.284	94.298	94.291	94.297	94.296	-	94.297	-0.006
C21	85.685	85.698	85.692	85.697	85.697	-	85.697	-0.005
C22	88.814	88.818	88.816	88.815	88.816	-	88.816	0.000
C23	144.439	144.462	144.451	144.458	144.456	-	144.457	-0.006
C24	143.130	143.131	143.130	143.134	143.134	-	143.134	-0.004
C25	148.062	148.072	148.067	148.073	148.075	-	148.074	-0.007
C26	142.953	142.961	142.957	142.958	142.959	-	142.959	-0.001
D1	145.809	145.827	145.818	145.813	145.809	-	145.811	0.007
D2	146.820	146.745	146.782	146.775	146.780	-	146.777	0.005
D3	147.373	147.345	147.359	147.345	147.347	-	147.346	0.013

Filter code	Pilot			Participant				Differ-ence
	Before	After	Mean	First	Second	Third	Mean	
D4	145.286	145.174	145.230	145.214	145.219	-	145.217	0.014
D5	143.269	143.193	143.231	143.200	143.208	-	143.204	0.027
D6	144.339	144.244	144.291	144.282	144.289	-	144.285	0.006
D7	145.469	145.364	145.416	145.392	145.413	-	145.402	0.014
D8	145.537	145.398	145.467	145.447	145.456	-	145.452	0.016
D9	145.882	145.822	145.852	145.834	145.852	-	145.843	0.009
D10	145.603	145.482	145.542	145.523	145.547	-	145.535	0.007
D11	91.190	91.100	91.145	91.142	91.163	-	91.153	-0.008
D12	91.558	91.514	91.536	91.534	91.543	-	91.539	-0.002
D13	88.103	88.108	88.105	88.099	88.106	-	88.103	0.003
D14	84.762	84.730	84.746	84.734	84.737	-	84.736	0.011
D15	89.049	89.047	89.048	89.045	89.048	-	89.047	0.001
D16	89.079	89.073	89.076	89.073	89.074	-	89.074	0.002
D17	87.822	87.786	87.804	87.794	87.798	-	87.796	0.008
D18	90.030	89.970	90.000	89.994	89.993	-	89.994	0.007
D19	86.173	86.185	86.179	86.181	86.187	-	86.184	-0.005
D20	91.344	91.350	91.347	91.350	91.354	-	91.352	-0.005
D21	89.222	89.224	89.223	89.226	89.228	-	89.227	-0.004
D22	89.736	89.739	89.737	89.737	89.742	-	89.739	-0.002
D23	145.991	145.994	145.993	145.987	145.989	-	145.988	0.005
D24	143.208	143.205	143.206	143.198	143.203	-	143.200	0.006
D25	148.034	148.044	148.039	148.036	148.041	-	148.039	0.001
D26	142.600	142.606	142.603	142.599	142.600	-	142.599	0.003
E1	144.173	144.110	144.141	-	144.140	144.138	144.139	0.002
E2	145.193	145.105	145.149	-	145.134	145.139	145.137	0.013
E3	145.892	145.808	145.850	-	145.836	145.842	145.839	0.011
E4	144.699	144.657	144.678	-	144.674	144.676	144.675	0.003
E5	144.083	144.081	144.082	-	144.081	144.081	144.081	0.001
E6	149.550	149.491	149.521	-	149.522	149.515	149.519	0.002
E7	148.336	148.271	148.303	-	148.293	148.294	148.294	0.010
E8	146.000	145.898	145.949	-	145.936	145.930	145.933	0.016
E9	147.493	147.395	147.444	-	147.441	147.438	147.440	0.005
E10	146.074	146.091	146.082	-	146.086	146.085	146.086	-0.003
E11	144.898	144.879	144.889	-	144.878	144.879	144.878	0.010
E12	146.013	146.000	146.006	-	146.002	146.000	146.001	0.005
E13	86.475	86.424	86.449	-	86.437	86.435	86.436	0.013
E14	90.483	90.399	90.441	-	90.430	90.427	90.429	0.013
E15	90.643	90.636	90.639	-	90.641	90.634	90.638	0.002
E16	88.708	88.708	88.708	-	88.702	88.704	88.703	0.005
E17	88.887	88.840	88.863	-	88.851	88.851	88.851	0.012
E18	92.208	92.166	92.187	-	92.185	92.188	92.187	0.001
E19	88.631	88.649	88.640	-	88.638	88.640	88.639	0.001

Filter code	Pilot			Participant				Differ-ence
	Before	After	Mean	First	Second	Third	Mean	
E20	91.488	91.496	91.492	-	91.494	91.495	91.495	-0.003
E21	88.131	88.141	88.136	-	88.138	88.138	88.138	-0.002
E22	89.473	89.485	89.479	-	89.480	89.481	89.481	-0.002
E23	147.268	147.299	147.284	-	147.295	147.295	147.295	-0.011
E24	143.168	143.165	143.167	-	143.172	143.171	143.171	-0.005
E25	147.431	147.459	147.445	-	147.451	147.452	147.452	-0.007
E26	147.369	147.396	147.383	-	147.377	147.379	147.378	0.005
F1	145.208	145.168	145.188	145.182	145.182	-	145.182	0.006
F2	145.556	145.579	145.568	145.573	145.574	-	145.574	-0.006
F3	147.222	147.111	147.166	147.173	147.172	-	147.173	-0.006
F4	149.772	149.735	149.753	149.747	149.747	-	149.747	0.006
F5	145.135	145.147	145.141	145.139	145.139	-	145.139	0.002
F6	147.362	147.364	147.363	147.361	147.358	-	147.360	0.003
F7	147.190	147.099	147.144	147.142	147.136	-	147.139	0.005
F8	146.677	146.666	146.671	146.667	146.671	-	146.669	0.002
F9	146.952	146.810	146.881	146.887	146.885	-	146.886	-0.005
F10	145.821	145.820	145.820	145.814	145.816	-	145.815	0.005
F11	146.144	146.131	146.138	146.136	146.134	-	146.135	0.003
F12	146.514	146.513	146.513	146.513	146.515	-	146.514	-0.001
F13	85.928	85.937	85.932	85.932	85.932	-	85.932	0.000
F14	86.144	86.068	86.106	86.099	86.101	-	86.100	0.006
F15	89.161	89.158	89.159	89.155	89.156	-	89.156	0.004
F16	87.543	87.404	87.473	87.461	87.462	-	87.462	0.012
F17	86.840	86.608	86.724	86.743	86.737	-	86.740	-0.016
F18	87.497	87.435	87.466	87.468	87.467	-	87.468	-0.002
F19	86.809	86.814	86.812	86.809	86.809	-	86.809	0.003
F20	91.132	91.141	91.137	91.134	91.134	-	91.134	0.003
F21	88.747	88.750	88.749	88.741	88.745	-	88.743	0.006
F22	87.566	87.573	87.569	87.562	87.565	-	87.564	0.006
F23	145.028	145.037	145.033	145.030	145.033	-	145.032	0.001
F24	145.696	145.696	145.696	145.687	145.686	-	145.687	0.009
F25	146.697	146.712	146.704	146.697	146.700	-	146.699	0.006
F26	147.670	147.762	147.716	147.732	147.732	-	147.732	-0.016
G1	144.300	144.292	144.296	144.286	144.268	-	144.277[k]	0.019
G2	145.695	145.715	145.705	145.692	145.679	-	145.686	0.019
G3	143.982	143.983	143.983	143.947	143.957	-	143.952	0.031
G4	148.360	148.359	148.359	148.348	148.335	-	148.342[k]	0.018
G5	148.456	148.458	148.457	148.452	148.425	-	148.439	0.019
G6	148.652	148.597	148.625	148.632	148.600	-	148.616[k]	0.009
G7	146.794	146.772	146.783	146.774	146.758	-	146.766	0.017
G8	146.968	146.965	146.967	146.942	146.933	-	146.938	0.029
G9	145.248	145.257	145.252	145.240	145.228	-	145.234	0.018

Filter code	Pilot			Participant				Differ-ence
	Before	After	Mean	First	Second	Third	Mean	
G10	146.319	146.266	146.292	146.293	146.299	-	146.296	-0.004
G11	145.070	144.991	145.030	145.031	145.064	-	145.048	-0.017
G12	146.264	146.233	146.249	146.234	146.254	-	146.244	0.005
G13	89.561	89.571	89.566	89.561	89.559	-	89.560	0.006
G14	88.954	88.964	88.959	88.954	88.949	-	88.952	0.007
G15	89.790	89.794	89.792	89.786	89.784	-	89.785	0.007
G16	86.700	86.696	86.698	86.694	86.675	-	86.685	0.014
G17	88.822	88.761	88.791	88.786	88.776	-	88.781	0.010
G18	89.056	88.996	89.026	89.020	89.001	-	89.011	0.015
G19	88.939	88.943	88.941	88.939	88.920	-	88.929	0.011
G20	92.420	92.427	92.423	92.425	92.424	-	92.425	-0.001
G21	87.638	87.635	87.637	87.638	87.626	-	87.632	0.004
G22	90.471	90.475	90.473	90.462	90.458	-	90.460	0.013
G23	146.388	146.393	146.390	146.386	146.377	-	146.382	0.009
G24	144.799	144.810	144.804	144.782	144.791	-	144.787	0.018
G25	144.481	144.485	144.483	144.474	144.462	-	144.468	0.015
G26	146.468	146.515	146.491	146.437	146.425[h]	-	146.431[k]	0.060
H1	144.677	144.677	144.677	144.670	144.670	-	144.670	0.007
H2	144.968	145.002	144.985	145.100[h]	145.080	-	145.090	-0.105
H3	145.208	145.226	145.217	145.300[h]	145.250	-	145.275[k]	-0.058
H4	147.290	147.297	147.293	147.340	147.340	-	147.340	-0.047
H5	145.162	145.115	145.139	145.140	145.170	-	145.155	-0.016
H6	142.787	142.810	142.799	142.810	142.810	-	142.810	-0.011
H7	147.711	147.762	147.736	147.750	147.750	-	147.750	-0.014
H8	148.719	148.751	148.735	148.910[h]	148.880	-	148.895	-0.160
H9	148.036	148.062	148.049	148.200	148.240[h]	-	148.220[k]	-0.171
H10	145.893	145.865	145.879	145.880	145.900	-	145.890	-0.011
H11	144.726	144.699	144.712	144.720	144.720	-	144.720	-0.008
H12	149.111	149.027	149.069	149.050	149.050	-	149.050	0.019
H13	84.516	84.522	84.519	84.510	84.510	-	84.510	0.009
H14	88.111	88.130	88.121	88.140	88.150	-	88.145	-0.024
H15	89.424	89.446	89.435	89.440	89.440	-	89.440	-0.005
H16	89.768	89.771	89.769	89.790	89.800	-	89.795	-0.026
H17	89.812	89.793	89.803	89.820	89.820	-	89.820	-0.017
H18	87.946	87.951	87.949	87.940	87.950	-	87.945	0.004
H19	87.431	87.437	87.434	87.410	87.430	-	87.420	0.014
H20	88.240	88.252	88.246	88.230	88.250	-	88.240[k]	0.006
H21	90.523	90.529	90.526	90.530	90.550	-	90.540[k]	-0.014
H22	88.350	88.354	88.352	88.340	88.330	-	88.335	0.017
H23	144.555	144.558	144.556	144.590	144.560	-	144.575[k]	-0.019
H24	145.245	145.249	145.247	145.240	145.220	-	145.230[k]	0.017
H25	147.293	147.302	147.297	147.280	147.300	-	147.290	0.007

Filter code	Pilot			Participant				Differ-ence
	Before	After	Mean	First	Second	Third	Mean	
H26	145.755	145.760	145.758	145.730	145.730	-	145.730	0.028

All weighing results are in milligrams. The difference is calculated by subtracting the mean weighing result of the participant laboratory by the mean weighing result of the pilot laboratory.
[h] Outlier as indicated by Mandel's *h* statistics (99% probability) in the 5th and 6th columns.
[k] Outlier as indicated by Mandel's *k* statistics (99% probability) in the 8th column.

Appendix 3 Weighing room conditions for all participants

Figure 6 Corrected temperature sensor values during their time in the weighing facilities of all participant laboratories.

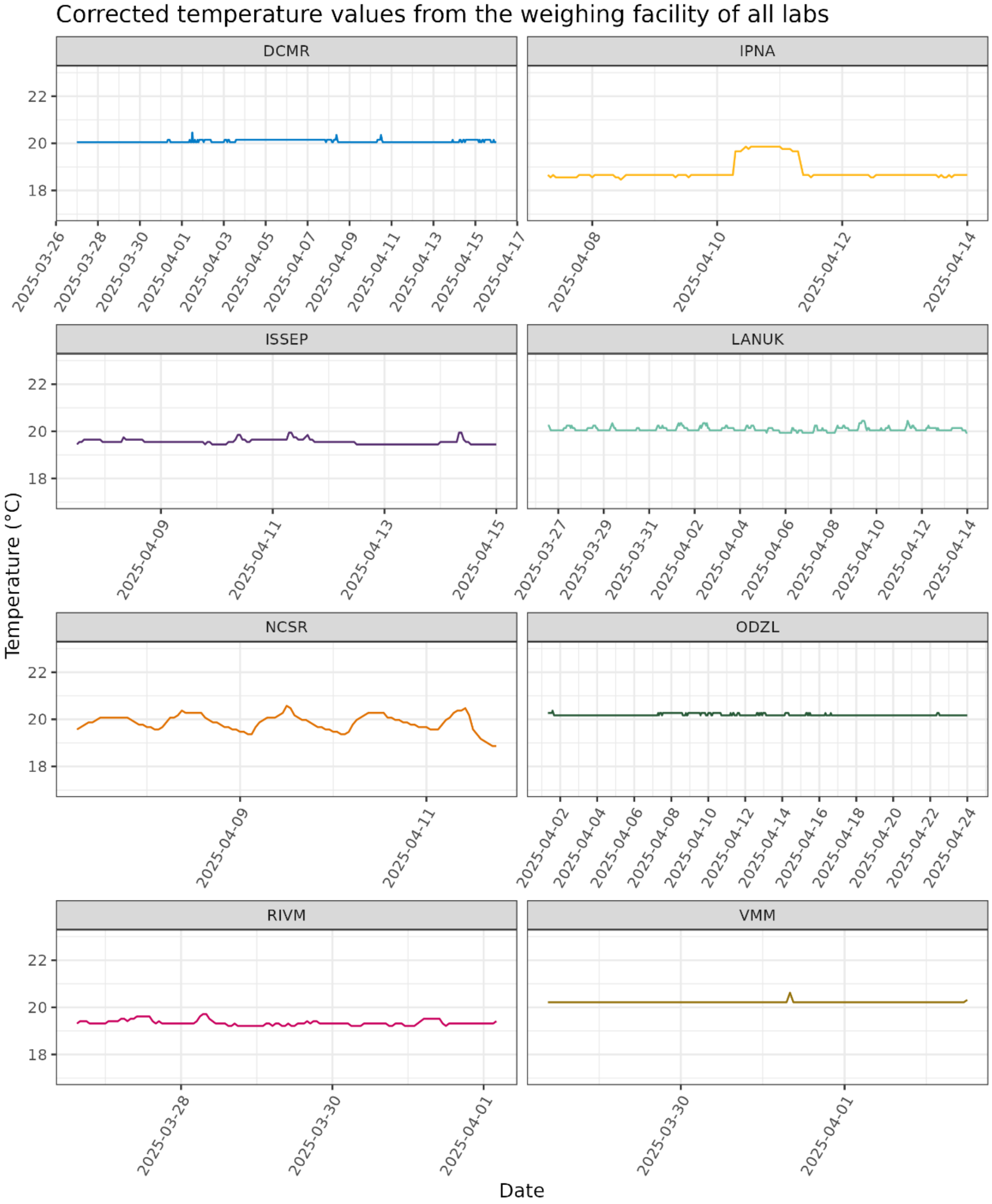
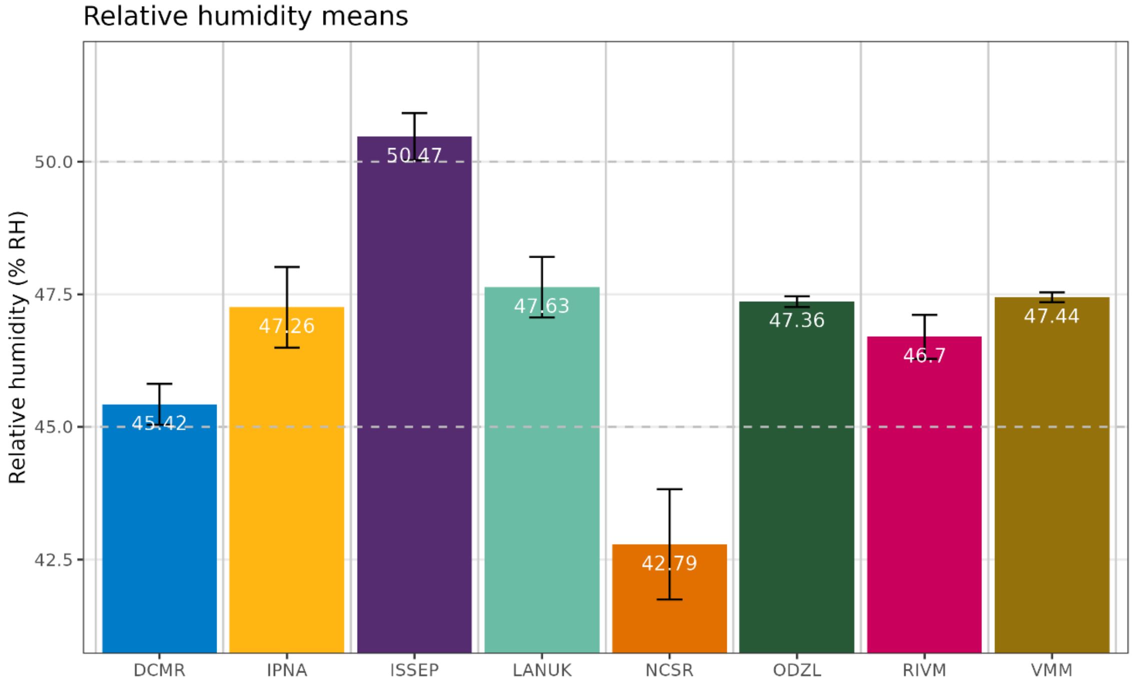


Figure 7 Mean relative humidity values as reported by the participants during the periods of weighing the filters. Error bars represent the standard deviation.



Appendix 4 Laboratory performance evaluation

Participant	Filter code	Pilot		Participant		E_n number
		Mean	Uncertainty	Mean	Uncertainty	
VMM	A1	86.986	0.022	87.018	0.008	0.39
VMM	A2	146.014	0.021	146.067	0.008	0.64
VMM	A3	144.925	0.008	144.973	0.008	0.65
VMM	A4	146.598	0.015	146.650	0.008	0.68
VMM	A5	143.805	0.008	143.853	0.008	0.65
VMM	A6	145.307	0.013	145.359	0.008	0.68
VMM	A7	146.175	0.022	146.227	0.008	0.62
VMM	A8	146.718	0.020	146.784	0.008	0.80
VMM	A9	149.276	0.028	149.334	0.008	0.64
VMM	A10	144.571	0.014	144.643	0.008	0.94
VMM	A11	145.761	0.009	145.824	0.008	0.86
VMM	A12	143.060	0.009	143.116	0.008	0.78
VMM	A13	88.696	0.022	88.737	0.008	0.49
VMM	A14	88.386	0.013	88.429	0.008	0.56
VMM	A15	92.467	0.020	92.509	0.008	0.52
VMM	A16	86.052	0.037	86.097	0.009	0.43
VMM	A17	90.205	0.009	90.240	0.008	0.48
VMM	A18	90.195	0.009	90.226	0.008	0.43
VMM	A19	83.987	0.009	84.016	0.008	0.55
VMM	A20	90.998	0.008	91.031	0.008	0.63
VMM	A21	87.691	0.008	87.722	0.008	0.60
VMM	A22	88.877	0.008	88.910	0.008	0.64
VMM	A23	142.574	0.008	142.623	0.008	0.95
VMM	A24	146.653	0.009	146.702	0.008	0.94
VMM	A25	150.595	0.009	150.644	0.008	0.93
VMM	A26	144.782	0.010	144.826	0.008	0.84
NCSR	B1	144.904	0.008	144.902	0.008	0.02
NCSR	B2	146.127	0.010	146.098	0.009	0.40
NCSR	B3	146.050	0.018	146.030	0.012	0.24
NCSR	B4	147.849	0.025	147.830	0.008	0.22
NCSR	B5	144.832	0.010	144.830	0.010	0.02
NCSR	B6	143.247	0.012	143.240	0.009	0.10
NCSR	B7	147.133	0.008	147.120	0.010	0.17
NCSR	B8	146.569	0.018	146.550	0.010	0.24
NCSR	B9	147.847	0.011	147.835	0.010	0.16
NCSR	B10	146.172	0.008	146.173	0.008	0.00
NCSR	B11	145.825	0.010	145.818	0.011	0.10
NCSR	B12	145.311	0.021	145.290	0.012	0.25
NCSR	B13	89.006	0.008	88.998	0.008	0.11

Participant	Filter code	Pilot		Participant		E_n number
		Mean	Uncertainty	Mean	Uncertainty	
NCSR	B14	86.296	0.009	86.295	0.009	0.01
NCSR	B15	92.904	0.019	92.887	0.008	0.20
NCSR	B16	90.747	0.019	90.723	0.011	0.29
NCSR	B17	90.699	0.009	90.663	0.009	0.49
NCSR	B18	88.646	0.009	88.643	0.009	0.05
NCSR	B19	86.769	0.008	86.770	0.010	0.03
NCSR	B20	87.563	0.009	87.550	0.009	0.25
NCSR	B21	85.923	0.008	85.917	0.008	0.10
NCSR	B22	88.394	0.008	88.385[k]	0.010	0.17
NCSR	B23	145.221	0.008	145.230	0.009	0.17
NCSR	B24	143.604	0.009	143.590	0.009	0.27
NCSR	B25	147.536	0.009	147.533	0.009	0.06
NCSR	B26	146.666	0.036	146.693	0.008	0.30
ISSEP	C1	146.014	0.025	146.001	0.009	0.15
ISSEP	C2	147.205	0.023	147.198	0.009	0.09
ISSEP	C3	146.184	0.011	146.186	0.008	0.02
ISSEP	C4	145.172	0.011	145.165	0.008	0.10
ISSEP	C5	145.191	0.026	145.178	0.009	0.15
ISSEP	C6	145.678	0.027	145.663	0.009	0.18
ISSEP	C7	147.468	0.009	147.483	0.008	0.20
ISSEP	C8	145.994	0.013	145.993	0.009	0.02
ISSEP	C9	148.530	0.010	148.542	0.008	0.16
ISSEP	C10	145.074	0.009	145.081	0.008	0.10
ISSEP	C11	145.176	0.019	145.174	0.009	0.03
ISSEP	C12	144.210	0.008	144.220	0.008	0.13
ISSEP	C13	86.656	0.008	86.660	0.008	0.05
ISSEP	C14	87.885	0.009	87.883	0.008	0.03
ISSEP	C15	92.516	0.027	92.510	0.009	0.07
ISSEP	C16	88.679	0.008	88.685	0.008	0.09
ISSEP	C17	88.380	0.011	88.375	0.008	0.07
ISSEP	C18	89.351	0.032	89.328	0.008	0.25
ISSEP	C19	87.012	0.009	87.019	0.008	0.12
ISSEP	C20	94.291	0.009	94.297	0.008	0.11
ISSEP	C21	85.692	0.009	85.697	0.008	0.10
ISSEP	C22	88.816	0.008	88.816	0.008	0.00
ISSEP	C23	144.451	0.011	144.457	0.008	0.12
ISSEP	C24	143.130	0.008	143.134	0.008	0.07
ISSEP	C25	148.067	0.009	148.074	0.008	0.13
ISSEP	C26	142.957	0.009	142.959	0.008	0.03
LANUK	D1	145.818	0.010	145.811	0.008	0.09
LANUK	D2	146.782	0.023	146.777	0.008	0.06
LANUK	D3	147.359	0.012	147.346	0.008	0.17

Participant	Filter code	Pilot		Participant		E_n number
		Mean	Uncertainty	Mean	Uncertainty	
LANUK	D4	145.230	0.033	145.217	0.008	0.14
LANUK	D5	143.231	0.023	143.204	0.009	0.31
LANUK	D6	144.291	0.028	144.285	0.009	0.06
LANUK	D7	145.416	0.032	145.402	0.010	0.15
LANUK	D8	145.467	0.041	145.452	0.009	0.15
LANUK	D9	145.852	0.019	145.843	0.010	0.11
LANUK	D10	145.542	0.036	145.535	0.011	0.07
LANUK	D11	91.145	0.027	91.153	0.010	0.08
LANUK	D12	91.536	0.015	91.539	0.009	0.03
LANUK	D13	88.105	0.008	88.103	0.009	0.04
LANUK	D14	84.746	0.013	84.736	0.008	0.14
LANUK	D15	89.048	0.008	89.047	0.008	0.01
LANUK	D16	89.076	0.009	89.074	0.008	0.03
LANUK	D17	87.804	0.013	87.796	0.008	0.10
LANUK	D18	90.000	0.019	89.994	0.008	0.08
LANUK	D19	86.179	0.009	86.184	0.009	0.09
LANUK	D20	91.347	0.009	91.352	0.008	0.10
LANUK	D21	89.223	0.008	89.227	0.008	0.08
LANUK	D22	89.737	0.008	89.739	0.008	0.04
LANUK	D23	145.993	0.008	145.988	0.008	0.09
LANUK	D24	143.206	0.008	143.200	0.008	0.11
LANUK	D25	148.039	0.009	148.039	0.008	0.01
LANUK	D26	142.603	0.009	142.599	0.008	0.06
DCMR	E1	144.141	0.020	144.139	0.008	0.03
DCMR	E2	145.149	0.027	145.137	0.008	0.14
DCMR	E3	145.850	0.026	145.839	0.009	0.13
DCMR	E4	144.678	0.015	144.675	0.008	0.04
DCMR	E5	144.082	0.008	144.081	0.008	0.02
DCMR	E6	149.521	0.019	149.519	0.009	0.03
DCMR	E7	148.303	0.021	148.294	0.008	0.12
DCMR	E8	145.949	0.031	145.933	0.009	0.17
DCMR	E9	147.444	0.029	147.440	0.008	0.05
DCMR	E10	146.082	0.010	146.086	0.008	0.05
DCMR	E11	144.889	0.010	144.878	0.008	0.14
DCMR	E12	146.006	0.009	146.001	0.008	0.07
DCMR	E13	86.449	0.017	86.436	0.008	0.17
DCMR	E14	90.441	0.025	90.429	0.008	0.14
DCMR	E15	90.639	0.009	90.638	0.009	0.03
DCMR	E16	88.708	0.008	88.703	0.008	0.07
DCMR	E17	88.863	0.016	88.851	0.008	0.16
DCMR	E18	92.187	0.015	92.187	0.008	0.01
DCMR	E19	88.640	0.010	88.639	0.008	0.02

Participant	Filter code	Pilot		Participant		E_n number
		Mean	Uncertainty	Mean	Uncertainty	
DCMR	E20	91.492	0.009	91.495	0.008	0.05
DCMR	E21	88.136	0.009	88.138	0.008	0.04
DCMR	E22	89.479	0.009	89.481	0.008	0.03
DCMR	E23	147.284	0.012	147.295	0.008	0.21
DCMR	E24	143.167	0.008	143.171	0.008	0.09
DCMR	E25	147.445	0.012	147.452	0.008	0.13
DCMR	E26	147.383	0.011	147.378	0.008	0.08
ODZL	F1	145.188	0.014	145.182	0.008	0.08
ODZL	F2	145.568	0.011	145.574	0.008	0.08
ODZL	F3	147.166	0.033	147.173	0.008	0.06
ODZL	F4	149.753	0.013	149.747	0.008	0.08
ODZL	F5	145.141	0.009	145.139	0.008	0.03
ODZL	F6	147.363	0.008	147.360	0.008	0.05
ODZL	F7	147.144	0.027	147.139	0.009	0.06
ODZL	F8	146.671	0.009	146.669	0.008	0.03
ODZL	F9	146.881	0.042	146.886	0.008	0.05
ODZL	F10	145.820	0.008	145.815	0.008	0.07
ODZL	F11	146.138	0.009	146.135	0.008	0.04
ODZL	F12	146.513	0.008	146.514	0.008	0.01
ODZL	F13	85.932	0.009	85.932	0.008	0.00
ODZL	F14	86.106	0.023	86.100	0.008	0.07
ODZL	F15	89.159	0.008	89.156	0.008	0.05
ODZL	F16	87.473	0.041	87.462	0.008	0.11
ODZL	F17	86.724	0.068	86.740	0.009	0.10
ODZL	F18	87.466	0.020	87.468	0.008	0.02
ODZL	F19	86.812	0.008	86.809	0.008	0.05
ODZL	F20	91.137	0.009	91.134	0.008	0.05
ODZL	F21	88.749	0.008	88.743	0.008	0.11
ODZL	F22	87.569	0.009	87.564	0.008	0.11
ODZL	F23	145.033	0.009	145.032	0.008	0.02
ODZL	F24	145.696	0.008	145.687	0.008	0.18
ODZL	F25	146.704	0.009	146.699	0.008	0.11
ODZL	F26	147.716	0.028	147.732	0.008	0.22
RIVM	G1	144.296	0.009	144.277[k]	0.010	0.26
RIVM	G2	145.705	0.010	145.686	0.009	0.26
RIVM	G3	143.983	0.008	143.952	0.009	0.42
RIVM	G4	148.359	0.008	148.342[k]	0.009	0.24
RIVM	G5	148.457	0.008	148.439	0.011	0.25
RIVM	G6	148.625	0.018	148.616[k]	0.012	0.11
RIVM	G7	146.783	0.010	146.766	0.010	0.23
RIVM	G8	146.967	0.008	146.938	0.009	0.40
RIVM	G9	145.252	0.009	145.234	0.009	0.24

Participant	Filter code	Pilot		Participant		E_n number
		Mean	Uncertainty	Mean	Uncertainty	
RIVM	G10	146.292	0.017	146.296	0.009	0.05
RIVM	G11	145.030	0.024	145.048	0.013	0.19
RIVM	G12	146.249	0.012	146.244	0.010	0.06
RIVM	G13	89.566	0.009	89.560	0.008	0.08
RIVM	G14	88.959	0.009	88.952	0.008	0.10
RIVM	G15	89.792	0.008	89.785	0.008	0.09
RIVM	G16	86.698	0.008	86.685	0.010	0.18
RIVM	G17	88.791	0.019	88.781	0.009	0.12
RIVM	G18	89.026	0.019	89.011	0.010	0.19
RIVM	G19	88.941	0.008	88.929	0.010	0.21
RIVM	G20	92.423	0.009	92.425	0.008	0.02
RIVM	G21	87.637	0.008	87.632	0.009	0.09
RIVM	G22	90.473	0.008	90.460	0.008	0.25
RIVM	G23	146.390	0.008	146.382	0.009	0.16
RIVM	G24	144.804	0.009	144.787	0.009	0.34
RIVM	G25	144.483	0.008	144.468	0.009	0.29
RIVM	G26	146.491	0.016	146.431[k]	0.009	1.03
IPNA	H1	144.677	0.008	144.670	0.008	0.10
IPNA	H2	144.985	0.013	145.090	0.010	1.37
IPNA	H3	145.217	0.010	145.275[k]	0.017	0.73
IPNA	H4	147.293	0.009	147.340	0.008	0.64
IPNA	H5	145.139	0.016	145.155	0.012	0.20
IPNA	H6	142.799	0.011	142.810	0.008	0.15
IPNA	H7	147.736	0.017	147.750	0.008	0.17
IPNA	H8	148.735	0.012	148.895	0.012	2.07
IPNA	H9	148.049	0.011	148.220[k]	0.014	2.19
IPNA	H10	145.879	0.012	145.890	0.010	0.15
IPNA	H11	144.712	0.011	144.720	0.008	0.10
IPNA	H12	149.069	0.026	149.050	0.008	0.21
IPNA	H13	84.519	0.009	84.510	0.008	0.13
IPNA	H14	88.121	0.010	88.145	0.009	0.33
IPNA	H15	89.435	0.011	89.440	0.008	0.07
IPNA	H16	89.769	0.008	89.795	0.009	0.35
IPNA	H17	89.803	0.010	89.820	0.008	0.23
IPNA	H18	87.949	0.008	87.945	0.009	0.05
IPNA	H19	87.434	0.009	87.420	0.010	0.26
IPNA	H20	88.246	0.009	88.240[k]	0.010	0.11
IPNA	H21	90.526	0.009	90.540[k]	0.010	0.26
IPNA	H22	88.352	0.008	88.335	0.009	0.33
IPNA	H23	144.556	0.008	144.575[k]	0.012	0.34
IPNA	H24	145.247	0.008	145.230[k]	0.010	0.33
IPNA	H25	147.297	0.009	147.290	0.010	0.13

Participant	Filter code	Pilot		Participant		E_n number
		Mean	Uncertainty	Mean	Uncertainty	
IPNA	H26	145.758	0.008	145.730	0.008	0.53

Weighing results (in mg), uncertainties (in mg) and E_n numbers. E_n numbers above 1 are indicated in red.
[k] Outlier as indicated by Mandel's *k* statistics (99% probability) in the 5th column.

Published by

National Institute for Public Health
and the Environment, RIVM
P.O. Box 1 | 3720 BA Bilthoven
The Netherlands
www.rivm.nl/en

November 2025

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