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MEASUREMENT OF PM2.5 AND PM10 IN OUTDOOR AIR WITH THE HARVARD IMPACTOR

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MEASUREMENT OF $PM_{2.5}$ AND PM_{10} IN OUTDOOR AIR WITH THE HARVARD IMPACTOR

1. PURPOSE AND APPLICABILITY

This SOP contains the protocol for performing measurements of PM2.5 and PM10 in outdoor air for the EU-multicenter study ESCAPE.
The principle of the method is that air is drawn by a pump through a size selective inlet (Harvard impactor) and next a filter on which airborne particles are collected quantitatively. The impactors are designed to sample particles of 2.5 µm (10 µm) with an efficiency of 50% at a flow rate of 10 l/min (larger particles less efficiently, smaller particles more efficiently). The collected fraction is denoted as $PM_{2.5}$ (PM_{10}). By weighing the filter before and after sampling the particle mass of the sample can be determined. Sample volume is determined by measurement of the sample flow before and after each sampling period and by recording of elapsed sample time.

2. DEFINITIONS

PM2.5: particle fraction with a 50% aerodynamic cutoff diameter of 2.5 µm
PM10: particle fraction with a 50% aerodynamic cutoff diameter of 10 µm
SOP: standard operating procedure

3. REFERENCES

Chow J. Measurement methods to determine compliance with ambient air quality standards for suspended particles. J Air Waste Manage Assoc 1995;45:320-82.

4. DISCUSSION

This protocol is based upon the protocols used for the EU studies CESAR, Three Cities Studies, Ultra-2 (http://www.ktl.fi/ultra), TRAPCA and RUPIOH. The filter weighing and conditioning criteria are based upon the 1997 EPA requirements.

5. RESPONSIBILITIES

1 The Coordinator and PI's are responsible for final review and approval of this SOP.
2 The local Principal Investigator is responsible that new versions of this SOP are available for every member of the project team and that older SOP versions are collected and destroyed.
3 Members of the project team are responsible for working according to this SOP and reporting of local and temporal deviations and local changes of this SOP

6. EQUIPMENT AND MATERIALS

6.1 Equipment

1 Impactor (impactor base, impactor body, impactor plate, nozzle, sampling head)
2 Spare impaction plates
3 Calibration adaptor
4 Spare O-rings
5 Pump units for outdoor air sampling
6 Rain caps to prevent rain entering the impactor

The impactors have been obtained from Air Diagnostics and Engineering, Inc. (Naples, Maine, USA). The impactor consists of the impactor base and body, a rubber ring to prevent leaks, the nozzle providing the size selective sampling, an impactor plate collecting the coarse particles and a sampling inlet. A calibrator adapter (a head with an 8 mm external diameter outlet plastic tube to which a rotameter can be connected) can be exchanged for the inlet to measure the flow rate before and after sampling. Between the impactor base and body the filter cassette is inserted. The filter cassette consists of two Andersen filter holder rings. In the filter cassette the filter is inserted above the drain disk which serves to support the filter. PM10 impactors are red, PM2.5 impactors silver.

All centers use the same pump units supplied by IRAS and produced by the workshop of Wageningen University. The pump unit contains a large pump capable of sampling considerably more than 10 l/min (capacity 100 l/minute), four flow regulators, two timers (a weekly and 24 hour) and an elapsed time indicator. All equipment is contained in a weatherproof case, equipped with sound reducing foam. Ventilators start operating if the temperature in the box gets too high. A constant flow of 10 l/min is maintained with critical orifices. Each pump unit contains four critical orifices allowing sampling of PM10 and PM2.5 with one pump unit. Quick-fittings are used to connect the sampling tubing to the impactors. The elapsed time indicator records the time that the pump has been running. The pump unit can be placed outdoors or inside a building, but the impactor inlet needs to be outside. The outlet of the pump is equipped with a HEPA-filter to prevent contamination of the site by pump exhaust. Tubing of 3 meter length is provided such that the pump exhaust air does not influence the impactor. The pump unit has provisions to attach four sampling poles to connect the impactors to.

We will always use two inlets, one for PM10 and one for PM2.5 sampling. Each sampling session, one inlet at one monitoring site will be used to obtain a duplicate PM10 measurement. The two other inlets can be used to connect additional impactors. If you do so, check that the pressure drop of the total system can be met by the pump.

The timers have three settings (ON / OFF / SETTING). If you leave the site after installing, the weektimer should be in the ON position and the daytimer in the SETTING position. With SETTING, it is possible to turn the pump on and off using a user defined schedule. The timers are operated on re-chargeable batteries that have a 7-week capacity. Power failures can thus be accommodated.

6.2 Materials

7 Filter holders (Andersen plastic filterholder rings, 37 mm part no SAFH240P)
8 Drain disks (37 mm PE drain disk filter supports; partnr SN230800, Costar Europe)
9 Filters (37 mm 2 μm pore size PALL Life Sciences PTFE Membrane W/PMP ring 2.0 um pore size 37 mm P/N R2PJ037 (25 per box)
10 Transport rings to prevent bouncing of the filter cassette during transport

11 Rotameters for measuring flows of 10 /l/min (supplied by IRAS)
12 Equipment to install the impactors in the field (laboratory clamps)
13 Petri dishes (diameter at least 55 mm) or other equipment to transport and store filters
14 Silicone oil (grade 316 or other but not less viscous to coat the impaction plates with a drop)
15 Flat pointed tweezers (to insert filter in the filter holder in the laboratory)
16 Rubber mats
17 Refrigerator at 4 ºC or less.
18 Extension wires
19 Tape
20 Elastics
21 Small tools
22 Rope
23 Something to carry/drive the pumps on
24 Long Stair case if pump unit is placed on the roof.

Items 17-24 needs to be provided by the local center. All other items will be supplied by IRAS.

6.3 Paper materials

25 Field forms to record data in the field (appendix 2)
26 Laboratory forms to record rotameter calibration

7. PROCEDURES

7.1 Preparations in the laboratory

7.1.1 Check of critical orifice, external rotameter, elapsed time indicator and filters

Before using the pump units, the critical orifice should be checked to ensure that the appropriate flow (10 l/min) is delivered. Sample flow should at the start of sampling be 10 l/min (± 0.5 l/min). Sample flow should be measured after 5 minutes warm-up. This can be done by measuring the flow through the critical orifice connected to the pump unit with a soap film meter or another flow measurement device.

Compare elapsed times of the different pump units by running the pump units simultaneously. Elapsed times should not differ more than 5 minutes for a 24-hour period. In addition, the flow stability should be checked by taking flow readings (after 5 minutes warm-up) at 0, 0.5, 1, 2 and (about) 24 hours.

In order to prevent overloading of the filter, timers will be used to turn the pump on for 15 minutes during each two hours. In each center, the timers will be programmed such that they are taken from 0-0[15], 2-2[15], 4-4[15], 6-6[15], 8-8[15], 10-10[15], 12-12[15], 14-14[15],16-16[15], 18-18[15], 20-20[15], 22-22[15]. In this way a representative sample can be taken. In 14 days in this method effectively a 42-hour sample is taken.

Calibration of the rotameters with a primary standard should be conducted. A five-point calibration with flows between 8 and 12 l/minute should be performed. Document consistency of rotameters by regular comparison with the same internal standard. Record the readings in a table. The comparison has to be performed before the study period, after three, six, nine, and after the study period. The internal standard can be a soap film meter, a dry gas meter or a rotameter that remains in the laboratory all the time. During a site visit to all study centers a comparison will be made with one certified standard flow measurement device.

Rotameters have to be transported carefully in order to prevent contamination, by closing the ends and / or transport in a clean, closed box.

Check a new lot of filters carefully before using them. If several filters show deficiencies, please inform the coordinator who will contact the manufacturer. Specifically, the filters should be reasonably flat (allowing reflectance measurement within 5%) and should not contain small holes.

We have observed that the reflectance of blank filters may differ between different lots of filters. Therefore, careful recording of the lot number has to be performed by the laboratory.

7.1.2 Weighing of filters

Filters will be weighed after conditioning for at least 24 hours according to the RUPIOH weighing protocol (SOP RUPIOH 3.0) by IRAS, University of Utrecht.

7.1.3 Filling the filter cassette with the drain disk and Teflon filter.

Use clean (ethanol) flat pointed tweezers to insert drain disk and Teflon filter in the filter holder rings. First, put the drain disk in one ring, next put the Teflon filter with the **support ring on the upside** on top of the drain disk. Finally put the second ring on top of the Teflon filter and click. The Teflon filter and drain disk are fixed now. The filter cassette can be transferred to the field in a petri dish with the sample ID. To prevent bouncing, the cassette is inserted in a transport ring. The upside ring must be marked, to ensure that the cassette is inserted correctly in the impactor in the field. This will be performed by IRAS, do not remove filters from the cassette.

7.1.4 Cleaning and oiling of impactor plates

Use subsequently a hot soap solution, pure water and ethanol to clean impactor plates that have been used in the field (and new ones). Dry the plates with the porous side down on clean tissue paper. The purpose of cleaning the impactor plate is to remove particles from the oil. It is not a problem if some oil remains on the plate.

Put <u>one</u> small drop of the appropriate grade (grade 316) of silicone oil on the porous side of the impaction plate. The plate absorbs oil, so it may not be visible after a while. Don't add more oil until it is visible, as this may result in spilling of oil in the impactor during sampling. Store the oiled impactor plate in a clean petri dish for transport to the field.

7.1.6. Cleaning critical orifices

If the flow of a critical orifice is too low, the orifice needs to be cleaned. Take the orifice from the tubing. Pour ethanol in the orifice and tubing (add stopper) and flush. Use a nylon thin wire (e.g. used for fishing) to carefully remove dirt from the orifice. Do not use metal wires as this may damage the orifice. Flush with ethanol and dry again. Connect the orifice to the tubing in the correct position again: the narrow opening should be facing the primary side of the airstream (incoming air,,compare other orifices).

7.1.6 Sample identification

The laboratory should mark the petri dishes with an ID number that is meaningful and easy to understand in the field. The system we use is:

CCGLLCCddmmyyA

Country	2 digits (2 letters)
Group	1 digit (1 letter)
Loc nr	01 - 80 2 digits (2 numbers)
Comp	P1 or P2 or NO 2 digits (2 letters ór 1 letter + 1 number)
Date	start ddmmyy 6 digits (6 numbers)
Add	S, B or D 1 digit (1 letter) (Sample, Blank or Duplicate)

IRAS will supply a laboratory filter number code that is entered on the petri dish and the field form. Each center should supply the unique sample code to identify the sample to link the field from information to the site.
It is very important that the PM10 and PM2.5 filters are not confused. A tip is to make separate stacks of PM10 and PM2.5 filters in a chronological order, to avoid mixing of filters.

7.2 Field procedures

The laboratory should provide the following items:
- pump unit
- impactors
- marked filter cassettes (containing filter plus drain disk) in petri dishes with sample identification
- petri dishes with oiled impactor plates
- field forms with brief instructions
- rotameter for 10 l/min
- rain caps

7.2.1 Installing equipment at the site

1. Install the complete impactors such that the inlet is about 1.5 above the surface on which the sampler is placed. There should be at least 1 meter between the PM2.5 inlet and another low volume pump unit and at least two meters from a High Volume sampler inlet. Further site criteria are specified in the study manual
2. The inlet of the impactor should be placed upside down (inlet down, impactor base up). It has been the experience of the Harvard School of Public Health (George Allen) that this is necessary for outdoor sampling to prevent condensation in the impactor affecting the filter.
3. Connect the impactor base to the pump unit inlet.

7.2.2 Preparing the impactor unit for sampling

4. Insert subsequently a rubber ring on the impactor base, a filter cassette with filter and drain disk. The Teflon filter should be on the UPSIDE, that is to the impactor body side (facing the inlet and thus the incoming airflow)
5. Clamp the impactor body on the impactor base
6. Gently push the first part of the nozzle on the body, making a twisting movement. It is important not to push too rough, since this will damage the O-rings!
7. Place an oiled clean impaction plate in the nozzle. A clean plate should be used for each sampling period. The oiled part should face the incoming air.
8. Gently push the second part of the nozzle on the body, making a twisting movement. It is important not to push too rough, since this will damage the O-rings!
9. Gently push the calibrator adaptor on the nozzle, making a twisting movement. It is important not to push too rough, since this will damage the O-rings! When the impactor base has been connected to the pump unit and the pump turned on and warmed up for five minutes, flow rate can be measured. After measuring the flow rate, remove the calibrator adaptor gently, making a twisting movement

10. Gently push the inlet on the nozzle, making a twisting movement. It is important not to push too rough, since this will damage the O-rings! The impactor is ready for sampling now.

7.2.3 Sample change instructions

A video will be provided to further detail handling.

Installing a new filter

1. Take a filter cassette containing a pre-weighed filter and a drain disk from a numbered petri dish and insert it on the impactor base. Record the ID number of the filter on the field form. Be sure to install the cassette with the Teflon side facing the impactor body (that is facing the inlet and thus the incoming airflow). Leave the petri dishes at the measurements site.
2. Install the impactor body, the oiled impactor plate, nozzle and calibrator adaptor on the impactor base.
3. Set the elapsed time indicator to zero (outdoor pump unit)
4. Turn the pump unit on by changing the setting of the timers to ON. Have the pump warm up for at least five minutes
5. Measure the flow rate by connecting a calibrated rotameter to the calibrator adaptor. Read the rotameter at the middle of the ball if it is stable. The flow rate should be 10 l/min (± 0.5 l/min). Record the measured value on the field form. If the flow at the calibrator adaptor is below 9.5 l/min step 6 should be conducted (section 3.2)
6. *(only if the flow is below 9.5 l/min)*
   Remove the impactor base from the pump unit and measure the flow at the PM2.5 inlet of the pump unit. This flow should be equal to the flow measured above at the calibrator adaptor (a 0.5 l/min difference is acceptable). Record the measured value on the field form. If the flow is higher, there probably is a leak in the impactor. In that case, the impactor should be dismantled, checked and reassembled. Reconnect the impactor base to the pump unit.
8. Remove the calibrator adaptor and connect the sampling head to the nozzle. Be sure to position the impactor UPSIDE DOWN (inlet down, base up)
9. Record start time (local time, hh.mm) and start date
10. Turn the settings of the timers to the correct position (week: ON and day: SETTING)

Collecting a sampled filter

Filter changing should occur at the site. Do not transport complete impactors to the lab.

1. Inspect the equipment and record irregularities on the field form (such as pump not running anymore, sampling lines not connected to pump, construction work near site).
2. Remove the inlet and instead install the calibrator adaptor on the nozzle. Measure the flow rate using a calibrated rotameter. The flow rate should be 10 l/min (± 0.5 l/min). If the flow rate is below 9 l/min, the orifice might be dirty and should be cleaned. When you measure the flow rate with a new filter installed, you will know which is the case. Record the measured value on the field form.
4. Turn the pump off
5. Read and record the elapsed time of the pump unit. Record the end time (local time, hh.mm) and end date
6. Remove the filter cassette containing the filter and drain disk from the impactor base. Store in the transport rings in the petri dish with the ID number of the filter (written on the field form).
7. Next, remove the impactor plate and take it back to the laboratory for cleaning. The order of points 6 and 7 is important as some oil may be spilled on the filter when removing the impactor plate. Check the impactor plate for visible particle loading. Record on the field form

if there is a visible 'mountain' of dust. This may change the particle cut-off, thus the measurement should be flagged. This step could be performed in the laboratory.

If impactor plates of PM2.5 impactors are regularly overloaded, the sampling time can be reduced by turning the pump ON and OFF each for example 15 minutes using a timer. Alternatively, the use of grease instead of oil could be tried, but we have no direct experiences with this.

Sampling flow
Sample flow is measured at the inlet of the impactor. Read the flow at the middle of the ball of the rotameter when it is stable. Rotameters should be kept in an exact vertical position when the flow reading is taken.

The sample flow will remain constant provided that the pressure drop over the filter due to sampled particles and humidity is not too large. Constant flow is important for two reasons. First, the sample flow (before and after sampling) is used in the calculation of sample volume. Second, particles larger than 2.5 μm will be sampled if the flow rate drops appreciably. Sample flow should at the start of sampling be 10 l/min (± 0.5 l/min). If the flow rate is lower than 9.5 l/min, a leak has probably occurred in the impactor system (possibly by a damaged O-ring). In case of a start flow below 9.5 L/min, flow should be measured at the pump inlet. If this flow is 10 l/min, a leak is present. If this flow is also low, the orifice is probably dirty (or an internal leak has developed). Is so, the orifice should be taken from the pump unit and replaced by a spare orifice and cleaned in the laboratory. Re-install the orifice so that the thinner part of the orifice is facing the impactor (compare the other orifices in the pump units).
A flow rate after a sampling period lower than 9.5 l/min may occur due to filter clogging or due to a dirty orifice. When the sampled filter has been exchanged for a new clean filter and start flow is measured, you will be able to differentiate between the two causes.

Sample flows read from rotameters are ambient temperature and pressure dependent. Correction for these influences at the time of flow reading will be made using routinely measured temperature and barometric pressure data.

7.3 Treatment of samples in the laboratory after sampling

After sampling filters should be collected from the field and stored in the refrigerator at 4 ºC or less as soon as possible but certainly within 24 hours. This is to limit weight losses due to volatilization of (among others) ammonium nitrate from Teflon filters which have been documented to occur in one week. Transport from a Teflon filter (in the filter cassette with the sampled side up) from the laboratory to the field and back should be done with plastic petri dishes in transport rings.
After each sampling period (that is if all 20 sites have been measured once), filters will be transported to IRAS laboratory (c/o Kees Meliefste). Transport will be done in the filter cassettes and transport rings using express mail to limit losses of particles from the filter (on dry ice?).
In IRAS laboratory the Teflon filter is removed from the cassette. Filter handling should be done with flat pointed tweezers, without touching the sampled area. Only touch the support ring on the filter. The filter is next transferred to a numbered petri dish (sampled side UP). The drain disk and filter holder rings can be re-used. Filters can be stored in the refrigerator for a maximum period such that the time between retrieval from the field and the weighing does not exceed 60 days.

The weighing and conditioning procedures for the exposed filters are specified in the weighing SOP (RUPIOH SOP 3.0). After weighing the filter should be stored in the same plastic petri dish for later analyses (reflectance, RUPIOH SOP 4.0), at 4 ºC or lower.

7.4. Quality control procedures

7.4.1 Internal quality control

1. Document consistency of rotameters by regular comparison with the same internal standard. The internal standard can be a soap film meter, a dry gas meter or a rotameter that remains in the laboratory all the time. Record the readings in a table. The comparison has to be performed before and after the study period and every three months after the start of the study.
2. Quality control procedures for weighing and reflectance measurement are in the above mentioned SOPs
3. Collect a field blank every measurement period so that 12 field blanks will be obtained. Take filter to the field, load the sampler with the filter, leave in the field for two weeks and take filter to the lab. Use the continuous sampling site for blanks. Use a PM10 impactor that is idle during the week. We will not take PM2.5 blanks. The blanks are used to determine the detection limit and average field blank.
4. Conduct measurements with two collocated PM10 samplers every measurement period (12 sampling days). Field duplicates are taken to document precision of the measurements. Duplicates will be obtained at the continuous reference site.

7.4.2 External quality control

During a site visit to all study centres a comparison will be made of the used rotameters with one certified standard flow measurement device.

The impact of transporting filters on weighing and reflectance measurements will be checked by a control program that will involve analysis of five freshly exposed and five blank filters before and after transport to one of the centres involved.

7.5 Calculations

The PM2.5 (and PM10) concentration is calculated as:

$C = M/V$

C = concentration of $PM_{2.5}$ (PM10) ($\mu g/m^3$)
M = collected particle mass (μg)
V = sample volume (m^3)

Collected particle mass is calculated as the difference in weight of the filter before and after sampling, see the specifications in the weighing SOP.

Sample volume is calculated as the product of the mean flow rate and the sampling time:

$V = ((A*F1+A*F2)/2)*T/1000$

A = calibration factor of rotameter used for taking flow reading
F1 = adjusted rotameter reading before sampling (l/min)
F2 = adjusted rotameter reading after sampling (l/min)

T = sampling time from elapsed time indicator of the sample changer (minutes)
1000 = transformation of litre to m^3

The calibration factor is calculated from the comparison of the rotameter with an external, certified flow measurement device. The actual value is the average calibration factor of the two calibrations in between which the flow measurement is made (e.g. the pre-study and month three calibration for a home measured during month 2).

Flow rates are adjusted for ambient pressure using the following formula:

F(P2) = F(P1) * 1 / SQRT(P2/ P1)

F(P1) flow at calibration conditions
F(P2) flow at measurement conditions
P1 temperature, pressure calibration conditions
P2 temperature, pressure measurement conditions
Given the precision of concentration determination, only one decimal will be given when individual concentration data are presented.

All calculations have been pre-programmed in Excel files that will be made available to all of you. Each center is responsible for data entry in their city. Filter analysis results will be supplied by IRAS. Do not change the format of the file, as this will make it more difficult for IRAS to perform a final consistency check on the data of each partner.

Concentration data will not be accepted if:

- The elapsed time is less than 28 hours (67% of time)
- Start or end flow < 8 l/min
- Weighing of check filters or mass pieces unacceptable (weighing SOP)

8. DATA RECORDS

- calibration table rotameter
- field forms containing sampling characteristics
- spread sheet containing all information for a specific sample

9. SAMPLE ARCHIVING

Filters are stored in petri-dishes in a refrigerator at 4 ^{o}C or lower until they are sent to the central laboratory for weighing. After weighing and reflectance measurement by the central laboratory (weighing and reflectance measurement), filters are stored in petri-dishes in a refrigerator at 4 ^{o}C or lower.

10. IMPLEMENTATION AND APPLICATION

NA

Appendix 1: Sample coding "E S C A P E" project

Coding samples :	**CCGLLCCddmmyyA**	
Country + group		3 digits (3 letters) (see coding list study manual, Appendix 2) [a]
Location nr	01 - 40	2 digits (2 numbers) [a]
Component	P1 ór P2 ór NO ór OX ór PH	2 digits (2 letters ór 1 letter + 1 number)
Date	ddmmyy	6 digits (6 numbers) start date
Additional	S or B or D	1 digit (1 letter) S=sample, B=blank, D=duplicate

a) Also used as location coding on site characterization form

Appendix 2: Coding list Study areas

Study Area	Code	Epidemiologic study acronym	Measurements
Györ, Hungary	HUG	APREG	PM+NOx
Florence, Italy	IFL	EPIC	NOx
Turin, Italy	ITU	EPIC, SIDRIA, ECRHS	PM+NOx
Varese, Italy	IVA	EPIC	NOx
Verona, Italy	IVE	ECRHS	NOx
Pavia, Italy	IPA	ECRHS	NOx
Rome, Italy	IRO	GASPII, SIDRIA	PM+NOx
Barcelona, Spain	SPB	ECRHS, INMA	PM+NOx
San Sebastian, Galdakao, Spain	SPS	EPIC, INMA, ECRHS	NOx
Huelva, Spain	SPH	ECRHS	NOx
Oviedo, Spain	SPO	ECRHS, INMA	NOx
Girona, Spain	SPG	REGICOR	PM+NOx
Athens, Greece	GRA	EPIC	PM+NOx
Heraklion, Greece	GRH	RHEA	PM+NOx
Oxford, Norfolk, Norwich, Ipswich, UK	UKO	EPIC, ECRHS, UK 1946 cohort	PM+NOx
Bradford, UK	UKB	BIB	NOx
Manchester, UK	UKM	MAAS, UK 1946 cohort	PM+NOx
Utrecht, Netherlands	NLU	EPIC	PM+NOx
Amsterdam, Netherlands	NLA	EPIC, ABCD	
Doetinchem, Netherlands	NLD	EPIC	
Maastricht, Netherlands	NLM	EPIC	PM+NOx
Rotterdam, Netherlands	NLR	PIAMA	
Antwerp, Belgium	BAN	ECRHS	
Heidelberg, Germany	GHE	EPIC	NOx
Erfurt, Germany	GER	ECRHS	NOx
Ruhr Area, Germany	GRU	SALIA, RECALL	PM+NOx
Munich, Germany	GMU	LISA + GINI	PM+NOx
Augsburg, Germany	GAU	KORA	
Lugano, Switzerland	SWL	SAPALDIA	PM+NOx
Basel, Switzerland	SWB	SAPALDIA, ECRHS	NOx
Geneva, Switzerland	SWG	SAPALDIA	NOx
Vorarlberg, Austria	AUV	VHM&PP	NOx
Copenhagen, Denmark	DCO	DCH, National Birth Cohort	PM+NOx
Oslo, Norway	NOS	HUBRO, MOBA	PM+NOx
Stockholm, Sweden	SST	BAMSE, TWINGENE, 60 YEAR OLDS	PM+NOx
Umea, Sweden	SUM	ECRHS, EPIC	NOx
Paris, France	FPA	ECRHS, EPIC, GAZEL, EGEA	PM+NOx
Grenoble, France	FGR	ECRHS, EGEA, GAZEL	NOx
Marseille, France	FMA	EPIC, EGEA, GAZEL	NOx
Lyon, France	FLY	EPIC, EGEA, GAZEL	NOx
Nancy, Poitiers, France	FNA	EDEN	NOx *
Helsinki, Turku, Finland	FIH	FINRISK	PM+NOx
Cracow, Poland	POC	HAPIEE	PM+NOx
Kaunas, Lithuania	LIK	KANC	PM+NOx

Appendix 3: Escape Field Form $PM_{2.5}$ and PM_{10}

	INLET 1	INLET 2	INLET 3	INLET 4	OGAWA	OGAWA
	PM 2.5	PM 10	□ blank □ duplicate □ additional	□ blank □ duplicate □ additional	NOx / NO_2	□ blank □ duplicate
lab number :						
I.D. sample code :						
GPS Coord.:						
pump unit number:						
start date :						
start time :						
start elapsed time counter :	0,0	0,0	0,0	0,0		
I.D. flowrater :						
start flow :						
*start flow pump unit : **						
end date :						
end time :						
end elapsed time counter :						
I.D. flowrater :						
end flow :						
Irregularities :						

* To be measured only if start flow is below 9.5 liters / minute