



Environmental Analysis Program

Pomona College
Biogeochemistry Laboratory

SOP-F505

Passive Air Samplers – Diffusion Tubes

Standard Operating Procedure

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1. Purpose

This procedure describes the deployment, retrieval, and documentation of passive (diffusion-based) air samplers for time-integrated measurement of gaseous air pollutants. Passive samplers require no pump or power supply: the target gas diffuses along a concentration gradient through a defined path length and is captured by a sorbent or reactive medium at the closed end of the tube. After a

known exposure period, the sampler is sealed, returned to the laboratory, and analyzed to determine the time-weighted average ambient concentration (Cape, 2009; Palmes et al., 1976).

Common target analytes include nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), ammonia (NH_3), and volatile organic compounds (VOCs). Passive samplers are widely used in spatial surveys and community-based exposure studies because they are inexpensive, silent, and require no electricity, making dense network deployments feasible (Vardoulakis et al., 2005; martin2014?).

Passive diffusion tubes are subject to known biases from wind speed, temperature, and tube geometry that must be understood and managed through quality control (Plaisance et al., 2004; Tang et al., 2001). When operated according to harmonized protocols and validated against active reference methods, passive samplers can provide data suitable for regulatory screening and spatial mapping (hafkenscheid2009?).

2. Scope

- **Applies to:** Deployment and retrieval of passive diffusion tube samplers (e.g., Palmes tubes for NO_2 , Ogawa badges for NO_2/O_3 , Radiello cartridges for VOCs/ NH_3) at EA Program field sites
- **Does not apply to:** Active (pump-based) gas sampling; passive PM samplers; low-cost electronic gas sensors; laboratory analysis of exposed samplers (handled by the analytical laboratory or per analyte-specific lab SOPs)
- **Location:** EA Program field deployment sites

3. Responsibilities

Role	Responsibility
PI / Field Lead	Approve sampling design, select sampler type and analytical lab
Trained Personnel	Deploy, retrieve, and document samplers
New Students	Complete training before independent deployment

4. Definitions

- **Passive (diffusion) sampler:** A device that collects a gaseous pollutant by molecular diffusion along a concentration gradient, without requiring a pump. The sampler relies on Fick's first law of diffusion to relate the mass of analyte captured to the ambient concentration over the exposure period (Palmes et al., 1976).
- **Palmes tube:** A cylindrical passive sampler (typically 7.1 cm long, 1.1 cm internal diameter) with a triethanolamine (TEA)-coated stainless steel grid at the closed end for NO_2 collection. Originally described by Palmes et al. (1976).
- **Ogawa badge:** A disk-shaped passive sampler with two collection pads separated by a diffusion barrier. Can be configured for NO_2 , O_3 , or SO_2 .

- **Radiello cartridge:** A radial-symmetry passive sampler with a cylindrical diffusive body surrounding a sorbent cartridge. Used for VOCs (Carbograph sorbent), NH_3 (acid-coated), and other gases.
- **Uptake rate:** The rate at which the target analyte diffuses into the sampler, determined by the diffusion coefficient of the gas, the cross-sectional area, and the path length. Published uptake rates are specific to each sampler-analyte combination and are used to convert captured mass to ambient concentration.
- **Time-weighted average (TWA):** The mean ambient concentration over the exposure period, calculated from the total mass captured and the exposure duration.
- **Shortening ratio:** The effective reduction in diffusion path length caused by wind-induced turbulence at the open end of a Palmes tube, which increases the uptake rate and causes overestimation of ambient concentration in windy conditions (Tang et al., 2001).
- **Field blank:** A sampler transported to the site, briefly opened and re-sealed without exposure, then returned to the lab. Field blank analyte mass quantifies contamination from handling, storage, and transport.
- **Triethanolamine (TEA):** A viscous organic amine used as the absorbent medium for NO_2 in Palmes tubes. TEA reacts with NO_2 to form nitrite, which is subsequently analyzed by the Griess colorimetric reaction.
- **Fick's first law:** The principle that the flux of a gas through a still-air column is proportional to the concentration gradient and the diffusion coefficient:

$$J = D \times \frac{A}{L} \times C$$

where J = flux (mass/time), D = diffusion coefficient, A = cross-sectional area, L = path length, and C = ambient concentration (Palmes et al., 1976).

5. Safety and Hazards

Hazards

- **Chemical:** Some sorbent media (e.g., triethanolamine for NO_2) are mild irritants. Handle prepared tubes with gloves and avoid skin contact with the open end.
- **Traffic:** Many monitoring locations are near roadways. Wear a high-visibility vest and follow [SOP-F001](#) traffic safety procedures.
- **Height:** Mounting samplers on poles or structures may require ladder work. Follow standard ladder safety.

5.1. Required PPE

- ☐ Nitrile gloves (when handling samplers)
- ☐ Closed-toed shoes
- ☐ High-visibility vest (if near roadways)
- ☐ Sun protection

6. Equipment and Materials

Item	Notes
Passive samplers (type matched to target analyte; see Section 7.1)	Pre-prepared by analytical lab or in-house
Protective rain shelters (inverted cup or tube shelter)	Shields the open end from rain and direct sunlight while allowing airflow
Mounting clips, zip ties, or cable ties	For attaching shelters and tubes to poles, posts, or structures
Airtight storage containers or bags	For transporting unexposed and exposed samplers
Cooler with ice packs (for heat-sensitive sorbents)	Maintain at 4 C during transport if required
GPS unit	Per SOP-F006
Field notebook and deployment log	For recording dates, times, and site conditions
Permanent marker (Sharpie)	For labeling tubes

7. Procedure

7.1. Sampler Selection

Select the sampler type based on the target analyte and exposure period:

Target Analyte	Sampler Type	Typical Exposure	Analytical Method
NO ₂	Palmes diffusion tube (TEA-coated grids)	1–4 weeks	Spectrophotometry (Griess reaction)
NO ₂ / O ₃	Ogawa passive sampler	1–2 weeks	Spectrophotometry
NH ₃	Radiello cartridge or acid-coated filter	1–4 weeks	Spectrophotometry or IC
VOCs (BTEX)	Radiello cartridge (Carbograph sorbent) or 3M OVM badge	1–4 weeks	GC-MS (thermal desorption)
SO ₂	Impregnated filter or Radiello cartridge	1–4 weeks	Ion chromatography

Note

The analytical laboratory typically prepares and supplies the samplers, pre-loaded with the appropriate sorbent. Confirm sampler type, handling instructions, and shipping requirements with the lab before each deployment.

7.2. Pre-Deployment

1. Keep sealed samplers refrigerated (4 C) until deployment day unless the analytical lab specifies otherwise
2. Assign a unique ID to each sampler and record it in the deployment log
3. Designate at least 2 field blanks per batch: samplers that travel to the site, are briefly unsealed (less than 30 seconds), re-sealed, and returned to the lab with the exposed samplers

7.3. Deployment

1. At the monitoring location, mount the rain shelter at a height of 2–3 m above ground, away from walls (at least 1 m), exhaust vents, and vegetation canopy
2. Remove the sampler from its sealed container, note the date and time, and attach the open end downward inside the rain shelter
3. Secure the sampler with clips or zip ties
4. Record in the field notebook: site ID, sampler ID, deployment date/time, GPS coordinates, mounting height, distance to nearest road, weather conditions, and any potential sources nearby
5. Photograph the installed sampler for documentation

! Wind Exposure

Palmes tubes are sensitive to wind speed: turbulence at the open end of the tube effectively shortens the diffusion path, increasing the uptake rate and overestimating the ambient concentration by 10–30% at exposed sites (Plaisance et al., 2004; Tang et al., 2001). Rain shelters provide partial wind screening, but sheltered or recessed mounting locations should be avoided because they restrict airflow and cause underestimation. The harmonized EU protocol recommends mounting in locations with moderate, representative air exchange (hafkenschaid2009?).

7.4. Exposure Period

- The exposure period depends on the expected ambient concentration and the sampler's capacity. Follow the analytical lab's recommendation (typically 1–4 weeks for NO₂ Palmes tubes).
- Note any unusual events during the exposure period (wildfires, construction, power outages affecting nearby sources) in the field notebook.

7.5. Retrieval

1. Record the retrieval date and time in the field notebook
2. Remove the sampler from the shelter, immediately cap or seal it, and place in an airtight container or bag
3. Calculate the total exposure time in hours
4. Place sealed samplers in a cooler with ice packs for transport (if required by the analytical lab)

5. Retrieve and seal the field blanks in the same manner

7.6. Shipping to Analytical Laboratory

1. Pack sealed samplers securely with cushioning material in an insulated shipping container with ice packs (if heat-sensitive)
2. Include a chain of custody form listing all sampler IDs, site locations, deployment and retrieval dates/times, and total exposure hours
3. Ship via overnight courier or deliver in person to the analytical lab

7.7. Concentration Calculation

The analytical laboratory reports the mass of analyte captured on each sampler. The time-weighted average ambient concentration is calculated using Fick's first law (Palmer et al., 1976):

$$C = \frac{m}{D \times A/L \times t}$$

where:

- C = ambient concentration ($\mu\text{g}/\text{m}^3$ or ppb, after unit conversion)
- m = mass of analyte on the sampler (μg)
- D = molecular diffusion coefficient of the analyte in air (cm^2/s)
- A = cross-sectional area of the diffusion path (cm^2)
- L = length of the diffusion path (cm)
- t = exposure time (s)

Note

The analytical lab typically performs this calculation using published uptake rates for the specific sampler-analyte combination. Confirm which party is responsible for the calculation.

8. Quality Control

- Deploy at least 2 field blanks per batch (minimum 10% of total samplers). Field blank analyte mass should be below the method detection limit; if not, subtract the mean field blank mass from all samples.
- Deploy co-located duplicate samplers at 10% of sites. Duplicates should agree within 20% for NO_2 Palmer tubes (Cape, 2009). Duplicate agreement worse than 25% indicates handling problems or site-specific wind interference (Plaisance et al., 2004).
- If collocating with an active reference sampler (chemiluminescence NO_2 analyzer, UV O_3 analyzer), compare the passive sampler result with the reference average over the same period. Palmer tubes for NO_2 typically overestimate the reference by 10–30% at high-wind sites and underestimate at sheltered sites due to restricted airflow (Tang et al., 2001).

- Document any site disturbances (construction, shelter damage, vandalism) that could affect results.
- Archive field notebooks and chain of custody forms with the project data.

9. Waste Disposal

Waste Type	Disposal Method
Exposed Palmes tubes (TEA grids)	Return to analytical lab or dispose as chemical waste (TEA is a mild irritant)
Radiello cartridges (used)	Return to analytical lab
Rain shelters and mounting hardware	Clean and reuse

10. References

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11. Related SOPs

SOP	Title	Relationship
F001	Field Safety	Required prerequisite
F502	Portable PM Sensors	Companion low-cost sensor SOP
F503	PM Filter Sampling	Active filter sampling companion
F504	Picarro GHG Analyzer	Companion field instrument
F510	Weather Monitoring	Wind data for interpreting bias

12. Training Record

Before deploying passive air samplers independently, personnel must:

1. Read this SOP and [SOP-F001](#) in full
2. Review the handling instructions provided by the analytical laboratory for the specific sampler type
3. Observe a trained operator demonstrate deployment and retrieval at one site
4. Deploy and retrieve samplers at one site under supervision, including field blank handling
5. Be signed off by the PI or field lead