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BIOINDICATORS — PAHs IN MOSSES

Technical chapter · reference criteria for the environmental indicator · 8 November 2026

1. Purpose and role

Monitoring polycyclic aromatic hydrocarbons (PAHs) in mosses is used to identify environmental pressure from atmospheric deposition. Concentrations in mosses provide an integrated indicator of exposure, not a direct estimate of residues in food crops. The final assessment of TDE qualification also considers the other environmental matrices.

2. Analytical panel and proposed thresholds

Values are expressed in µg/kg dry weight (numerically equivalent to ng/g dry weight).

Indicator	TDE reference	Review band	Interpretation
Σ16 EPA PAHs	≤ 60	> 60 and ≤ 120	Main indicator; above 120, further investigation is mandatory
Σ4 ICP Vegetation PAHs	≤ 7	> 7 and ≤ 14	Supplementary indicator for selected PAHs; above 14, further investigation is mandatory

The values of 60 and 7 µg/kg are rounded TDE guidance values derived from the median of the national medians in the 2015/2016 European survey (61.0 and 7.235 µg/kg, respectively). They are neither toxicological thresholds nor statutory limits. Exceeding a value does not automatically entail exclusion: the integrated assessment already defined in the TDE RULES applies.

IMPORTANT — The Σ4 used by the ICP Vegetation programme comprises benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene and indeno[1,2,3-cd]pyrene. It differs from the “PAH4” used in EU food legislation, which comprises benzo[a]pyrene, benzo[a]anthracene, benzo[b]fluoranthene and chrysene.

3. Decision rule

Result for at least one indicator	Operational TDE outcome
≤ guidance value	PAH criterion compatible with TDE; continue the other checks.
> guidance value and ≤ twice the guidance value	Assessment to be integrated with other matrices, recent exposure history and the profile of individual PAHs.
> twice the guidance value	Significant anomaly: targeted investigation and possible suspension; exclusion only if the assessment confirms environmental incompatibility.

The two sums are parallel indicators: they are not added together, because the PAHs included in Σ4 are already part of Σ16. The laboratory must provide individual compound values and sums that can be independently reconstructed.

4. European basis for the guidance values

Country/area	Sites	Σ16 median	Σ4 median
Austria	26	121	8.4
Germany	8	24.3	6.07
Ireland	9	23.4	1.21
Latvia	20	80.3	15.2
Norway	20	40.2	4.31
Spain (Rioja)	25	44.7	2.99
Sweden	20	77.3	21.1
Switzerland	22	138	14.8

Median of the eight national medians: Σ16 = 61.0 µg/kg; Σ4 = 7.235 µg/kg. TDE operational rounding: 60 and 7 µg/kg. The national medians carry equal weight in this calculation; this is not the median of all pooled European samples.

5. Plausibility check against 2020/2021 monitoring

Area	Sites	Σ16 median	Σ4 median
Germany	21	278.2	25.1
Spain	5	61.6	3.4
Switzerland	22	79.5	16.3

The more recent data show variability between survey periods and areas. They do not replace the 2015/2016 basis because the comparison covers only three countries and not necessarily equivalent sites. A value above the threshold requires contextual interpretation, not an automatic decision.

6. Operational requirements

• Sample mosses using a standardised procedure, documenting species, collected living portion, season, exposure and site.

• Express results in µg/kg dry weight and state the limits of quantification for each PAH; any broader analytical panel must be reducible to the Σ16 and Σ4 sums.

• Define and report how results below the LOQ are handled, to make the sums comparable.

• Any PAH anomalies in bioindicators trigger targeted checks on potentially exposed food products: routine PAH analysis is NOT required for every TDE product, without prejudice to applicable statutory obligations.

• Periodically review the guidance values when more robust European monitoring or significant changes in analytical methods become available.

7. Bibliography and documentary sources

1. Frontasyeva, M. et al. (2020). Mosses as biomonitors of air pollution: 2015/2016 survey on heavy metals, nitrogen and POPs in Europe and beyond. ICP Vegetation / UNECE. Table of national PAH medians and methodological annex.
https://icpvegetation.ceh.ac.uk/sites/default/files/REPORT-Frontasyeva.pdf

2. Hayes, F. and Sharps, K. (2025). Mosses as biomonitors of air pollution: 2020/2021 survey on heavy metals, nitrogen and POPs in Europe and beyond. ICP Vegetation / UNECE. Tables 3 and 4 (national medians and composition of the sums).
ICP Vegetation 2020/2021 report (PDF)

3. ICP Vegetation, programme under the UNECE Convention on Long-range Transboundary Air Pollution: https://icpvegetation.ceh.ac.uk/our-science/pops