TRUSTYFOOD | LANDS OF EXCELLENCE

Sentinel Vegetation — Preliminary Species × Contaminants Matrix

Technical reference document • 9 November 2026 • Preliminary scientific assessment

Objective: identify leaf analyses of local vegetation that have a scientific evidence base and may complement or replace moss biomonitoring. This matrix is NOT a sampling plan and does NOT introduce additional mandatory tests.

1. Preliminary evidence and suitability matrix

D = direct published evidence for the species or a very closely related group; P = possible but insufficiently documented for TDE decisions; — = not proposed. A D does not imply numerical comparability among species, laboratory validation or the existence of environmental thresholds.

Parameter	Deciduous oaks	Holm oak	Beech	Hazel	Chestnut	Poplar	Willow	Wild herbaceous plants	Black locust
Metals	P	D	P	P	P	P	P	P	P
Dioxins and furans	P	P	P	—	—	P	P	P	P
Dioxin-like PCBs	P	P	P	—	—	P	P	P	P
Non-DL PCBs	P	P	P	P	P	D	P	P	P
Historical pesticides	P	P	P	P	P	P	P	P	P
Current pesticides	P	P	P	P	P	P	P	D	P
PFAS	P	P	P	P	P	D	D	D	P
PAHs	P	D	D	P	P	D	P	P	D
BTEX / VOCs	—	—	—	—	—	—	—	—	—
AOX	—	—	—	—	—	—	—	—	—
Phosphonic acid	P	P	P	P	P	P	P	P	P
Dithiocarbamates	—	—	—	—	—	—	—	—	—

Methodological note: evidence on Quercus ilex (evergreen) must not automatically be transferred to deciduous oaks. For herbaceous plants, evidence depends on the actual species investigated. P mainly identifies a research avenue, not a definitive favourable assessment.

2. Comments on species

Holm oak (Quercus ilex) — Strong direct evidence for PAHs in Italy: Alfani et al. (2001) reported approximately 106.6 µg/kg dry weight at a control site and 4,607.5 µg/kg dry weight near a heavily trafficked road. As an evergreen, its accumulation period differs from deciduous broadleaf species.

Black locust (Robinia pseudoacacia) — Direct evidence (D) for PAHs in leaves: Capozzi et al. (2017) used black locust leaves and mosses for atmospheric biomonitoring. Yang et al. (2024) measured PAHs associated with black locust leaf wax in an urban setting. Other contaminants are marked P only, without species-specific validation. Black locust is a priority candidate, not the sole permissible species.

Beech (Fagus sylvatica) — Included in the German comparison by Dreyer et al. (2018) with mosses for PAHs. Potentially relevant to the mountain Apennines; an individual leaf result is not quantitatively equivalent to moss.

Poplar (Populus spp.) — Direct documentation for PFAS (Populus nigra), comparisons with mosses for PAHs, and further PCB studies. Riparian setting and water availability affect exposure.

Willow (Salix spp.) — Direct PFAS evidence, with marked differences from poplar and alder at the German site. As a water-demanding species, it must not be treated as a universal reference for cropland.

Hazel and chestnut — Highly relevant locally, but robust reference series for comparing several leaf contaminants are currently lacking. Analytical feasibility is not equivalent to interpretability.

Deciduous oaks — Potentially representative of agricultural hillsides; species-specific evidence is needed. Do not confuse with holm oak.

Wild herbaceous plants — Potentially suitable for current pesticides and PFAS, but botanically heterogeneous. The Verona study examines deciduous garden vegetation; it does not validate every herbaceous species.

3. Assessment by contaminant group

Metals: Already monitored in soil and moss. Do not routinely add them to leaves unless gaps are identified after reviewing the full multi-matrix evidence.

Dioxins/furans and DL-PCBs: Leaf analysis may substitute when moss is unavailable, but highly lipophilic compounds may be retained less effectively by deciduous leaves. Check LOQs, congeners and result handling; do not transfer soil thresholds or food TEQs.

Non-DL PCBs: Evidence supports leaves as atmospheric bioindicators (e.g., plane trees in France) and poplars. Check compatibility with the six indicator congeners and available species background values.

Historical and current pesticides: Leaf residues have been documented near fields (Verona). Avoid extrapolating automatically to unstudied species or compounds. Dithiocarbamates are excluded from routine TDE monitoring because of persistence and interpretation limitations; phosphonic acid remains covered by a dedicated determination.

PAHs: Direct evidence exists for holm oak and moss/beech/poplar comparisons. Results from different species are not quantitatively interchangeable; use consistent analyte panels and units.

PFAS: Already approved for sentinel vegetation. The German willow/poplar/alder comparison shows variation linked to species, water setting and spatial distribution; integrated evaluation with water and earthworms is required.

Phosphonic acid: Already included. BIOFOSF documents potentially persistent residues in woody plants and movement into leaves and fruit; a leaf detection does not demonstrate recent drift.

BTEX/VOCs and AOX: Excluded from routine TDE monitoring; investigate only where specific sources or problems are identified.

4. Operational approach

• Prefer naturally growing vegetation representative of the area; do not set up sentinel gardens.

• Retain PFAS and phosphonic acid as already planned; other contaminant groups are conditional proposals depending on moss availability.

• If mosses are unavailable, assess the coverage of organic contaminants using leaves without assuming analytical or environmental equivalence.

• Integrate leaf findings with soil, earthworms, water and available bioindicators. Direct atmospheric deposition sampling is excluded from routine TDE protocols.

• Do not transfer thresholds indiscriminately among species and matrices: specific provisional TDE thresholds for leaf pesticides and PAHs require field validation; foliar PFAS use an integrated species-specific approach without a universal threshold. Phosphonic acid has a

provisional, non-exclusionary guidance value of 0.25 mg/kg.

• Sampling, LOQ requirements and analytical details must be specified in the relevant operational protocols.

5. Verified bibliography and relevance

1. Dreyer A., Nickel S., Schröder W. (2018). (Persistent) Organic pollutants in Germany: results from a pilot study within the 2015 moss survey. Environmental Sciences Europe 30, 43. https://doi.org/10.1186/s12302-018-0172-y — TDE relevance: direct moss–leaf comparison (beech and poplar) for PAHs; most PCDD/F and PCB measurements in moss.

2. Alfani A., Maisto G., Prati M.V., Baldantoni D. (2001). Leaves of Quercus ilex L. as biomonitors of PAHs in the air of Naples (Italy). Atmospheric Environment 35, 3553–3559. https://doi.org/10.1016/S1352-2310(01)00087-5 — PAHs in holm oak, remote–urban numerical comparisons.

3. Granier L., Chevreuil M. (1992). On the use of tree leaves as bioindicators of the contamination of air by organochlorines in France. Water, Air, and Soil Pollution 64, 575–584. https://doi.org/10.1007/BF00483367 — PCBs and lindane on plane-tree leaves; variability across sites.

4. Beghini G., Danieli G., Marcolungo C., Lauriola P., Caobelli R., Biggeri A. (2025). From fields to gardens: Pesticide contamination in residential areas. A participatory study in Verona (Veneto Region, Italy), 2021–2022. Epidemiologia & Prevenzione 49(5–6), 404–414. https://doi.org/10.19191/EP25.5-6.A901.091 — Leaf pesticides near Italian farmland.

5. Phytoscreening for Per- and Polyfluoroalkyl Substances at a Contaminated Site in Germany (2023). Environmental Science & Technology. https://doi.org/10.1021/acs.est.2c04519 — PFAS in white willow, black poplar and black alder.

6. Trinchera A. et al. (2020). Assessing the Origin of Phosphonic Acid Residues in Organic Vegetable and Fruit Crops: The Biofosf Project Multi-Actor Approach. Agronomy 10(3), 421. https://doi.org/10.3390/agronomy10030421 — Phosphonic acid residues, persistence and translocation in trees.

7. Manghi M.C. et al. (2021). The use of phosphonates in agriculture. Chemical, biological properties and legislative issues. Chemosphere 283, 131187. https://doi.org/10.1016/j.chemosphere.2021.131187 — Chemical, agricultural and regulatory background.

8. Leaf uptake of atmospheric monocyclic aromatic hydrocarbons depends on plant species and compounds (2022). Ecotoxicology and Environmental Safety 236, 113433. https://doi.org/10.1016/j.ecoenv.2022.113433 — Caution in the use of leaves for benzene and toluene.

9. Müller G. (2003). Sense or no-sense of the sum parameter for water soluble adsorbable organic halogens (AOX) and absorbed organic halogens (AOX-S18) for the assessment of organohalogens in sludges and sediments. Chemosphere 52, 371–379. https://doi.org/10.1016/S0045-6535(03)00215-7 — Conceptual limitations of AOX; not leaf-specific validation.

10. Capozzi F., Di Palma A., Adamo P., Spagnuolo V., Giordano S. (2017). Monitoring chronic and acute PAH atmospheric pollution using transplants of the moss Hypnum cupressiforme and Robinia pseudoacacia leaves. Atmospheric Environment 150, 45–54. https://doi.org/10.1016/j.atmosenv.2016.11.046 — Direct PAH evidence for black locust leaves.

11. Yang et al. (2024). Occurrences of Deposited Polycyclic Aromatic Hydrocarbons in Wax of Plant Leaves Using Laser Scanning Microscopy and Gas Chromatography–Mass Spectrometry. Atmosphere 15(10), 1165. https://doi.org/10.3390/atmos15101165 — PAHs in leaf wax of black locust in urban settings.

6. Limits of this review

The matrix summarises selected scientific literature; it is not an exhaustive systematic review. D identifies published evidence as a starting point, not validation for all TDE uses. P denotes a research possibility and should not be interpreted as favourable evidence.

Reading note: D = published evidence for the species or relevant group; P = possible use, to be verified; — = not proposed. These symbols do not replace analytical method validation, sampling design or an integrated TDE assessment.