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Bioindicators — Mosses

Metals: European reference values, TDE thresholds and geogenic exemption for Ni and Cr

Technical fact sheet • 8 November 2026 • Values in mg/kg dry weight (dw)

1. Method used to establish the thresholds

National/regional medians from the 2015/2016 European ICP Vegetation survey [1] were used, selecting 12 previously examined areas. For each metal, the TDE reference value is the median of the 12 medians (each area contributes one value, without weighting by the number of sites). This is a conventional, descriptive criterion, not a health-based limit or a median reconstructed from individual European samples.

General TDE rule: up to the median = compatible; above the median and up to twice the median = integrated assessment; above twice the median = mandatory investigation and possible suspension/non-qualification if incompatible environmental pressure is confirmed. Exceeding the moss reference value alone does not trigger automatic exclusion.

2. TDE table — metals in mosses

Parameter	TDE median	2 × median	Interpretation
Arsenic (As)	0.150	0.300	General rule
Cadmium (Cd)	0.115	0.230	General rule
Total chromium (Cr)	1.040	2.080	Documented geogenic exemption
Mercury (Hg)	0.034	0.068	General rule
Nickel (Ni)	1.105	2.210	Documented geogenic exemption
Lead (Pb)	1.865	3.730	General rule
Copper (Cu)	4.365	8.730	General rule

Fe and Al: auxiliary determinations without a TDE threshold, useful for interpreting mineral particles in mosses. Cr(VI) determination is not envisaged in biological matrices.

3. Rationale for the geogenic exemption for nickel and chromium

In mosses, elevated concentrations of Ni or total Cr may also result from deposition of local mineral dust, rather than necessarily from anthropogenic emissions. Italian literature describes mixed contributions from soil particulate matter and anthropogenic sources for Fe, Ni and Cr [2]. European studies use lithogenic elements (including Al and Fe), enrichment factors and multi-element associations to distinguish possible sources, without treating these as unequivocal proof [3].

Therefore, Ni or Cr concentrations in mosses exceeding the reference value, even above twice the median, do not automatically lead to TDE exclusion. The following are compared: (i) soil concentrations and characteristics already available in TDE-P01; (ii) Fe and Al in mosses as indications of particulate contributions; and (iii) evidence from other matrices and local sources. The exemption is allowed only when the geogenic interpretation is documented and no independent evidence of significant anthropogenic pressure emerges.

The presence of ophiolites alone is insufficient to grant an exemption; conversely, high Ni/Cr values in mosses do not, in themselves, demonstrate contamination of food products. The rule also applies to areas not yet identified, without presupposing any particular geology.

4. Series of medians used for the calculation

Area	As	Cd	Cr	Hg	Ni	Pb	Cu
Austria	0.22	0.099	1	0.034	0.9	1.9	4.1
Germany	0.11	0.14	0.57	0.034	0.68	1.83	4.66
France	0.18	0.13	1.23	0.1	1.7	1.95	5.13
Norway	0.13	0.082	0.66	0.056	1.09	1.58	4.2
Ireland	0.082	0.049	0.46	0.034	0.64	0.74	3.23
Italy (Bolzano)	0.2	0.072	6.67	0.055	3.81	2.17	6.49
Estonia	0.12	0.11	1.09	0.031	0.6	1.27	3.69
Poland	0.38	0.21	2.22	0.045	2.94	4.98	7.6
Slovenia	0.16	0.2	1.08	0.034	1.75	3.1	4.53
Switzerland	0.14	0.12	0.85	0.03	1.12	2.13	4.84
Sweden	0.069	0.11	0.26	0.035	0.45	1.1	3.9
Spain (Rioja)	0.62	0.12	1.92	0.026	1.16	0.97	3.99

Methodological note: values extracted from the selection of areas for the 2015/2016 survey. “Italy–Bolzano” and “Spain–Rioja” are subregions, not complete national medians. These figures must always be accompanied by this clarification in any subsequent summary. Underlying statistical source: Annex 3 of report [1].

5. Application and measurement quality

Comparison requires dry-weight concentrations, moss material and sampling/preparation procedures consistent with the ICP Vegetation protocol [4]. Different species, adhering dust and collection conditions may affect comparability. The final TDE assessment integrates soil, water and organism findings and is not a compensatory average across different results.

6. References and methodological documents

[1] Frontasyeva, M., Harmens, H., Uzhinskiy, A., Chaligava, O., and participants of the moss survey (2020). Mosses as biomonitors of air pollution: 2015/2016 survey on heavy metals, nitrogen and POPs in Europe and beyond. ICP Vegetation Moss Survey Coordination Centre, JINR, Dubna, 136 pp. ISBN 978-5-9530-0508-1. Annex 3, pp. 51 ff. https://icpvegetation.ceh.ac.uk/sites/default/files/REPORT-Frontasyeva.pdf

[2] Gerdol, R., Bragazza, L., Marchesini, R., et al. (2000). Monitoring of heavy metal deposition in Northern Italy by moss analysis. Environmental Pollution. DOI: 10.1016/S0269-7491(99)00189-X. https://iris.unife.it/handle/11392/1203574

[3] Lazo, P., et al. (2018). Origin and spatial distribution of metals in moss samples in Albania: A hotspot of heavy metal contamination in Europe. Chemosphere. DOI: 10.1016/j.chemosphere.2017.09.132. https://nora.nerc.ac.uk/id/eprint/517990/

[4] ICP Vegetation (2015; materials updated for the 2020 survey). Moss Survey Protocol. Programme Coordination Centre, Centre for Ecology & Hydrology. https://icpvegetation.ceh.ac.uk/moss-survey-protocol

[5] Harmens, H., et al. (2015). Heavy metal and nitrogen concentrations in mosses are declining across Europe whilst some hotspots remain in 2010. Environmental Pollution 200, 93–104. DOI: https://doi.org/10.1016/j.envpol.2015.01.036