International Atomic Energy Agency
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REFERENCE SHEET

REFERENCE MATERIAL

IAEA-336

TRACE AND MINOR ELEMENTS IN LICHEN

Date of issue: June 1999$^{\oplus}$

Recommended Values
(Based on dry weight)

Element	Recommended Value mg/kg	95% Confidence Interval* mg/kg	N**
As	0.63	0.55 - 0.71	17
Ba	6.4	5.3 - 7.5	11
Br	12.9	11.2 - 14.6	18
Ce	1.28	1.11 - 1.45	13
Co	0.29	0.24 - 0.34	19
Cs	0.110	0.097 - 0.123	13
Cu	3.6	3.1 - 4.1	21
Fe	430	380 - 480	35
Hg	0.20	0.16 - 0.24	15
K	1840	1640 - 2040	24
La	0.66	0.56 - 0.76	12
Mn	63	56 - 70	29
Na	320	280 - 360	20
Sb	0.073	0.063 - 0.083	12
Se	0.22	0.18 - 0.26	12
Sm	0.106	0.092 - 0.120	15
Sr	9.3	8.2 - 10.4	19
Th	0.14	0.12 - 0.16	16
Zn	30.4	27.0 - 33.8	38

*   *It should be noted that the confidence interval was calculated from the combination of the standard deviation of the mean value and an additional 5% to account for any variation due to sample inhomogeneity.*

**   *Number of accepted laboratory means which were used to calculate the recommended values and confidence intervals.*

$\oplus$ *Revision of the original reference sheet dated October 1994*

Information Values
(Based on dry weight)

Element	Information Value mg/kg	95% Confidence Interval* mg/kg	N**
Al	680	570 - 790	15
Cd	0.117	0.100 - 0.134	14
Cl	1900	1600 - 2200	13
Cr	1.06	0.89 - 1.23	22
Eu	0.023	0.019 - 0.027	9
Lu	0.0066	0.0042 - 0.0090	5
Nd	0.60	0.42 - 0.78	5
P	610	490 - 730	12
Pb	4.9	4.3 - 5.5	23
Rb	1.76	1.54 - 1.98	16
Sc	0.17	0.15 - 0.19	13
Tb	0.014	0.012 - 0.016	7
V	1.47	1.25 - 1.69	8
Yb	0.037	0.025 - 0.049	5

* *It should be noted that the confidence interval was calculated from the combination of the standard deviation of the mean value and an additional 5% to account for any variation due to sample inhomogeneity.*

** *Number of accepted laboratory means which were used to calculate the information values and confidence intervals.*

The values listed above were established on the basis of statistically valid results submitted by laboratories which had participated in an international intercomparison exercise organized during 1992/1994. The details concerning the criteria for qualification as a recommended or an information value can be found in the report NAHRES-33 (IAEA/AL/79) "Intercomparison run for the determination of trace and minor elements in lichen material IAEA-336" [1]. This report is available free of charge upon request.

Intended Use

This sample is intended to be used as a reference material for the measurement of trace and minor elements in lichens. It can also be used as a quality control material for the assessment of a laboratory's analytical work, for the validation of analytical methods and for quality assurance within a laboratory.

Origin and preparation of the material

The epiphytic lichen *Evernia prunastri (L.) Ach.* was selected and collected by hand. The lichen was collected from areas in Portugal remote from pollution sources. These areas included Gavião (center of Portugal), Ourique and Serra do Cladeirão (south of Portugal). The lichen was harvested from both the *Cistus ladanifer* and *Quercus* species of tree. About 25 kilograms were collected, separated from debris and other epiphytic lichen species by visual inspection, then washed in deionized water and oven-dried at 40 °C for 24 hours. The lichen was ground using a Teflon "Mikro-dismembrator" mill. The final material was passed through a 125 µm sieve and mixed in a rotating plastic drum. Sufficient material was obtained to produce 800 units of 20 g. The material was radiation-sterilized to a total dose of 12 kGy using a ^{60}Co source.

Homogeneity

Homogeneity tests were performed on two 100 mg sub-samples taken from each of 20 bottles. The homogeneity was evaluated based on the variation in the concentration of the elements As, Br, Fe, K, La, Mn, and Sm which were determined by instrumental neutron activation analysis using the k_0 method [2]. The results of a one way ANOVA test showed no significant difference between the within-bottle variance and the between-bottle variance. The relative standard deviation of these results varied from 3 to 11 %. Taking into account the measurement uncertainty, the relative uncertainty due to inhomogeneity was estimated to be between 3 and 6%. Additional measurements for Br, Ca, Fe, Sr, and Zn using X-ray fluorescence [3] supported these results. For these latter measurements the additional uncertainty due to inhomogeneity was estimated to be between 1 and 5 %. Although the degree of inhomogeneity was not the same for all the elements, an additional component of uncertainty (5%) was added in quadrature to expand the confidence interval of each analyte. The final confidence interval includes this additional uncertainty.

Dry weight determination

All recommended and information values are expressed on a dry weight basis. Therefore the dry weight must be determined at the time of analysis, using separate sub-samples of 500 mg dried to constant weight in a drying oven set to 100 °C. Subsequent weighings should differ by less than 5 mg.

Instructions for use

The recommended minimum sample size for analysis is 100 mg. Analysts are reminded to take appropriate precautions in order to avoid contaminating the remaining material in the bottle. It is recommended that the material be stored in a dark place, below 20°C (refrigeration is advised).

Legal disclaimer

The IAEA makes no warranties, expressed or implied, with respect to the data contained in this reference sheet and shall not be liable for any damage that may result from the use of such data.

References

[1] Heller-Zeisler S. F., Zeisler R., Zeiller E., Parr R. M, Radecki Z., Burns K. I. and De Regge P., Intercomparison Run for the Determination of Trace and Minor Elements in Lichen Material IAEA-336.
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[2] Freitas M. C., Catarino F. M., Branquinho C. and Maguas C., Preparation of a Lichen Reference Material.
J. Radioanal. Nucl. Chem. **169** (1993) 47-55.

[3] Stone S. F., Freitas M. C., Parr R. M. and Zeisler, R., Elemental Characterization of a Candidate Lichen Research Material IAEA-336.
Fresenius J. Anal. Chem. **352** (1995) 227-231.