Plants as Biomonitors

Indicators for Heavy Metals in the Terrestrial Environment

Edited by Bernd Markert



Weinheim · New York · Basel · Cambridge

Editor:
Dr. Bernd Markert
University of Ósnabrück
Systems Research Group
P. O. Box 4469
D-4500 Osnabrück
Federal Republic of Germany

This book was carefully produced. Nevertheless, authors, editor and publisher do not warrant the information contained therein to be free of errors. Readers are advised to keep in mind that statements, data, illustrations, procedural details or other items may inadvertently be inaccurate.

Published jointly by
VCH Verlagsgesellschaft mbH, Weinheim (Federal Republic of Germany)
VCH Publishers Inc., New York, NY (USA)

Editorial Director: Dr. Hans-Joachim Kraus
Production Manager: Dipl.-Wirt.-Ing. (FH) H.-J. Schmitt

Cover illustration: Decreasing concentration of Cr (mmol · kg^{-1} dry weight) in *Polytrichum formosum* (above ground parts) collected from autumn 1985 to autumn 1991 in a forest ecosystem near Osnabrück, FRG (from: MARKERT, B. and WECKERT, U., 1993, submitted).

Library of Congress Card No.: applied for

British Library Cataloguing-in-Publication Data:
A catalogue record for this book
is available from the British Library

Deutsche Bibliothek Cataloguing-in-Publication Data:
Plants as biomonitors : indicators for heavy metals in the terrestrial environment / ed. by Bernd Markert. – Weinheim ; New York ; Basel ; Cambridge : VCH, 1993
ISBN 3-527-30001-5 (Weinheim)
ISBN 1-56081-272-9 (New York)
NE: Markert, Bernd [Hrsg.]

© VCH Verlagsgesellschaft mbH, D-6940 Weinheim (Federal Republic of Germany), 1993

Printed on acid-free and low chlorine paper

All rights reserved (including those of translation into other languages). No part of this book may be reproduced in any form – by photoprinting, microfilm, or any other means – nor transmitted or translated into a machine language without written permission from the publishers. Registered names, trademarks, etc. used in this book, even when not specifically marked as such are not to be considered unprotected by law.
Composition, Printing and Bookbinding:
Druckhaus "Thomas Müntzer" GmbH, D-5820 Bad Langensalza
Printed in the Federal Republic of Germany.

Outline

List of Contributors XXIX

Part I: General Aspects 1

1 General Aspects of Biomonitoring Heavy Metals by Plants 3
R. Wittig

Part II: Chemical Aspects 29

2 Chemical Properties of Metals and the Process of Bioaccumulation in Terrestrial Plants 31
B. Streit, W. Stumm

Part III: Analytical Aspects 63

3 Instrumental Analysis of Plants 65
B. Markert

Part IV: Geobotanical and Biogeochemical Prospecting and Analysis for Heavy Metal Deposits 105

4 Geobotanical and Biogeochemical Prospecting for Heavy Metal Deposits in Europe and Africa 107
W. H. O. Ernst

5 Geobotanical and Biogeochemical Methods for Detecting Mineralization and Pollution from Heavy Metals in Oceania, Asia, and The Americas 127
R. R. Brooks

6 Higher Plants as Indicators of Uranium Occurrence in Soil 155
L. Steubing, J. Haneke

7 Plant Distributions and Soil Chemistry at a Serpentine/Non-Serpentine Boundary in California 167
B. Streit, R. J. Hobbs, S. Streit

8 Serpentine Endemics as Biological Indicators of Soil Elemental Concentrations 179
M. Arianoutsou, P. W. Rundel, W. L. Berry

Part V: Biomonitoring Terrestrial Heavy Metal Pollution by Plants 191

A. Lichens 191

9 Lichens as Biomonitors for Heavy Metal Pollution 193
J. Garty

10 Lichens as Bioindicators of Heavy Metal Pollution: A Case Study at La Spezia (N Italy) 265
P. L. Nimis, M. Castello, M. Perotti

11 Multi-Residue Analysis with Passive Biomonitoring: A New Approach for Volatile Multi-Element Contents, Heavy Metals and Polycyclic Aromatic Hydrocarbons with Lichens in Switzerland and the Principality of Liechtenstein 285
R. Herzig

12 Bioindication of Road Motor Traffic Caused Heavy Metal Pollution by Lichen Transplants 329
Z. Tuba, Z. Csintalan

B. Fungi 343

13 Monitoring of Heavy Metals in Soils by Higher Fungi 345
I. Wondratschek, U. Röder

14 Applicability of Fungi to the Monitoring of Environmental Pollution by Heavy Metals 365
V. Mejstřik, A. Lepšová

C. Mosses 379

15 Some Aspects of Biomonitoring of Air Pollutants Using Mosses, as Illustrated by the 1976 Norwegian Survey 381
E. Steinnes

16 Mosses as Biomonitors of Heavy Metal Contamination within Urban Areas 395
F. Brüning, K. H. Kreeb

17 The Use of Moss Transplantation Technique for Bioindication of Heavy Metal Pollution 403
Z. Tuba, Z. Csintalan

D. Higher Plants 413

18 The Effects of Heavy Metal Stress on Higher Plants and their Use as Biomonitors 415
J. A. C. Verkleij

19 Large-Scale Screening of Heavy Metal Burdens in Higher Plants 425
G. Wagner
20 Monitoring of Heavy Metal Pollution by *Taraxacum officinale* 435
R. Djingova, I. Kuleff
21 Plant Leaves and Lichens as Biomonitors of Natural or Anthropogenic Emissions of Mercury 461
R. Bargagli
22 Trace Metals in Legumes and Monocotyledons and their Suitability for the Assessment of Soil Contamination 485
A. Kabata-Pendias, M. Piotrowska, S. Dudka
23 Heavy Metal Accumulation by Ruderal and Cultivated Plants in a Heavily Polluted District of Budapest 495
M. Kovács, G. Turcsányi, K. Penksza, L. Kaszab, P. Szőke
24 Heavy Metals in the Vegetation as Indicators for the Environmental Pollution in the Area of the Former USSR 507
F. Ya. Rovinsky, L. V. Burtseva, T. B. Chicheva
25 Heavy Metal Accumulation by Plants Growing alongside the Motor Roads: A Case Study from Turkey 515
M. A. Öztürk, İ. Türkan
26 Passive Monitoring of Airborne Pollutants, Particularly Trace Metals, with Tree Bark 523
A. Walkenhorst, J. Hagemeyer, S. W. Breckle
27 Monitoring Trace Metal Pollution with Tree Rings: A Critical Reassessment 541
J. Hagemeyer

Part VI: Analysis of Heavy Metals in Plants for the Selection of Future Monitoring Species 565

28 Do Phytopathogenic Arthropods Alter Metal Levels of Bioindicator Plants 567
T. Reijonen, P. Nuorteva
29 Seasonal Variations of Foliar Metal Content in Three Fruit Tree Species 577
M. Deu, K. H. Kreeb
30 Changes of Cadmium Concentration in the Xylem Sap of *Fagus sylvatica* L. with Increasing Altitude 593
R. Heimerich

31 Effects of Altitude on Heavy Metal Accumulation in Soils of Beech Forest Ecosystems 601
H. Jochheim, V. Glavac, H. Koenies, R. Heimerich
32 Concentrations of Selected Heavy Metals in Different Compartments of a Mountain Rain Forest Ecosystem in Sri Lanka 613
R. Jayasekera

Index 623