OBSERVATIONS MYCOLOGIQUES

2. BIO-ACCUMULATION DES METAUX LOURDS ET AUTRES ELEMENTS-TRACES PAR LES LICHENS
Laurent JACQUIOT et *Olivier DAILLANT*

Bulletin de l'Observatoire Mycologique, numéro 12, Juillet 1997

Siège : F-71250 MAZILLE France
Edition : J. D. 4 la Malavisée, F-08800 TOURNAVAUX France

Bio-accumulation des Métaux Lourds et d'autres Eléments Traces par les Lichens

Revue Bibliographique

Bio-accumulation of Heavy Metals and other Trace-Elements by Lichens

Review

Laurent JACQUIOT* - Olivier DAILLANT**

Mots clés: métaux lourds; éléments traces; bio-accumulation
Key words: heavy metals; trace-elements; bio-accumulation

RESUME: Une revue bibliographique se voulant aussi complète que possible a été réalisée sur les publications faites en langue anglaise et en langue française sur le thème de la bio-accumulation d'éléments traces (et en particulier de métaux lourds) par les lichens. Les éléments radioactifs feront l'objet d'une revue ultérieure et ne sont pas repris ici. Après une présentation générale, un tableau fait figurer en face des publications, le site, les métaux analysés et les espèces étudiées; la liste des références figure en fin d'article.

ABSTRACT: Over the past two decades the analytical methods for trace elements and heavy metals have developed such as to make systematic analysis of these elements in lichens a matter of routine. Lichens are particularly useful in bio-monitoring of trace-elements in atmospheric deposition, being more frequent and widespread than physico-chemical sensors.

This paper analyses the publications in french and english on the bio-accumulation of trace-elements - heavy metals in particular - in lichens. Studies on radioactivity in lichens will be reviewed in a later paper; radioactive elements are only mentioned here if the authors have looked for them along with stable elements.

PRESENTATION: The fist column of Table 1 gives the name of the first author and the year of publication: the complete reference can then be found in the list at the end of this article. The second column presents the geographical location of the research. The third column describes the type of work: is stands for "*in situ*", T for "transplants" and l for "laboratory research". The fourth column lists the chemical symbols of the elements under study and in the last column, the abbreviations of the species studied are provided; the corresponding species are shown on Table 2.

The letters N.D. stand for "Not Determinated", representing few cases in which the authors did not give the information.

The present article deals with 290 publications from about 40 countries; these publications deal with 59 elements and more than 260 lichen taxa.

The authors tried to make this review as complete as possible; in case of omissions, they present their apologies and would be grateful for any further information which would be taken into account in an updated version. Moreover, in this later version, it would be useful to include papers not written in french or in english; so we suggest to authors to send us the reference of their papers (in latin alphabet) and their results, as it is done in Table 1.

* Observatoire Mycologique; 45 rue du Berry; F - 01 000 Bourg-en-Bresse - France
** Observatoire Mycologique - F 71 250 - Mazille - France

INTRODUCTION:

"...la plupart des lichens semblent fuir les villes, et ceux qu'on rencontre n'y arrivent souvent qu'à un développement incomplet ... les lichens donnent à leur manière, la mesure de la salubrité de l'air..." (NYLANDER, 1866).

En guise d'épigraphe, cette remarque du lichénologue Nylander rend compte de l'utilité que pouvait apporter l'observation des lichens. Depuis la révolution industrielle cependant, les types de pollution sont devenus plus complexes et les lichens ne sont plus uniquement utilisés en bio-indication par leur présence/absence.

- Le "bio-monitoring" au sens de SLOOF & al. (1988), NIMIS (1990) et MARKERT (1991a) permet une quantification de la qualité de l'air.
- De plus, le développement des méthodes analytiques durant ces dernières décennies a permis de procéder au dosage de très nombreuses substances présentes dans l'atmosphère: outre le SO_2 déjà largement étudié, on peut citer: l'ozone, les NOx, les PAN, le fluor, les métaux lourds, les radioéléments... si certaines de ces substances peuvent avoir un impact sur la répartition des lichens, d'autres sont accumulées par le thalle, parmi celles-ci les métaux lourds et les éléments radioactifs.

L'intérêt des lichens dans ces derniers cas réside dans le fait que l'influence de paramètres autres que le transport atmosphérique est réduite au minimum, ce qui permet d'établir des échelles de contamination atmosphérique; dans les lieux considérés comme exempts de pollution, l'abondance de ces éléments dans les lichens peut servir de référence.

De plus, les lichens ont une distribution géographique beaucoup plus étendue que les capteurs physico-chimiques - lesquels ne couvrent que partiellement une zone étudiée - et, présents depuis plus longtemps, ils représentent mieux l'évolution de la pollution.

LES ARTICLES RECENSES:

La présente étude bibliographique porte sur les articles traitant de la bio-accumulation des métaux lourds et de quelques autres éléments traces par les lichens. (A titre d'exemple, l'arsenic et le baryum ne sont pas des métaux lourds mais les publications en traitant ont été recensées).

Outre le dosage de ces éléments dans les lichens, les travaux peuvent aussi porter sur:

- leurs effets sur la physiologie, la morphologie des lichens.
- la différence de sensibilité intergénérique, interspécifique, intraspécifique et entre le phycobionte et le mycobionte.
- l'interaction entre les métaux (antagonisme, synergie d'effets).
- les mécanismes de préhension, d'accumulation et leur localisation dans le thalle.

En revanche, ne sont pas repris les éléments radioactifs qui feront l'objet d'une revue ultérieure; dans certains cas, les auteurs ont cependant étudié en même temps métaux lourds et radioéléments: ceux-ci sont alors mentionnés dans le Tableau 1. Certaines recherches portent aussi sur l'uranium: elles figurent ici dans la mesure où les méthodes utilisées sont des dosages chimiques plus que des méthodes physiques ou radiochimiques.

Enfin ne sont recensées que les publications en français et en anglais dont nous disposons à la date du 10 mai 1997.

METHODES DE PRESENTATION:

La première colonne du Tableau 1 présente le nom du premier auteur et l'année d'une publication; les références complètes pourront ainsi être retrouvées dans la liste bibliographique.

La deuxième colonne présente les indications géographiques: les abréviations des noms de pays sont explicitées en début du Tableau 2.

Troisième colonne: l'étude de la bio-accumulation des éléments traces par les lichens peut se faire de trois façons: la première méthode consiste à doser les éléments dans les thalles prélevés sur le lieu étudié, *in situ* (is). La seconde permet de déterminer les quantités et les effets des métaux lourds sur des lichens provenant de zones non polluées et transplantés sur des sites pollués (T). Le travail en laboratoire (l), consiste à prélever des thalles et à les soumettre à diverses expériences comme le trempage dans des solutions chargées en métaux lourds, des études cinétiques d'adsorption, d'absorption, de relargage...

La quatrième colonne indique les symboles des éléments faisant l'objet de chaque travail.

La dernière colonne présente, sous forme abrégée, les différentes espèces étudiées, d'après la nomenclature utilisée par les auteurs. Les abréviations sont également expliquées dans le Tableau 2.

AUTRES ETUDES ET REVUES BIBLIOGRAPHIQUES:

Depuis quelques décennies, des revues bibliographiques sur l'utilisation des lichens dans l'étude de la pollution atmosphérique et des éléments traces ont été publiées (AMMANN & al., 1987; BROWN & BECKETT, 1984; GARTY, 1993a; HALE, 1983; KERSHAW, 1965; JAMES, 1973; NASH, 1989; NASH & GRIES, 1995a et b; NASH & SIGAL, 1980; NIEBOER & al., 1978; RICHARDSON 1987, 1988; TYLER, 1989; TUOMINEN & JAAKKOLA, 1973, WANNER & al., 1986). D'autres études comparent les lichens et d'autres bio-indicateurs/accumulateurs végétaux ou animaux (CROWDER, 1991; MARGOT & ROMAIN, 1976; NIMIS, 1990; RAO & al., 1977; TYLER & al., 1989). En 1980, SEAWARD publie une critique sur l'utilisation des lichens dans ce domaine. A signaler également la publication de NUORTEVA (1990) qui cite des résultats publiés par ailleurs et d'autres non publiés et donc non repris ici.

Des auteurs font paraître régulièrement les références d'articles lichénologiques traitant de la pollution et des polluants tels que ceux qui nous intéressent (BELLEMERE, 1990-1995; CULBERSON, 1951-1978; EGAN 1979-1991; ESSLINGER 1991-

1994; HAWKSWORTH, 1974-1978; HAWKWORTH & HENDERSON, 1978; HENDERSON & HAWKSWORTH, 1979; HENDERSON, 1979-1996; LAMY, 1974-1994; PUEYO, 1985-1994).

Dans le cadre de notre étude, il paraît intéressant de citer certaines publications sur la répartition des lichens dans des milieux connus pour leur contamination ou comme riches, par exemple, en cuivre (PURVIS & JAMES, 1985b), en fer (RICHARDSON, 1978) ou en plomb et zinc (HANSEN, 1991; LAMBINON, 1964; LAMBINON & AUQUIER, 1964). BRIGHTMAN & SEAWARD (1977) mentionnent des lichens se développant sur des substrats d'origine humaine dont les métaux non ferreux et le fer. Dans un article, PURVIS & HALLS (1996) étudient les différentes associations d'espèces de lichens sur des substrats riches en cuivre, en fer, en plomb/zinc ou en chrome/nickel. Il en résulte que chaque milieu subit une colonisation par des communautés lichéniques différentes.

Par ailleurs les lichens sont susceptibles de servir à la prospection géologique et en pédologie (SYERS & ISKANDAR, 1973), de par leur activité de dégradation des substrats sous-jacents: préhension, rétention et recyclage des éléments comme les métaux lourds. Dans le Tableau 1, quelques publications sont relatives à ce sujet. Il convient également de citer la revue périodique de PIERVITTORI & al. (1994 et 1996), relative aux interactions lichens/pierres, sols.

Parmi les méthodes d'analyses des éléments, RICHARDSON & al. (1995) présentent les avantages et les inconvénients, ainsi que la préparation des échantillons, dans l'utilisation de la XRF (X-Ray Fluorescence) pour l'analyse des macro et microéléments dans les lichens.

La capacité d'accumuler les métaux lourds est mise à profit dans l'établissement de matériels de référence pour la mesure des quantité de certains éléments par différentes méthodes. Parmi ces références, un lichen, *Evernia prunastri*, a été choisi par l'IAEA pour 32 éléments (PARR & ZEISLER, 1994; IEAE, 1995).

Enfin, en 1976, CAMPBELL publie une étude mathématique sur la relation entre le contenu en métaux lourds des lichens et la distance par rapport à la source d'émission. SHEARD (1986b) fait une analyse statistique sur l'accumulation des métaux et des radioéléments chez les lichens et chez d'autres végétaux.

La présente revue comporte 290 titres d'environ 40 pays différents; les articles portent sur 59 éléments et sur plus de 260 taxons conformément à la nomenclature utilisée dans chacun des articles cités. Les auteurs se sont efforcés d'être raisonnablement complets, suffisamment complets du moins pour que les informations soient exploitables par un chercheur souhaitant travailler avec les lichens pour évaluer la contamination de l'environnement par les éléments traces; c'est un type de recherche à encourager, surtout dans certains pays où il est encore peu développé.

Il n'a pas été possible d'avoir accès à certaines études, les auteurs présentent d'avance leurs excuses pour ces omissions et sont reconnaissants de toute information supplémentaire qui pourrait leur être communiquée et qui serait reprise dans une mise à jour.

D'autre part, seules les publications en français et en anglais ont été prises en compte. Nous proposons aux auteurs publiant dans d'autres langues de nous adresser leurs résultats sous forme d'un tableau, comme le Tableau 1 de cet article. Il sera également nécessaire de mentionner la référence complète de l'article. Toutefois nous ne pourrons traiter que les informations écrites en alphabet latin. Nous nous chargeons donc de collecter et de regrouper les renseignements qui nous serons parvenus.

REMERCIEMENTS :

Nous remercions les auteurs qui ont eu l'amabilité de nous envoyer leurs publications. Nous adressons un remerciement spécial à Monsieur Serge DERUELLE, du Laboratoire de Cryptogamie de l'Univertsité Pierre et Marie Curie, Paris VI, pour la lecture de notre article et ses conseils.

Tableau 1: Recensement des publications disponibles au 10 mai 1997.

(Pour la légende, voir texte)

AUTEUR(S)	SITE(S)	TYPE(S)	ELEMENT(S)	ESPECE(S)
ADDISON 1980	CAN, N Alberta	is	Al Ti V	Car Em Hp
ALLAN 1994	CAN, Ontario, Experimental Lakes Area	is	Al Fe+Mg	N.D. C
ALSTRUP 1977	O GROENLAND, Ile Disko	is	Cu Fe Mn Ni Pb Zn	Ap Lp UMly
ANDERSEN 1978	DK, Copenhague	is	Cd Pb V Zn	Lco
ASCASO 1976a		I	Al Fe	Composés lichéniques
ASCASO 1976b		I	Al Fe	Pco RHCg UMpu Composés lichéniques
ASCASO 1982	E ESPAGNE	is	Fe	CAc Dlo PBt SQo
BARGAGLI 1989a	C I, Toscane	is	Al Cd Co Cr Cu Fe Hg Mn Pb Se Zn	Pca Psa Psu
BARGAGLI 1990	I, S Toscane, Mt Amiata	is	Al Cu Fe Mn Zn	Psu
BARGAGLI 1991	I, S Toscane et Iles Eoliennes	is	Hg	P PHb Rfar Xpa
BARGAGLI 1986	I, S Toscane, Mt Amiata	is	Hg	P X
BARGAGLI 1989b	I, Mt Amiata et Etna	is	Al Cu Fe Hg Mn Zn	Psu
BARGAGLI 1993	ANTARCTIQUE, Terre Victoria	is	Al Hg	UMde USa
BARGAGLI 1987a	I, O Toscane, Parc San Rossore	is	Co Cr Cu Fe Hg Mn Ni Pb Zn	Pca
BARGAGLI 1987b	I, S Toscane, Mt Amiata	is	Hg	Psu
BARGAGLI 1987c	I, S Toscane, Mt Amiata	is	Al Cr Cu Fe Hg Mn Pb Se Zn	Pca Psa Psu
BARGHIGIANI 1988a	I, Etna	is	Hg	Pac Pca Ppa Pplu Psa Psu Rfar
BARGHIGIANI 1988b	I, Etna	is	Cu Fe Hg Mn	P Rfar Rfas Xpa
BARGHIGIANI 1990	I, Iles Eoliennes et Sicile	is	Hg	Pca Psu Xpa
BARGHIGIANI 1989	I, Mt Amiata	is	Hg	Pca Psu Rfas Xpa
BARTOK 1988	ROUMANIE, Vallée Ampoi	T	Cu Mn Pb Zn	Ls Pco PEc
BARTOK 1992	ROUMANIE, Dej	T	Cd Cr Cu Fe Mn Ni Pb Zn	Xpa
BECK 1990	USA, SO Louisiane	T	Cd Cr Cu Fe Hg Mn Ni Pb Zn	Ppr
BECKETT 1982	CAN, Ontario	is	Pb U	C Cmi Cra
BECKETT 1983	SO ANGLETERRE, PdG, C ECOSSE	is,I	Cu Zn	PEho PEhy PEm
BECKETT 1984a		I	Cd	PEho PEhy PEm PEpr
BECKETT 1984b	SO ANGLETERRE, SE PdG	is,I	Cd	PEho PEhy PEm PEpr
BERTRAND 1954	N.D.	is	Li	N.D.
BERTRAND 1947	NORV; F, Chamonix, Fontainebleau	is	Ru	Cra Pca USb
BIAZROV 1993	FIN, Kevo; NORV, fjord Varanger; RUSSIE, baie Menshikov, baie Kandalaksha	is	Cd Cu Mn Pb Zn	As Bfu Car Cdi Cra Cste CEi CEn Em Hp STpa USs
BIAZROV 1995	RUSSIE, Moscou	is	Cd Cu Mn Pb Zn	Hp
BOILEAU 1982	CAN, Ontario	is	Fe Ni Pb Ti U	Cmi Cra ST UM

AUTEUR(S)	SITE(S)	TYPE(S)	ELEMENT(S)	ESPECE(S)
BOONPRAGOB 1990, 1991	USA, SO Californie	T,is	Al Ba Cd Cu Fe Mn Pb Sr Ti Zn	Rme
BRANQUINHO 1994		I	Pb	Cpo
BROWN 1973	SO ANGLETERRE, Somerset	is	Pb Zn	Cfi Cfu Cr Csu PEpo STpi
BROWN 1976	SO ANGLETERRE, Somerset	T,I	Co Cu Ni Pb Zn	Cr Pg
BROWN 1993		I	Cd	PEm
BROWN 1983		I	Cd Cu Zn	Ccon Cr COt Dm Dw Ep Llp LOp LOs Nl PEa PEho PEhy PEm ROp Sc Sl Ss USs
BROWN 1985		I	Pb Zn	Cr
BROWN 1972		I	Pb	Cr
BURGUERA 1989	VENEZUELA, Merida City	is	Pb	PAa PAh PAt PUr USb
BURKITT 1972	SO ANGLETERRE	is	Cd Pb Zn	P
BURTON 1981		I	Cu Ni Tl	Cra
BYLINSKA 1992	SO POLOGNE, Brzeg Dolny	is	Hg	Hp PEs
CALLIARI 1995	NE I, Milan, Piacenza	T	Cu Fe Mn Pb Zn	PSf
CHISHOLM 1987	NORV, Gjersvik; SUEDE, Ramundberget; ANGLETERRE, Coniston	is	Cu	ACsm LEi LEla
CONNOR 1991		I	Cu Pb	Cpo LOp RO
CRETE 1992	CAN, N Québec	is	Cd ^{137}Cs Hg Pb	Ao Cmi Cste CORd
CZEHURA 1977	USA, NE Californie	is	Cu	Ap ACc Lca Lm LEa UMph
DAILLANT 1995	F, Saône & Loire, Mâcon	is	As Cd Co Cr ^{134,137}Cs Cu Hg ^{40}K Mn Ni Pb ^{210}Pb ^{226,228}Ra Zn	Psu Xpa
DE BRUIN 1990	NL	is	Al As Br Cd Co Cr Cs Cu Fe Ga Hf Hg La Lu Mn Ni Pb Rb Sb Sc Se Sr Th Tl U V W Yb Zn	Psu
DE BRUIN 1986	De Kempen, frontière B/NL Centre	is	Al As Ba Br Cd Co Cr Cu Fe Hf La Mn Sb Sc W Zn	Psu
DE BRUIN 1987a	NL	is	Cd ^{137}Cs	Lco Psu X
DE BRUIN 1988	NL et De Kempen (frontière B/NL)	is	Al As Br Cd Co Cr Cu Eu Fe Mn Sb Sc Se Th Zn	Psu
DE BRUIN 1987b	De Kempen, C frontière B/NL	is	Al As Au Br Cd Ce Co Cr Dy Eu Fe Hf Hg La Lu Mn Sb Sc Se Th Ti U V W Yb Zn	Lco Psu
DE BRUIN 1984	O NL, Rotterdam et estuaire du Lek	is	Al As Cd Cr Co Fe Hg Sb Sc Se Sm V Zn	Psu
DEMPSEY 1992		I	Cu Hg Pb	Cpo LOp RO
DERUELLE 1983a	F, Fontainebleau, Autoroute A6	T,is	Pb	Cch Cpo Ep Lco Pb Pca Pco Pful Pph Rfar UMg UMpo UMpu USh
DERUELLE 1984	F, Fontainebleau, Autoroute A6	T,is	Pb	Cch Cpo Ep Lco Pb Pca Pco Pful Pph Rfar UMg UMpo UMpu USh

AUTEUR(S)	SITE(S)	TYPE(S)	ELEMENT(S)	ESPECE(S)
DERUELLE 1992	F, Fontainebleau, Autoroute A6	T,is	Pb	Cch Cpo Ep Lco Pb Pca Pco Pful Pph Rfar UMg UMpo Umpu
DERUELLE 1995	F, Fontainebleau, Autoroute A6	is	Pb	Cch Cpo Ep Hp Lco Lapu Pca UMg USh
DERUELLE 1994	F, Loire-Atlantique, Paimboeuf	is	Pb	Cch Cgr Cpy Cr Cste Pca Ppe PEpo PHa PPo Rfas Xpa
DERUELLE 1983b	F, Loire-Atlantique, Paimboeuf	is	Pb	Ep Pph Pca
DOYLE 1973	NO CAN, frontière Yukon/Terr. NW	is	Cu Mn Mo Zn	A Cal ST UM
DYKEMAN 1966	E CAN, Tantramar, N-Bruns./N Scotia	is	Cu	C STpa
ERÄMETSÄ 1971a	FIN	is	Ba Ce Dy Er Eu Gd Ho La Lu Nd Pr Sm Tb Tm Y Yb	Cal Car Nar STpa STs
ERÄMETSÄ 1971b	FIN	is	Hf Mo Nb Th U W	Cal Car Nar STpa STs
ERDMAN 1977	USA, NE Wyoming/SE Montana, Powder River Basin	is	Al As B Ba Cd Co Cr Cu Fe Hg Li Mn Ni Pb Sb Se Sr Ti U V Y Zn Zr	Pch
FARKAS 1985	HONGRIE, Budapest	is	Cd Mn Pb Zn	Ccon Hp
FARKAS 1989	HONGRIE, Budapest et Mt Pilis	is	Al Co Cu Fe Ni Ti V Zn	Hp
FLETCHER 1976	GRANDE-BRETAGNE, littoral	is	Cu Fe Mn Ni Pb Zn	ANf Llc Llp Po Ppro Rsi Vma Vmu
FLORA 1980		I	Ni	UMmu
FOLKESON 1979	S SUEDE, Gusum	is	Cd Cu Fe Ni Pb Zn	Cra Hp PSf USfi
FOLKESON 1981	S SUEDE, Gusum	is	Cu Zn	Hp
FOLKESON 1984	S SUEDE, Gusum	is	Cu Zn	C
FOLKESON 1988	S SUEDE, Gusum	is	Cu Zn	C Cu
FREITAS 1993a		I	Ba Ce Co Cr Cs Fe Rb Sb Sc Th Zn	Ep
FREITAS 1995	N.D.	is	Co Cr Fe Hg Sb Se Zn	Zn
FREITAS 1993b	C et S PORTUGAL, Gaviao, Ourique, Serro do Caldeirao	is	As Ba Br Ce Co Cr Cs Eu Fe Hg La Mn Nd Rb Sb Sc Se Sm Sr Ta Tb Th Zn	Ep
FREITAS 1993c	PORTUGAL, Sines, Pego	is	Ce Eu Gd La Lu Nd Sm Tb Tm Yb	Ep Pca Psu
FRENZEL 1990	USA, E état de Washington	is	As Cd Cu Pb Zn	As
FUCHS 1983	ISRAEL	is	Br Li Sr Ti	Rd
GAILEY 1986a,b,c	C ECOSSE, Armadale	T,is	Cd Co Cr Cu Fe Mn Ni Pb Zn	Hp Lco N.D.
GAILEY 1993	C ECOSSE, Armadale	is	Cd Co Cr Cu Fe Mn Ni Pb Zn	Lco
GALUN 1984	CN ISRAEL et Tel Aviv	T,is	Br Cd Cr Cu Fe Mn Ni Pb Ti Zn	CAa Rd
GARTY 1985a	S ISRAEL, Negev Desert	is	Cr Cu Mn Ni Pb Zn	CAeh Dlst Rma SQc TELI
GARTY 1987a	ISRAEL	T	Cr Cu Fe Mn Ni Pb Zn	Rd
GARTY 1988a	ISRAEL	T	Cr Cu Ni Pb Zn	Rd
GARTY 1987b	CH	is	Cr Cu Fe Mn Ni Pb Zn	CEi Cra Hp LETv Psu PSf US
GARTY 1991		I	Al Fe Mn Ti	Nar

AUTEUR(S)	SITE(S)	TYPE(S)	ELEMENT(S)	ESPECE(S)
GARTY 1982	ISRAEL	T	Cd Cr Cu Ni Pb Zn	Rd
GARTY 1977	ISRAEL	is,I	Cd Cr Cu Fe Mn Ni Pb Zn	CAa
GARTY 1986	ISRAEL, Tel Aviv, Rakeveth	is	Cd Cr Cu Fe Mn Ni Pb Zn	CAa
GARTY 1979	ISRAEL	is	Cr Cu Fe Mn Ni Pb Sr Ti Zn Zr	CAa
GARTY 1988b	NO ISRAEL	T	Cr Cu Ni Pb Zn	Rd
GARTY 1992	N ISRAEL, HaZorea	is,I	Al Cr Cu Fe Mn Ni Pb Ti Zn	Rd
GARTY 1993b	NO ISRAEL	T	Fe	Rd
GARTY 1988c	ISRAEL	T	Cr Cu Ni Pb Zn	Rd
GARTY 1985b	ISRAEL, Tel Aviv/Kefar ha Yaroq	T,I	Cu Ni Pb	Rd
GARTY 1990		I	Pb	Rd
GARTY 1985c	ISRAEL	T	Br Fe Pb Sr Ti Zn	
GLENN 1995	NE ESPAGNE, E Catalogne, Montseny Biosphere Reserve	is	Cu Pb Zn	ANc Psu Psub
GLENN 1991	USA, états de N-York et N-Jersey	is	Cu Pb Zn	Cra Pca
GONZALEZ 1994	CN ARGENTINE, La Calera et Cordola	is,T	Al Cu Fe Mn Pb Zn	PUs
GOUGH 1977	USA, Wyoming	is	Ag Al As B Ba Cd Co Cr Cu Fe Ga Hg Li Mn Ni Pb Sc Se Sn Sr Ti U V Y Yb Zn Zr	Pch
GOUGH 1988a	USA, NO Californie, Redwood Park	is	Al Ba Ce Cr Co Cu Fe Li Mn Ni Sr Ti V Zn	He US
GOUGH 1988b	USA, N Dakota, T.Roosvelt Nat. Park	is	Al As B Ba Cr Cu Fe Hg Mn Ni Sr Ti V Y Zn	Pch Psu
GOYAL 1981a	ANGLETERRE, ECOSSE, IRELANDE	is	Cr Cu Fe Mn Ni Pb Zn	Cfu Cpo Cu PEc PEpo PEr
GOYAL 1981b	ANGLETERRE, N Lincolnshire	is	Co Cr Cu Fe Mn Ni Pb Zn	Cfu COEa PEm PEr
GOYAL 1982a	ANGLETERRE, N Lincolnshire	is	Co Cr Cu Fe Mn Ni Pb Zn	PEc PEr
GOYAL 1982b		I	Cu Fe Mn Ni Pb Zn	PEc
GRODZINSKA 1993	ARCTIC, S Spitzberg	is	Cd Cu Ni Pb Zn	An Cam Cgr Cmi Cu CEcu CEd CEi CEn CORd Of SPg STa THs UMar
GYDESEN 1981	N et SE DK	is	Cd Cu Pb Zn	Hp Lco
HALE 1985	USA, Iles Plummers et Bear, Potomac	is	Pb	PSPb
HALONEN 1993	O FIN, Kristiinankaupunki, Kaskinen, Golfe de Botnie	is	Al Cd Cr Cu Fe Mn Ni Pb Ti Zn	Hp
HANDLEY 1968		I	Cs ^{137}Cs Li Rb Sr	Rr
HERZIG 1989, 1990	CH	is	Al B Cd Co Cr Cu Fe Li Mn Mo Ni Pb Sn Zn	Hp
HOLM 1992	C SUEDE, Lake Rogen	is	Ni ^{63}Ni	Cal
HOROVITZ 1974	SO ALLEMAGNE, Tübingen	is	Ag Co Cr Cs Fe Rb Sc Th Zn	Cre
ILA 1988		I	Al As Br Ce Co Cr Cs Dy Eu Fe Hf La Lu Mn Sb Sc Sm Th Ti U V Yb	Te

AUTEUR(S)	SITE(S)	TYPE(S)	ELEMENT(S)	ESPECE(S)
ISKANDAR 1972		I	Al Fe	Composés lichéniques
JAAKKOLA 1969	N et S FIN	is	^{137}Cs Fe ^{55}Fe	Cal
JAAKKOLA 1967	FIN, Inari et Tuusula	is	Cr Cu Fe Mn Sr Zn	Cal Car Cmi Cra CEi
JACKSON 1970	HAWAI	is	Al Fe	STvu
JENKINS 1987	COLOMBIE, Bogota, El Dorado, Rosas; CRETE; ISLANDE; NIGERIA, Ibadon, Idanre, Ife; N-ZELANDE; Iles SEYCHELLES; ex-URSS; USA, Wisconsin	is	Ag Be Co Cr Cu Ga Ge Mn Mo Ni Pb Sn Ti V Y Yb Zn Zr	P Pful Pom
JENKINS 1966	NO PdG	is	Be Co Cr Cu Ge Mn Mo Ni Pb Sn Ti Zn	Pom
JOHNSEN 1981	DK, Glostrup	is	Pb	Lco
JONES 1982	ANGLETERRE, NO Yorkshire, Langthwaite	is	Pb	STve
JONES 1981	ANGLETERRE et ECOSSE	is	Fe Mn	LEd PERc
JOVANOVIC 1995	MONTENEGRO	is	Al As Au Ba Br Ce Co Cr Cs Dy Eu Fe Ga Hf La Mn Nd Rb Sb Sc Se Sm Tb Th Ti U V W Zn	
KANERVA 1988	S FIN, Espoo	is	Al Cd Fe Hg Zn	Hp
KANSANEN 1991	NO FIN, Tornio, Golfe de Botnie	is	Cr Fe Ni	Hp
KAPU 1991	NO NIGERIA, Zaria	is	Cr Cu Fe Pb Zn	P
KARDISH 1987	ISRAEL	T	Cu Pb Zn	Rd
KAUPPI 1992	CO FIN, Oulu, Golfe de Botnie	is	Al Cd Cr Cu Fe Mn Ni Pb Ti Zn	Hp
KAUPPI 1980	CN FIN, Raahe, Rautaruukki, Golfe de Botnie	is	Fe	Hp
KEINONEN 1992	S FIN et Laponie	is	Pb ^{204}Pb ^{206}Pb	N.D.
KORTESHARJU 1989	NO FIN/NE SUEDE, Kolari	is	Cu Fe Mn Pb Zn	Bfr Bfu+Bl
KORTESHARJU 1990	NO FIN/NE SUEDE, Kolari	is	Cu Fe Mn Pb Zn	Car Cmi Cra Cste PEc
KRAL 1989	O TCHECOSLOVAQUIE, Bohême	is	Cd Pb	Hp
KUBIN 1990, 1991	FIN	is	Al Cd Cr Cu Fe Mn Ni Pb Ti Zn	Hp
KYTÖMAA 1995	FIN, Mäntä	is	Al Cd Cu Fe Hg Zn	Hp
LAAKSOVIRTA 1977	O FIN, Kokkola, Golfe de Botnie	is	Fe Ti V Zn	Hp
LAAKSOVIRTA 1979	S FIN, Valkeakoski	is	Fe Ti V Zn	Hp
LAAKSOVIRTA 1976	S FIN, Espoo	is	Pb	Hp
LAMBINON 1964c	BELGIQUE	is	Zn	Car Ccor Cfi Cfu Cma Cpo Cpy Cr Cte Cv Dlsc STd STn STve
LANE 1979		I	Ag Al Ba Co Cu Li Mo Ni Se Sr U V	Cra
LAWREY 1977	USA, Ohio, Perry County	is	Al Au Fe	Ccr
LAWREY 1980	USA, Iles Plummers et Bear, Potomac	is	Cu Fe Mn Pb Zn	XPc
LAWREY 1993	USA, Iles Plummers et Bear, Potomac, Virginia, Shenandoah Nat. Park	is	Al Cd Cr Cu Ni Pb Zn	FPb

AUTEUR(S)	SITE(S)	TYPE(S)	ELEMENT(S)	ESPECE(S)
LAWREY 1979	USA, Iles Plummers et Bear, Potomac	is	Pb	PSPb
LAWREY 1981	USA, Iles Plummers et Bear, Potomac, Virginia et Connecticut	is	Pb	Cst PSPb XPc
LAWREY 1988	USA, Virginia, Shenandoah Nat. Park	is	Pb	FPb
LAWREY 1975	USA, SE Ohio, Clayton township	is	Al Cu Fe Mn Mo Zn	Cca Ccr Csc Cst Cv
LEHTIMÄKI 1990	NE FIN	is	Al Cd Fe Ni Zn	Hp Pol
LEMAISTRE 1983, 1985	F, Fontainebleau	is,l	Pb	Cpo Pca
LEMAISTRE 1986	F, Fontainebleau, Autoroute A6	is	Pb	Cpo Pca
LEROY 1962	USA, Colorado	is	Ag Be Cr Cu Mo Ni Pb Sn Sr U V Y Zn	CAel Lr Pco UMhy
LESUEUR 1980		l	V	Car Cra Ctu Cu STs UMma
LLOYD 1987	C ECOSSE, Armadale	is,T	Cd Co Cr Cu Fe Mn Ni Pb Zn	Hp Lco
LODENIUS 1981, 1989	FIN	is	Hg	Hp
LODENIUS 1991	N FIN, Kevo	is	Cd Hg	C
LODENIUS 1983	S FIN, Vusaari	is	Cd Fe Zn	Hp
LODENIUS 1979	SE FIN, Kuusankoski	is	Hg	Hp
LODENIUS 1990	N FIN, Kevo	is	Al Cd Hg Mn Zn	C/Cra
LODENIUS 1984	SO FIN	is	Hg	Hp
LOONEY 1986	CAN, Terr.NW	is	^{137}Cs Cu Fe Ni Pb Ti U	CEcu CEn DAa
LOPPI 1992, 1994a	CN I, Toscane Pistoia	is	Cd Cr Cu Hg Ni Pb Zn	Pca
LOPPI 1994b	CN I, Toscane Pistoia	is	Cd Cr Cu Ni Pb Zn	Pca
LOUNAMAA 1956	FIN	is	Ag B Cd Co Cr Cu Ga Mn Mo Ni Pb Sn Y Zn Zr	Cal Csy CEi CENg Pph LOp Pce Pi Pm Psa Psty PEc STpa UMhy UMpu
LOUNAMAA 1965	S FIN	is	Fe Mn Zn	Cal Car Cu Cra CEcr CEi Ep Hi Hp LApu Pce Pom Psa Pste Psty PLag PSf STpa UMhi
LÜHMANN 1989		l	Pb	Hp
LUPSINA 1992	O YOUGOSLAVIE, Slovénie	is	Hg	Hp
LURIE 1991		l	Ag Co Cu Fe Mn Pb	Rd
LYON 1970	C NEW-ZEALAND, Nelson, Mt Dun	is	Co Cr Cu Ni Pb	N.D.
MAQUINAY 1961	E B, Angleur, Oneux ; Warche	is	Zn	STn STve
MARKERT 1991b	RUSSIE, 350 Km NO Moscou	is	Ce Dy Er Eu Gd Ho La Lu Nd Pm Pr Sm Tb Tm Yb	Hp
MARKERT 1992	RUSSIE, 350 Km NO Moscou	is	Al As Ba Br Cd Ce Co Cr Cs Cu Dy Er Eu Fe Ga Gd hf Hg Ho La Li Lu Mn Mo Nb Nd Ni Pb Pr Rb Sb Sc Se Sm Sn Sr Tb Th Tm V Y Yb Zn Zr	Hp
MISZALSKI 1993		l	Cu Fe Mn	Hp PSf USfi
MOORE 1978	USA, N-Mexico, Santa Fe Ski Basin	is	Cu Fe Mn Pb	US

AUTEUR(S)	SITE(S)	TYPE(S)	ELEMENT(S)	ESPECE(S)
MOSER 1983	USA, Washington/Oregon	is	Al	LOo PEa
MUELLER 1987	USA, Louisiane	is	Al Mn V	Rst
MUKHERJEE 1994	CO FIN, Raahe, Rautaruukki Oy	is	Al Cd Cu Fe Hg Mn Zn	Hp
NASH 1975	USA, N-Jersey/Pennsylvanie	is,l	Cd Zn	Ccr Csq Cu LApa LApe Mt Pco Ppli Pta TRa TRe UMma Vn
NASH 1981	USA, NO N-Mexique, San Juan	is	Ag As B Be Co Cr Cu Fe Hg Li Mo Mn Ni Pb Se Zn	ACst CAt Dm La Lf Ln RHPm
NAZAROV 1995	Terre François Joseph, Ile Alexandre	is	Ag Al As Au Ba Br Cd Ce Co Cr Cs Cu Eu Fe Gd Hf Hg Ir La Lu Mn Mo Nd Ni Rb Re Ru Sb Sc Se Sm Sn Sr Ta Tb Te Th Tm U V W Yb Zn Zr	US
NIEBOER 1972	CAN, Ontario, Sudbury District	is	Cd Co Cu Fe Mn Ni Pb Zn	Cal Cde Cmi Cra Cu STpa UMmu UMv
NIEBOER 1976a		l	Ni Sr Tl	UMmu
NIEBOER 1984		l	As	UMmu
NIEBOER 1976b		l	Ni	UMmu
NIEBOER 1982	CAN, Ontario	is	Fe Ti	C Cmi Cra ST UM
NIEBOER 1979		l	Cu Ni Pb Sr Zn	UMmu
NUORTEVA 1988	FIN, Bromarv	is	Al Cd Fe Hg Zn	Hp
NUORTEVA 1986	FIN, S Espoo	is	Al Cd Fe Hg Zn	Car Cra Cste Hp PLg PSf
NYGARD 1983	SO FIN, Kristiinankaupunki	is	V	Hp
OBORN 1960	USA, Colorado, Gunnison	is	Fe	CANs GAe Lr Pco
ORSI 1991	USA, N-York/N-Jersey	is	Pb?	Pca
PAKARINEN 1981	FIN	is	Cu Fe Mn Pb Zn	Car Cmi Cste
PAKARINEN 1978	FIN et N NORV	is	Cu Fe Mn Pb Zn	Car Cmi
PALIOURIS 1992	CAN, Wood Buffalo Nat. Park	is	Cu	Hp USs
PEARSON 1987	USA, Idaho	is	Cd Cu Hg Mn Ni Pb Zn	Lm LElu Pex Xpo
PEREZURRIA 1986		l	Ni	Ep
PERSSON 1974	C SUEDE, lac Rogen et Musée Bot. Lund	is	Pb ^{210}Pb ^{210}Po	C Cal
PFEIFFER 1992	CAN, NO Ontario, Lac Supérieur	is	Al As Cd Cu Fe Hg Pb Zn	Hp
PILEGAARD 1978	DK, Frederiksvaerk	is	Cd Cr Cu Fe Mn Ni Pb V Zn	Lco
PILEGAARD 1979a	DK, Frederiksvaerk	T	Cd Cr Cu Fe Mn Ni Pb V Zn	Hp
PILEGAARD 1983	CO GROENLAND, Maarmorilik	is	Ag As Cd Cu Fe Hg Pb Sb Zn	CEn UMle
PILEGAARD 1985	GROENLAND, Maarmorilik et Ilimaussaq	is	Ag Au Br Cd Ce Co Cr Cs Cu Eu Fe Hf Hg La Lu Nd Pb Rb Sb Sc Se Sm Sr Ta Th U Yb Zn	CEn UMle
PILEGAARD 1987a	CO GROENLAND, Maarmorilik	is	Pb	CEn

AUTEUR(S)	SITE(S)	TYPE(S)	ELEMENT(S)	ESPECE(S)
PILEGAARD 1987b	SO GROENLAND, Ilimaussaq	is	Ag As Au Br Cd Ce Co Cr Cs Eu Fe Hf Hg La Lu Nd Pb Rb Sb Sc Se Sm Sr Ta Tb Th U W Yb Zn	CEn
PILEGAARD 1993	SO GROENLAND, Sartartoq	is	Cd Ce La Nb Nd Pb Ta Th U Zn	CEn
PILEGAARD 1994	CO GROENLAND, Maarmorilik	is	Ag As Au Ba Br Cd Ce Co Cr Cs Cu Eu Fe Hf Hg La Pb Rb Sb Sc Se Sm Th Yb Zn	CEn UMly
PILEGAARD 1979b	DK	is	Cd Cr Cu Fe Mn Ni Pb V Zn	Hp Lco
PRUSSIA 1991	USA, University Rhode Island	is	Cu Fe Mn Zn	FPb FPc
PUCKETT 1976		l	Ag Cd Co Cu Hg Ni Pb	UMmu
PUCKETT 1980	CAN, Terr.NW	is	Al As Cr Co Cu Fe Mn Ni Pb Sb Ti V Zn	Ao An Cam Car Cra Cste CEcu CEd CEi CEl CEn CEt THs UMhy
PUCKETT 1973		l	Co Cu Fe Ni Pb Zn	Cal Cde Cmi Cra Cu STpa UMd UMma UMmu UMpa UMv
PUNZ 1979		l	Pb	Hp Xp
PURVIS 1984	NORV, Gjersvik; SUEDE, Ramundberget	is	Cu	ACr LEi LEla
PURVIS 1987	SO GROENLAND; SUEDE, Mt Gruvvalen; NORV, Gjersvik	is	Cu	ACsm ASa LEla
PURVIS 1990	NORV, Gjersvik	is	Cu	LEb LEc TEPt
PURVIS 1985a	GROENLAND, NORV, SUEDE, GB, ALLEMAGNE	is	Cu	ACsm
PYATT 1976	•	l	Cu Hg Pb	GRs LEli LEm
PYATT 1992	N PdG	is	Al Fe Mn Ni Pb Ti Zn	STd
RAMELOW 1991		l	Cu Pb	B LETc PAp Rst
RASMUSSEN 1991	CAN, Ontario, Huntsville	is	Hg	C ?
RICHARDSON 1983		l	Ni	PEc PEe UMhi UMma UMmu UMv
RICHARDSON 1979		l	Cu Ni Pb Sr Zn	UMmu
RICHARDSON 1984		l	As	UMmu
ROPE 1990	USA, SE Idaho	is	Ag Al As Ba Be Bi Cd Co Cr Cu Fe Hg Mn Mo Ni Pb Sb Se Sn Sr Ti Zn	Lm
ROUSSEL 1993	F, Saône & Loire, Chalon-sur-Saône	is	Ag As Cd Cr ^{134}Cs ^{137}Cs Cu Hg Ni Pb Zn	Psu PHt PHYg Xpa
SAEKI 1977	JAPON, Hondo, Sendai	is	Al Cd Cr Cu Fe Hg Mn Pb Zn	Pca Pcl Pco Pti
SAEKI 1975	JAPON, Hondo, Sendai	is	Cu Pb	Pco
SÄRKELÄ 1987	N FIN	is	Al Cd Fe Hg Zn	Hp
SCHATZ 1962		l	Fe	Composés lichéniques
SCHUTTE 1977	USA, Ohio et W Virginia	is	Cr	Pca Pr
SCHWARTZMAN 1987	USA, Plummers Island, Great Falls, Rock Creek Park	is	Cd Pb ^{210}Po Zn V	PSPb
SCOTT 1989	NE AMERIQUE et ALLEMAGNE	is	Al Fe Mn Pb Zn	Hp

AUTEUR(S)	SITE(S)	TYPE(S)	ELEMENT(S)	ESPECE(S)
SEAWARD 1973	ANGLETERRE, Lincolnshire, Risby Warren	is	Cr Cu Fe Mn Ni Pb	Cfu CORa PEr
SEAWARD 1974, 1977	ANGLETERRE, N Yorkshire, Falling Foss	is	Cu Fe Pb Zn	Hp
SEAWARD 1981	SO POLOGNE	is	Cr Cu Fe Mn Ni Pb Zn	UMc UMd UMg UMhi UMn UMpo UMpu
SEAWARD 1978	ANGLETERRE, ECOSSE, SE IRELANDE	is	Cr Co Cu Fe Mn Ni Pb Zn	Cfu Cpo Cu CORa CORm PEc PEr
SEMADI 1989, 1993	ALGERIE, Annaba	T	Pb	Rd Rfar
SHERIDAN 1979		I	Pb	COt LE
SHIMWELL 1972	ANGLETERRE, Yorkshire et Derbyshire	is	Pb Zn	CORm PEc
SHOWMAN 1989	USA, Ohio River, Ohio/W Virginie	is	As Ce Cr Cu Co Fe La Ti V Zn	FPc
SHOWMAN 1992	USA, Pennsylvanie	is	Al Cd Cr Cu Fe Ni Pb Zn	Hp
SIEGEL 1976	MONTENEGRO	is	Hg	C CO HA US
SIEGEL 1968		I	^{60}Co Li	Cra
SIEGEL 1975	HAWAI, ISLANDE, N AMERIQUE	is	Hg	C HA P ST US
SIGAL 1986	USA, Tennessee, Oak Ridge Park	is,I	Al Fe	UMma
SKACEL 1992	TCHECOSLOVAQUIE, C Bassin Rivière Zelivka	is	Cd Hg Pb	Hp
SLOOF 1995a	NL	T	Co Sc Zn	Psu
SLOOF 1995b	NL	is	Al As Br Cd Co Cr Cs Fe Hg La Mn Ni Pb Sb Sc Se Th V W Zn	Psu
SLOOF 1993a	De Kempen, C frontière B/NL	is	As Br Cd Co Cr Cu Fe Lu Sb Se V W Zn	Lco Psu
SLOOF 1993b	NL, Rotterdam, Broekpoler	is	As Cd Co Cr Cu Fe Hg Mn Sc V Zn	Lco
SLOOF 1991a	NL	is	As Br Cd Cr Cs Fe Hg La Ni Pb Se V W Zn	Psu
SLOOF 1991b	NL	is	Al As Br Cd Co Cr Cs Fe Hg La Mn Ni Pb Sb Sc Se Th V W Zn	Psu
SOLBERG 1967	S NORV	is	B Mn	Ai Aj An Ao As ANf Cal Cb Cde Cgr Cmi Cpl Cra Cste Csy Cu CEd CEi CEn CORd Ep GYc GYh HAv LOp LOs Ot Pal Pce Pe Pfur Pph Pste PARa Rfr Rp Rsi Slc
SOLBERG 1978	NORV	is	Hg	A Ac Af An Ao As Cal Cde Cgo Cmi Cra CEcu CEd CEi CORd Ep Psa PEc PSf Rsi SPf STe STpa UMhi UMpu UMs US
ST CLAIR 1990	USA, Utah Valley	is	Pb	RHPm
STEINNES 1977	S NORV, Sarpsborg	T	As Hg Se	Hp
STONE 1995	26 pays N.D.	is	Al As Ba Br Cd Ce Co Cr Cs Cu Eu Fe Hg La Mn Pb Rb Sb Sc Se Sm Sr Th U V Zn	Ep

AUTEUR(S)	SITE(S)	TYPE(S)	ELEMENT(S)	ESPECE(S)
STUBBS 1990	USA, Maine	is	Al B Cu Fe Mn Pb Zn	Hp PLg USs
TAKALA 1976	CE FIN, Kuopio	is	Pb	PSf
TAKALA 1981	CE FIN, Kuopio	is	Pb	Hp
TAKALA 1985	FIN	is	Ti	A B C Hp Nar PEa PSf ST
TAKALA 1994	FIN	is	Fe Ti	A B C Hp Nar PEa PSf
THOMAS R.S. 1995	USA, Colorado, Rocky Flats Plant	is	^{238}Pu $^{239+240}Pu$ Ti	XP
THOMAS W. 1984	SO SUEDE, Stenungsund	is	Cd Cu Pb V Zn	Cra
THOMAS W. 1985	SO SUEDE, Kolhätten	is	Cd Cr Cu Ni Pb V Zn	Cra
THOMPSON 1987	USA, SO Louisiane	is	Ce Co Cr Eu Fe Hg Ir Sb Sc Se Ta Th Zn	Ppr Rst
TOMASSINI 1976	CAN, Territoires NW et Ontario	is	Cu Fe Ni	Ao Cal Cam Cde Cgr Cmi Cpl Cra Cu CEcu CEi CEl CEn CEr COR DAa Nar PEa PEpo STpa STt THv UMd UMv
TUOMINEN 1967		I	Cs Sr	Ai Aj Cal Car Cra Cu CEi PSf STpa UMd USc+USd
TUOMINEN 1971		I	^{137}Cs Sr ^{90}Sr	Cal
TYLER 1972	C SUEDE, Finspang	is	Cd Cu Ni Zn	Pph
UPRETI 1994	E ANTARCTIQUE	is	Cr Cu Fe Pb	UMap UMde
VAN DEN BERG 1992	UKRAINE, autour de Tchernobyl	is	^{137}Cs Pb	Psu
VESTERGAARD 1986	E DK, Frederiksvaerk	is	Cd Cr Cu Fe Mn Pb Zn	Hp
WAINWRIGHT 1975		I	Zn	USfl
WALTHER 1990a	USA, SE Louisiane, Baton Rouge	is	Al Cu Fe Zn Pb	PAp Rst
WALTHER 1990b	USA, SO Louisiane	is	Al Cd Cr Cu Fe Hg Pb Zn	PAp Rst
WARREN 1955	NO CAN	is	Cu Zn	CORa
WELLS 1995		I	Cd	PEm
WIERSMA 1992	S CHILI, Torres del Paine, Nat. Park	is	Al Cd Cu Pb Zn	Nan
WIETSCHORKE 1990		I	Pb	Hp
WILLIAMS 1974		I	Fe	Ccr Csq CAh Ld
WILSON 1984	NE ECOSSE, Banffshire, Lecht Mines	is	Mn	PERc
YLIRUOKANEN 1975	FIN	is	Ce Dy Er Eu Gd Ho La Lu Nd Pb Pr Sm Tb Th Tm U Y Yb	Cal Car CEi
ZAKSHEK 1986	E CAN	is	Pb	Cra

Tableau 2 : Légende des sites et des espèces du Tableau 1

N.D. = Non Déterminé

SITE:
- N = Nord
- S = Sud
- E = Est
- O = Ouest
- C = Centre

- Mt = Mont, Montagne

- B = Belgique
- GB = Grande-Bretagne
- CAN = Canada
- CH = Suisse
- DK = Danmark
- F = France
- FIN = Finlande
- I = Italie
- NL = Pays-Bas
- NORV = Norvège
- PdG = Pays de Galles

ESPECES:

- A *Alectoria* spp
- Ac *A. capillaris*
- Af *A. fremontii*
- Ai *A. implexa*
- Aj *A. jubata*
- An *A. nigricans*
- Ao *A. ochroleuca*
- Ap *A. pubescens*
- As *A. sarmentosa*

- ACc *Acarospora chlorophana*
- ACr *A. rugulosa*
- ACsm *A. smaragdula*
- ACst *A. strigata*

- ANc *Anaptychia ciliaris*
- ANf *A. fusca*

- ASa *Aspicilia alpina*

- B *Bryoria* spp
- Bfr *B. fremontii*
- Bfu *B. fuscescens*
- Bl *B. lanestris*

- C *Cladonia/Cladina* spp
- Cal *C. alpestris*
- Cam *C. amaurocraea*
- Car *C. arbuscula*
- Cb *C. bellidiflora*
- Cca *C. capitata*
- Cch *C. chlorophaea*
- Ccon *C. convoluta*
- Ccor *C. cornutoradiata*
- Ccr *C. cristatella*
- Cde *C. deformis*
- Cdi *C. digitata*
- Cfi *C. fimbriata*
- Cfu *C. furcata*
- Cgo *C. gonecha*
- Cgr *C. gracilis*
- Cma *C. macilenta*
- Cmi *C. mitis*
- Cpl *C. pleurota*
- Cpo *C. portentosa* (= *C. impexa*)
- Cpy *C. pyxidata*
- Cr *C. rangiformis*
- Crà *C. rangiferina*
- Cre *C. retipora*
- Csc *C. subcariosa*
- Csq *C. squamosa*
- Cst *C. subtenuis*
- Cste *C. stellaris*
- Cstr *C. strepsilis*
- Csu *C. subulata*
- Csy *C. sylvatica*
- Cte *C. tenuis*
- Ctu *C. turgida*
- Cu *C. uncialis*
- Cv *C. verticillata*

- Caa *Caloplaca aurentia*
- CAc *C. callopisma*
- CAeh *C. ehrenbergii*
- CAel *C. elegans*
- CAh *C. holocarpa*
- CAt *C. trachyphylla*

- CANs *Candellariella spraguei*

- CEcr *Cetraria crispa*
- CEcu *C. cucullata*
- CEd *C. delesii*
- CEi *C. islandica*
- CEl *C. laevigata*
- CEn *C. nivalis*
- CEr *C. richardsonii*
- CEt *C. tilesii*

- CENg *Cenomyce gracilis*

- COt *Collema tenax*

- COEa *Coelocaulon aculeatum*

- COR *Cornicularia* spp
- CORa *C. aculeata*
- CORd *C. divergens*
- CORm *C. muricata*

- Dm *Dermatocarpon miniatum*
- Dw *D. weberi*

- DAa *Dactylina arctica*

- Dlo *Diploschistes ocellatus*
- Dlsc *D. scruposus*
- Dlst *D. steppicus*

- Em *Evernia mesomorpha*
- Ep *E. prunastri*

- FPb *Flavoparmelia baltimorensis*
- FPc *F. caperata*

- GAe *Gasparrinia elegans*

- GRs *Graphis scripta*

- GYc *Gyrophora cirrhosa*
- GYh *G. hyperborea*

- He *Hypogymnia enteromorpha*
- Hi *H. intestiniformis*
- Hp *H. physodes*

- HA *Haematoma* spp
- HAv *H. ventosum*

- La *Lecanora alphoplaca*
- Lca *L. cascadensis*
- Lco *L. conizaeoides*
- Ld *L. dispersa*
- Lf *L. frustulosa*
- Lm *L. melanophthalma*
- Ln *L. novomexicana*
- Lp *L. polycarpa*
- Lr *L. rubina*
- Ls *L. subfusca*

- LApa *Lasallia papulosa*
- LApe *L. pensylvanica*
- LApu *L. pustulata*

- LE *Lecidea* spp
- LEa *L. atrobrunnea*
- LEb *L. bullata*
- LEc *L. cascadensis*
- LEd *L. dicksonii*
- LEi *L. inops*
- LEla *L. lactea*
- LEli *L. limitata*
- LElu *L. luridella*
- LEm *L. macrocarpa*

- LETc *Letharia columbiana*
- LETv *L. vulpina*

- LIc *Lichina confinis*
- LIp *L. pygmaea*

- LOo *Lobaria oregana*
- LOp *L. pulmonaria*
- LOs *L. scrobiculata*

- Mt *Micarea trisepta*

- Nan *Nephroma antarcticum*
- Nar *N. arcticum*
- Nl *N. laevigatum*

- Of *Ochrolechia frigida*
- Ot *O. tartarea*

- P *Parmelia* spp
- Pac *P. acetabulum*
- Pal *P. alpicola*
- Pb *P. borreri*
- Pca *P. caperata*

Pce	*P. centrifuga*
Pch	*P. chlorochroa*
Pcl	*P. clavulifera*
Pco	*P. conspersa*
Pe	*P. encausta*
Pex	*P. exasperatula*
Pful	*P. fuliginosa*
Pfur	*P. furfuraceae*
Pg	*P. glabratula*
Pi	*P. intestiformis*
Pm	*P. molliuscula*
Pol	*P. olivacea*
Pom	*P. omphalodes*
Ppa	*P. pastillifera*
Ppe	*P. perlata*
Pph	*P. physodes*
Ppli	*P. plittii*
Pplu	*P. plumbea*
Ppr	*P. praesorediosa*
Ppro	*P. prolixa*
Pr	*P. rudecta*
Psa	*P. saxatilis*
Pste	*P. stenophylla*
Psty	*P. stygia*
Psu	*P. sulcata*
Psub	*P. subrudecta*
Pta	*P. taractica*
Pti	*P. tinctorum*
PAa	*Parmotrema austrosinesis*
PAh	*P. hababiana*
PAp	*P. praesorediosum*
PAt	*P. tinctorum*
PARa	*Parmeliopsis ambigua*
PBt	*Protoblastemia testacea*
PEa	*Peltigera aphthosa*
PEc	*P. canina*
PEe	*P. elizabethae*
PEho	*P. horizontalis*
PEhy	*P. hymenina*
PEm	*P. membranacea*
PEpo	*P. polydactyla*
PEpr	*P. praetextata*
PEr	*P. rufescens*
PEs	*P. spuria*
PERc	*Pertusaria corallina*
PHa	*Physcia adscendens*
PHb	*P. biziana*
PHt	*P. tenella*
PHYg	*Physconia grisea*
PLg	*Platismatia glauca*
PLAg	*Platysma glaucum*
PPo	*Phaeophyscia orbicularis*
PSf	*Pseudevernia furfuracea*
PSPb	*Pseudoparmelia baltimorensis*
PUr	*Punctelia reddenda*
PUs	*P. subrudecta*
Rd	*Ramalina duriaei*
Rfar	*R. farinacea*
Rfas	*R. fastigiata*
Rfr	*R. fraxinea*
Rma	*R. maciformis*
Rme	*R. menziesii*
Rp	*R. populina*
Rr	*R. reticulata*
Rsi	*R. siliquosa*
Rst	*R. stenospora*
RHCg	*Rhizocarpon geographicum*
RHPm	*Rhizoplaca melanophthalma*
RO	*Roccella* spp
ROp	*R. phycopsis*
Sc	*Sticta canariensis*
Sl	*S. limbata*
Ss	*S. sylvatica*
Slc	*Siphula ceratites*
SPf	*Sphaerophorus fragilis*
SPg	*S. globosus*
SQc	*Squamarina crassa*
SQo	*S. oleosa*
ST	*Stereocaulon* spp
STa	*S. alpinum*
STd	*S. dactylophyllum*
STe	*S. evolutum*
STn	*S. nanodes*
STpa	*S. paschale*
STpi	*S. pileatum*
STs	*S. saxatile*
STt	*S. tomentosum*
STve	*S. vesuvianum*
STvu	*S. vulcani*
Te	*Trypethelium eluteriae*
TEPt	*Tephromela testaceoatra*
TELl	*Teloschistes lacunosus*
THs	*Thamnolia subuliformis*
THv	*T. vermicularis*
TRa	*Trebouxia anticipata* (algue de Ccr)
TRe	*T. erici* (algue de Pca)
UM	*Umbilicaria* spp
UMap	*U. aprina*
UMar	*U. arctica*
UMc	*U. cylindrica*
UMd	*U. deusta*
UMde	*U. decussata*
UMg	*U. grisea* (= *U. murina*)
UMhi	*U. hirsuta*
UMhy	*U. hyperborea*
UMle	*U. Leiocarpa*
UMly	*U. lyngei*
UMma	*U. mammulata*
UMmu	*U. muhlenbergii*
UMn	*U. nylanderiana*
UMpa	*U. pappulosa*
UMph	*U. phaea*
UMpo	*U. polyphylla*
UMpu	*U. pustulata*
UMs	*U. spodochroa*
UMv	*U. vellea*
US	*Usnea* spp
USa	*U. antarctica*
USb	*U. barbata*
USd	*U. dasypoga*
USfi	*U. filipendula*
USfl	*U. florida*
USh	*U. hirta*
USl	*U. longissima*
USs	*U. subfloridana*
Vma	*Verrucaria maurica*
Vmu	*V. mucosa*
Vn	*V. nigrescens*
X	*Xanthoria* spp
Xpa	*X. parietina*
Xpo	*X. polycarpa*
XP	*Xanthoparmelia* spp
XPc	*X. conspersa*

REFERENCES BIBLIOGRAPHIQUES

ADDISON P.A. & PUCKETT K.J., 1980. Deposition of atmospheric pollutants as measured by lichen element content in the Athabasca oil sands area. Canadian Journal of Botany 58, 2323-2334.

ALLAN C.J. & ROULET N.T., 1994. Solid phase controls of dissolved aluminum within upland Precambrian shield catchments. Biogeochemistry 26, 85-114.

ALSTRUP V. & HANSEN E.S., 1977. Three species of lichens tolerant of light concentrations of copper. Oikos 29, 290-293.

AMMANN K., HERZIG R., LIEBENDÖRFER L. & URECH M., 1987. Multivariate correlation of deposition data of 8 different air pollutants to lichen data in a small town in Switzerland. Advances in Aerobiology 401-406.

ANDERSEN A., HOVMAND M.F. & JOHNSEN I., 1978. Atmospheric heavy metal deposition in the Copenhagen area. Environmental Pollution 17, 133-151.

ASCASO C. & GALVAN J., 1976a. Studies on the pedogenetic action of lichen acids. Pedobiologia 16, 321-331.

ASCASO C., GALVAN J. & ORTEGA C., 1976b. The pedogenic action of *Parmelia conspersa*, *Rhizocarpon geographicum* and *Umbilicaria pustulata*. Lichenologist 8, 151-171.

ASCASO C., GALVAN J. & RODRIGUEZ-PASCUAL C., 1982. The weathering of calcareous rocks by lichens. Pedobiologia 24, 219-229.

BARGAGLI R., 1989a. Determination of metal deposition patterns by epiphytic lichens. Toxicological and Environmental Chemistry 18, 249-256.

BARGAGLI R., 1990. Assessment of metal air pollution by epiphytic lichens: the incidence of crustal materials and of the possible uptake from substrate barks. Studia Geobotanica 10, 97-103.

BARGAGLI R. & BARGHIGIANI C., 1991. Lichen biomonitoring of mercury emission and deposition in mining, geothermal and volcanic areas of Italy. Environmental Monitoring and Assessment 16, 265-275.

BARGAGLI R., BARGHIGIANI C. & MASERTI B.E., 1986. Mercury in vegetation of the Mount Amiata area (Italy). Chemosphere 15, 8, 1035-1042.

BARGAGLI R., BARGHIGIANI C., SIEGEL B.Z. & SIEGEL S.M., 1989b. Accumulation of mercury and other metals by the lichen, *Parmelia sulcata*, at an italian minesite and a volcanic area. Water, Air, and Soil Pollution 45, 315-327.

BARGAGLI R., BATTISTI E., FOCARDI S. & FORMICHI P., 1993. Preliminary data on environmental distribution of mercury in northern Victoria Land, Antarctica. Antarctic Science 5, 1, 3-8.

BARGAGLI R., D'AMATO M.L. & IOSCO F.P., 1987a. Lichen biomonitoring of metals in the San Rossore Park: contrast with previous pine needle data. Environmental Monitoring and Assessment 9, 285-294.

BARGAGLI R., IOSCO F.P. & BARGHIGIANI C., 1987b. Assessment of mercury dispersal in an abandoned mining area by soil and lichen analysis. Water, Air, and Soil Pollution 36, 219-225.

BARGAGLI R., IOSCO F.P. & D'AMATO M.L., 1987c. Zonation of trace metal accumulation in three species of epiphytic lichens belonging to the genus *Parmelia*. Cryptogamie, Bryologie et Lichenologie 8, 4, 331-337.

BARGHIGIANI C., BARGAGLI R. & GIOFFRE D., 1988a. Mercury in the environment of the Mt. Etna volcanic area. Environmental Technology Letters 9, 239-244.

BARGHIGIANI C., BARGAGLI R., SIEGEL B. & SIEGEL S., 1988b. Source and selectivity in the accumulation of mercury and other metals by the plants of Mt. Etna. Water, Air, and Soil Pollution 39, 395-408.

BARGHIGIANI C., BARGAGLI R., SIEGEL B.Z. & SIEGEL S.M., 1990. A comparative study of mercury distribution on the aeolian volcanoes, Vulcano and Stromboli. Water, Air, and Soil Pollution 53, 179-188.

BARGHIGIANI C., SIEGEL B.Z., BARGAGLI R. & SIEGEL S.M., 1989. The contribution of mercury from thermal springs to the environmental contamination of Mt. Amiata. Water, Air, and Soil Pollution 43, 169-175.

BARTOK K., 1988. Heavy metal distribution in several lichen species in a polluted area. Revue Roumaine de Biologie - Biologie Végétale 33, 2, 127-134.

BARTOK K., NICOARA A., BERCEA V. & OSVATH T., 1992. Biological responses in the lichen *Xanthoria parietina* transplanted in biomonitoring stations. Revue Roumaine de Biologie - Biologie Végétale 37, 2, 135-142.

BECK J.N. & RAMELOW G.J., 1990. Use of lichen biomass to monitor dissolved metals in natural waters. Bulletin of Environmental Contamination and Toxicology 44, 2, 302-308.

BECKETT P.J., BOILEAU L.J.R., PADOVAN D., RICHARDSON D.H.S. & NIEBOER E., 1982. Lichens and mosses as monitors of industrial activity associated with uranium mining in northern Ontario, Canada - Part 2: Distance dependent uranium and lead accumulation patterns. Environmental Pollution (Series B) 4, 91-107.

BECKETT R.P. & BROWN D.H., 1983. Natural and experimentally-induced zinc and copper resistance in the lichen genus *Peltigera*. Annals of Botany 52, 43-50.

BECKETT R.P. & BROWN D.H., 1984a. The control of cadmium uptake in the lichen genus *Peltigera*. Journal of Experimental Botany 35, 156, 1071-1082.

BECKETT R.P. & BROWN D.H., 1984b. The relationship between cadmium uptake and heavy metal tolerance in the lichen genus *Peltigera*. The New Phytologist 97, 301-311.

BELLEMERE A.. Bulletin de l'Association Française de Lichénologie. Informations lichénologiques - Nouvelles récentes 1990 (15, 1, 17-23). Eléments de bibliographie 1990 (15, 2, 15-20). Eléments de bibliographie récente 1991 (16, 1, 27-36 et 16, 2, 53-63). Eléments de bibliographie lichénologique récente 1992 (17, 1, 39-50 et 17, 2, 42-52), 1993 (18, 1, 47-54), 1994 ("1993" 18, 2, 37-50), 1994 (19, 1, 33-46), 1995 (20, 1, 29-45).

BERTRAND D., 1954. Recherches sur le lithium chez les cryptogames. Bulletin de la Société de Chimie Biologique. 36, 6-7, 907-909.

BERTRAND G. & BERTRAND D., 1947. Recherches sur le rubidium chez les cryptogames. Annales de l'Institut Pasteur 73, 797-803.

BIAZROV L.G. & ADAMOVA L.I., 1993. The toxic metals in lichens of trans-polar Europe. In: International Nordic Symposium on Chemicals in the Arctic-Boreal Environment (M. Luotola & E. Nurmi, eds), May 12-14, 1993, Helsinki, Finland, p 57.

BIAZROV L.G. & ADAMOVA L.I., 1995. The estimation of some trace and toxic elements behaviour in Moscow city with help of lichens. In: Contaminated Soils, 3rd International Conference on the Biogeochemistry of Trace Elements, 15-19 May 1995, Paris, France, C2.

BOILEAU L.J.R., BECKETT P.J., LAVOIE P., RICHARDSON D.H.S. & NIEBOER E., 1982. Lichens and mosses as monitors of industrial activity associated with uranium mining in northern Ontario, Canada - Part 1: Field procedures, chemical analysis and interspecies comparisons. Environmental Pollution (Series B) 4, 69-84.

BOONPRAGOB K. & NASH III T.H., 1990. Seasonal variation of elemental status in the lichen *Ramalina menziesii* Tayl. from two sites in southern California: evidence for dry deposition accumulation. Environmental and Experimental Botany 30, 4, 415-428.

BOONPRAGOB K. & NASH III T.H., 1991. Physiological responses of the lichen *Ramalina menziesii* Tayl. to the Los Angeles urban environment. Environmental and Experimental Botany 31, 2, 229-238.

BRANQUINHO C. & BROWN D.H., 1994. A method for studying the cellular location of lead in lichens. The Lichenologist 26, 1, 83-90.

BRIGHTMAN F.H. & SEAWARD M.R.D., 1977. Lichens on man-made substrates. In: Lichen Ecology (M.R.D. Seaward, ed.), London & New-York, Academic Press, 253-293.

BROWN D.H., 1973. The lichen flora of the lead mines at Charterhouse, Mendip Hills. Proceedings of the Bristol Naturalists' Society 32, 267-274.

BROWN D.H., 1976. Mineral uptake by lichens. In: Lichenology: Progress and Problems (D.H. Brown, D.L. Hawksworth & R.H. Bailey, eds), Academic Press, London and New-York, 419-439.

BROWN D.H. & AVALOS A., 1993. The role of calcium in intracellular cadmium uptake by the lichen *Peltigera membranacea*. Annals of Botany 71, 467-473.

BROWN D.H. & BECKETT R.P., 1983. Differential sensitivity of lichens to heavy metals. Annals of Botany 52, 51-57.

BROWN D.H. & BECKETT R.P., 1984. Uptake and effect of cations on lichen metabolism. The Lichenologist 16, 2, 173-188.

BROWN D.H. & BUCK G.W., 1985. The cellular location of metals in two bryophytes and a lichen. Cryptogamie, Bryologie et Lichénologie 6, 3, 279-286.

BROWN D.H. & SLINGSBY D.R., 1972. The cellular location of lead and potassium in the lichen *Cladonia rangiformis* (L.) Hoffm. The New Phytologist 71, 297-305.

BURGUERA J.L., BURGUERA M. & BELANDRIA M.G., 1989. The amounts of lead in roadside soil and some lichen species and their correlation with motor vehicles traffic volume. International Conference on Heavy Metals in the Environment (J.P. Vernet, ed.), Geneva, sept. 1989, vol.2, 460-463.

BURKITT A., LESTER P. & NICKLESS G., 1972. Distribution of heavy metals in the vicinity of an industrial complex. Nature 238, 327-328.

BURTON M.A.S., LESUEUR P. & PUCKETT K.J., 1981. Copper, nickel and thallium uptake by the lichen *Cladonia rangiferina*. Canadian Journal of Botany 59, 91-100.

BYLINSKA E.A., MARCZONEK A. & SEAWARD M.R.D., 1992. Mercury accumulation in varous components of a forest influenced by factory emissions. In: Urban Ecology (M.A. Ozturk, U. Erdem & G. GOEK, eds), Ege University Press, Izmir, 41-61.

CALLIARI I., CANAGLIA G., NARDI S., TOLLARDO A.M. & CALLEGARO R., 1995. EDXRS study of lichens as biomonitors and effect of washing procedure on element concentrations. X-Ray Spectrometry 24, 143-146.

CAMPBELL J.A., 1976. A mathematical treatment of the variation of heavy-metal content of lichens with distance from a source. The Lichenologist 8, 83-86.

CHISHOLM J.E., JONES G.C. & PURVIS O.W., 1987. Hydrated copper oxalate, moolooite, in lichens. Mineralogical Magazine 51, 715-718.

CONNOR M., DEMPSEY E., SMYTH M.R. & RICHARDSON D.H.S., 1991. Determination of some metal ions using lichen-modified carbon paste electrodes . Electroanalysis 3, 331-336.

CRETE M., LEFEBVRE M.A., ZIKOVSKY L. & WALSH P., 1992. Cadmium, lead, mercury and 137cesium in fruticose lichens of nothern Québec. The Science of the Total Environment 121, 217-230.

CROWDER A., 1991. Acidification, metals and macrophytes. Environmental Pollution 71, 171-203.

CULBERSON W.L., 1951 - 1978. Recent literature on lichens. The Bryologist.

CZEHURA S.J., 1977. A lichen indicator of copper mineralization, Lights Creek District, Plumas County, California. Economic Geology 72, 796-803.

DAILLANT O. & JACQUIOT L., 1995. Observation de la qualité de l'air par les lichens à Mâcon. Terre Vive 97, 1-16.

DE BRUIN M., 1990. Applying biological monitors and neutron activation analysis in studies of heavy-metal air pollution. IAEA Bulletin, 4/1990, 22-27.

DE BRUIN M. & HACKENITZ E., 1986. Trace element concentrations in epiphytic lichens and bark substrate. Environmental Pollution 11, 153-160.

DE BRUIN M. & SLOOF J.E., 1987a. Some aspects of the use of epiphytic lichens as biological monitors for heavy metal air pollution. In: Proceedings of the 6th International Conference on Heavy Metals in the Environment, New Orleans, 15-17 sept. 1987, 4p.

DE BRUIN M. & VAN WIJK P.M., 1988. Trace-element patterns obtained by INAA as a basis for source identification. Journal of Radioanalytical and Nuclear Chemistry, Articles, 123, 1, 227-238.

DE BRUIN M., VAN WIJK P.M., VAN ASSEMA R. & ROOS C., 1987b. The use of multi-element concentration datasets obtained by INAA in the identification of sources of environmental pollutants. Journal of Radioanalytical and Nuclear Chemistry, Articles, 112, 1, 199-213.

DE BRUIN M. & WOLTERBEEK H.Th., 1984. Identification of sources of heavy metals in the Dutch atmosphere using air filter and lichen analysis. In: Proceedings of the 5th International Conference on Nuclear Methods in Environmental and Energy Research, Puerto Rico, April 1984, 266-276.

DEMPSEY E., SMYTH M.R. & RICHARDSON D.H.S., 1992. Application of lichen-modified carbon paste electrodes to the voltammetric determination of metal ions in multi-element and speciation studies. Analyst 117, 1467-1470.

DERUELLE S., 1983a. Ecologie des lichens du Bassin Parisien: impact de la pollution atmosphérique (engrais, SO2, Pb) et relations avec les facteurs climatiques. Thèse, Université Pierre et Marie Curie, Paris, 360 p. + annexe 202 p.

DERUELLE S., 1984. L'utilisation des lichens pour la détection et l'estimation de la pollution par le plomb. Bulletin d'Ecologie 15, 1-6.

DERUELLE S., 1992. Accumulation du plomb par les lichens. Bulletin de la Société botanique de France, Actualités botaniques, 139, 1, 99-109.

DERUELLE S., 1995. La fiabilité des lichens comme bioindicateurs de la pollution plombique. In: Colloque International sur les Marqueurs Biologiques de Pollution, Chinon, France, 21-22 Sept. 1995, 271-280.

DERUELLE S. & GUILLOUX F., 1994. Réhabilitation in situ des sols pollués par le plomb. Estimation des retombées plombiques autour d'une source d'émission en utilisant les lichens comme bioindicateurs. Rapport du contrat de Recherches 91-124. Ministère de l'environnement, 48p.

DERUELLE S. & PETIT P.J.X., 1983b. Preliminary studies on the net photosynthesis and respiration responses of some lichens to automobile pollution. Cryptogamie, Bryologie et Lichénologie 4, 3, 269-278.

DOYLE P., FLETCHER W.K. & BRINK V.C., 1973. Trace element content of soils and plants from the Selwyn Mountains, Yukon and Northwest Territories. Canadian Journal of Botany 51, 421-427.

DYKEMAN W.R. & DE SOUSA A.S., 1966. Natural mechanisms of copper tolerance in a copper swamp forest. Canadian Journal of Botany 44, 871-878.

EGAN R.S., 1979 - 1991. Recent literature on lichens. The Bryologist.

ERÄMETSÄ O. & YLIRUOKANEN I., 1971a. The rare earths in lichens and mosses. Suomen Kemistilehti B 44, 4, 121-128.

ERÄMETSÄ O. & YLIRUOKANEN I., 1971b. Niobium, molybdenum, hafnium, tungsten, thorium and uranium in lichens and mosses. Suomen Kemistilehti B 44, 4, 121-128.

ERDMAN J.A. & GOUGH L.P., 1977. Variation in the element content of *Parmelia chlorochroa* from the Powder River Basin of Wyoming and Montana. The Bryologist 80, 292-303.

ESSLINGER T.L., 1991 - 1994. Recent literature on lichens. The Bryologist.

FARKAS E., LOKÖS L. & VERSEGHY K., 1985. Lichens as indicators of air pollution in the Budapest agglomeration. I. Air pollution map based on floristic data and heavy metal concentration measurements. Acta Botanica Hungarica 31, 1-4, 45-68.

FARKAS E. & PATKAI T., 1989. Lichens as indicators of air pollution in the Budapest agglomeration. II. Energy dispersive X-ray microanalysis of *Hypogymnia physodes* (L.) Nyl. thalli. Acta Botanica Hungarica 35, 1-4, 55-71.

FLETCHER A., 1976. Nutritional aspects of marine and maritime lichen ecology. In: Lichenology: Progress and Problems (D.H. Brown, D.L. Hawksworth & R.H. Bailey, eds), Academic Press, London and New-York, 359-384..

FLORA C.J. & NIEBOER E., 1980. Determination of nickel by differential pulse polarography at a dropping mercury electrode. Analytical Chemistry 52, 1013-1020.

FOLKESON L., 1979. Interspecies calibration of heavy metal concentrations in nine mosses and lichens: applicability to deposition measurements. Water, Air, and Soil Pollution 11, 253-260.

FOLKESON L., 1981. Impact of air-borne copper and zinc pollution on lichen and bryophyte vegetation near a brass foundry. Silva Fennica 15, 4, 446-449.

FOLKESON L., 1984. Deterioration of the moss and lichen vegetation in a forest polluted by heavy metals. Ambio 13, 1, 37-39.

FOLKESON L. & ANDERSSON-BRINGMARK E., 1988. Impoverishement of vegetation in a coniferous forest polluted by copper and zinc. Canadian Journal of Botany 66, 3, 417-428.

FREITAS M.C., 1993a. Element concentrations in candidate biological and environmental reference materials by Ko-standardized INAA. Fresenius' Journal of Analytical Chemistry 345, 304-307.

FREITAS M.C., 1995. Elemental bioaccumulators in air pollution studies. Journal of Radioanalytical and Nuclear Chemistry, Articles, 192, 2, 171-181.

FREITAS M.C., CATARINO F.M., BRANQUINHO C. & MAGUAS C., 1993b. Preparation of a lichen reference material. Journal of Radioanalytical and Nuclear Chemistry, Articles, 169, 1, 47-55.

FREITAS M.C., DE CORTE F., GOUVEIA M.A., PRUDENCIO M.I. & CABRAL J.M.P., 1993c. Determination of the Ree in environmental samples near a coal power station based on ko-standardized NAA with counting in a LEPD. Journal of Radioanalytical and Nuclear Chemistry, Articles, 169, 1, 219-228.

FRENZEL R.W., WITMER G.W. & STARKEY E.E., 1990. Heavy metal concentrations in a lichen of Mt. Rainier and Olympic National Parks, Washington, USA. Bulletin of Environmental Contamination and Toxicology 44, 1, 158-164.

FUCHS C. & GARTY J., 1983. Elemental content in the lichen *Ramalina duriaei* (De Not.) Jatta at air quality biomonitoring stations. Environmental and Experimental Botany 23, 1, 29-43.

GAILEY F.A.Y. & LLOYD O.L., 1986a. Methodological investigations into low technology monitoring of atmospheric metal pollution: Part 1 - The effects of sampler size on metal concentrations. Environmental Pollution (Series B) 12, 41-69.

GAILEY F.A.Y. & LLOYD O.L., 1986b. Methodological investigations into low technology monitoring of atmospheric metal pollution: Part 2 - The effects of length of exposure on metal concentrations. Environmental Pollution (Series B) 12, 61-74.

GAILEY F.A.Y. & LLOYD O.L., 1986c. Methodological investigations into low technology monitoring of atmospheric metal pollution: Part 3 - The degree of replicability of the metal concentrations. Environmental Pollution (Series B) 12, 85-109.

GAILEY F.A.Y. & LLOYD O.L., 1993. Spatial and temporal patterns of airborne metal pollution: the value of low technology sampling to an environmental epidemiology study. The Science of the Total Environment 133, 201-219.

GALUN M., GARTY J. & RONEN R., 1984. Lichens as biomonitors of air pollution. Webbia 38, 371-383.

GARTY J., 1985a. The amounts of heavy metals in some lichens of the Negev Desert. Environmental Pollution (Series B) 10, 287-300.

GARTY J., 1987a. Metal amounts in the lichen *Ramalina duriaei* (De Not.) Bagl. transplanted at biomonitoring sites around a new coal-fired power station after 1 year of operation. Environmental Research 43, 1, 104-116.

GARTY J., 1988a. Comparisons between the metal content of a transplanted lichen before and after the start-up of a coal power station in Israel. Canadian Journal of Botany 66, 668-671.

GARTY J., 1993a. Biomonitoring terrestrial heavy metal pollution by plants. A. Lichens. In: Plants as Biomonitors Indicators for Heavy Metals in the Terrestrial Environment (B. Markert, ed.), VCH Weinheim, pp 193-263.

GARTY J. & AMMANN K., 1987b. The amounts of NI, Cr, Zn, Pb, Cu, Fe, and Mn some lichens growing in Switzerland. Environmental and Experiemntal Botany 27, 2, 127-138.

GARTY J. & DELAREA J., 1991. Localization of iron and other elements in the lichen *Nephroma arcticum* (L.) Torss. Environmental and Experimental Botany 31, 3, 367-375.

GARTY J. & FUCHS C., 1982. Heavy metals in the lichen *Ramalina duriaei* transplanted in biomonitoring stations. Water, Air, and Soil Pollution 17, 175-183.

GARTY J., GALUN M., FUCHS C. & ZISAPEL, 1977. Heavy metals in the lichen *Caloplaca aurantia* from urban, suburban and rural regions in Israel (a comparative study). Water, Air, and Soil Pollution 8, 171-188.

GARTY J., GALUN M. & HOCHBERG Y., 1986. The accumulation of metals in *Caloplaca aurantia* growing on concrete roof tiles. The Lichenologist 18, 3 257-263.

GARTY J., GALUN M. & KESSEL M., 1979. Localization of heavy metals and other elements accumulated in the lichen thallus. The New Phytologist 82, 159-168.

GARTY J. & HAGEMEYER J., 1988b. Heavy metals in the lichen *Ramalina duriaei* transplanted at biomonitoring stations in the region of a coal-fired power plant in Israel after 3 years of operation. Water, Air, and Soil Pollution 38, 311-323.

GARTY J., KARARY Y. & HAREL J., 1992. Effect of low pH, heavy metals and anions on chlorophyll degradation in the lichen *Ramalina duriaei* (De Not.) Bagl. Environmental and Experimental Botany 32, 3, 229-241.

GARTY J., KARARY Y., HAREL J. & LURIE S., 1993b. Temporal and spatial fluctuations of ethylene production and concentrations of sulphur, sodium, chlorine and iron on/in the thallus cortex in the lichen *Ramalina duriaei* (De Not.) Bagl. Environmental and Experimental Botany 33, 4, 553-563.

GARTY J., KARDISH N., HAGEMEYER J. & RONEN R., 1988c. Correlations between the concentration of adenosine tri phosphate, chlorophyll degradation and the amounts of airborne heavy metals and sulphur in a transplanted lichen. Archives of Environmental Contamination and Toxicology 17, 5, 601-611.

GARTY J., RONEN R. & GALUN M., 1985b. Correlation between chlorophyll degradation and the amount of some elements in the lichen *Ramalina duriaei* (De Not.) Jatta. Environmental and Experimental Botany 25, 1, 67-74.

GARTY J. & THEISS H.B., 1990. The localization of lead in the lichen *Ramalina duriaei* (De Not.) Bagl. Botanica Acta 103, 311-314.

GARTY J., ZIV O. & ESHEL A., 1985c. The effect of coating polymers on accumulation of airborne heavy metals by lichens. Environmental Pollution (Series A) 38, 213-220.

GLENN M.G., GOMEZ-BOLEA A. & LOBELLO R., 1995. Metal content and community structure of cryptogam bioindicators in relation to vehicular traffic in Montseny Biosphere Reserve (Catalonia, Spain). The Lichenologist 27, 4, 291-304.

GLENN M.G., ORSI V.E. & HEMSLEY M.E., 1991. Lichen metal contents as correlates of air filter measurements. Grana 30, 44-47.

GONZALEZ C.M. & PIGNATA M.L., 1994. The influence of air pollution on soluble proteins, chlorophyll degradation, MDA, sulphur and heavy metals in a transplanted lichen. Chemistry and Ecology 9, 105-113.

GOUGH L.P. & ERDMAN J.A., 1977. Influence of a coal-fired powerplant on the element content of *Parmelia chlorochroa*. The Bryologist 80, 492-501.

GOUGH L.P., JACKSON L.L. & SACKLIN J.A., 1988a. Determining baseline element composition of lichens. II. *Hypogymnia enteromorpha* and *Usnea* spp. at Redwood National Park, California. Water, Air, and Soil Pollution 38, 169-180.

GOUGH L.P., SEVERSON R.C. & JACKSON L.L., 1988b. Determining baseline element composition of lichens. I. *Parmelia sulcata* at Theodore Roosevelt National Park, North Dakota. Water, Air, and Soil Pollution 38, 157-167.

GOYAL R. & SEAWARD M.R.D., 1981a. Metal uptake in terricolous lichens. I. Metal localization within the thallus. The New Phytologist 89, 631-645.

GOYAL R. & SEAWARD M.R.D., 1981b. Lichen ecology of the Scunthorpe heathlands. II. Industrial metal fallout pattern from lichen and soil assays. The Lichenologist 13, 3, 289-300.

GOYAL R. & SEAWARD M.R.D., 1982a. Metal uptake in terricolous lichens. II. Effects on the morphology of *Peltigera canina* and *Peltigera rufescens*. The New Phytologist 90, 73-84.

GOYAL R. & SEAWARD M.R.D., 1982b. Metal uptake in terricolous lichens. III. Translocation in the thallus of *Peltigera canina*. The New Phytologist 90, 85-98.

GRODZINSKA K., GODZIK B. & SZAREK G., 1993. Heavy metals and sulphur in lichens from southern Spitsbergen. Fragmenta Floristica et Geobotanica Supplementum 2, 2, 699-708.

GYDESEN H., RASMUSSEN L., PILEGAARD K., ANDERSEN A. & HOVMAND M.F., 1981. Differences in the regional deposition of cadmium, copper, lead and zinc in Denmark as reflected in bulk precipitation, epiphytic cryptogams and animal kidneys. Ambio 10, 5, 229-230.

HALE Jr. M.E., 1983. Lichens and air pollution. In: The Biology of Lichens (A.J. Willis & M.A. Sleigh, eds), Arnold, London, 97-107.

HALE Jr. M.E. & LAWREY J.D., 1985. Annual rate of lead accumulation in the lichen *Pseudoparmelia baltimorensis*. The Bryologist 88, 1, 5-7.

HALONEN P., HYVÄRINEN M. & KAUPPI M., 1993. Emission related and repeated monitoring of element concentrations in the epiphytic lichen Hypogymnia physodes in a coastal area, W Finland. Annales Botanici Fennici 30, 251-261.

HANSEN E.S., 1991. The lichen flora near a lead-zinc mine at Maarmorilik in West Greenland. The Lichenologist 23, 4, 381-391.

HAWKSWORTH D.L.. Literature on air pollution and lichens. The Lichenologist 1974 (I, 6, 122-125), 1975 (II, 7, 62-66 et III, 7, 173-177), 1976 (IV, 8, 87-91 et V, 8, 179-182), 1977 (VI, 9, 77-82 et VII, 9, 147-151), 1978 (VIII, 10, 95-100).

HAWKSWORTH D.L. & HENDERSON A., 1978. Literature on air pollution and lichens, IX. The Lichenologist 10, 227-230.

HENDERSON A. & HAWKSWORTH D.L., 1979. Literature on air pollution and lichens, X. The Lichenologist 11, 91-95.

HENDERSON A.. Literature on air pollution and lichens. The Lichenologist 1979 (XI, 11, 313-319), 1980 (XII, 12, 145-148 et XIII, 12, 397-402), 1981 (XIV, 13, 93-95 et XV, 13, 301-305), 1982 (XVI, 14, 53-56 et XVII, 14, 273-277), 1983 (XVIII, 15, 95-98 et XIX, 15, 297-301), 1984 (XX, 16, 81-84 et XXI, 16, 305-310), 1985 (XXII, 17, 213-219), 1986 (XXIII, 18, 191-198 et XXIV, 18, 363-370), 1987 (XXV, 19, 205-210 et XXVI 19, 433-437), 1988 (XXVII, 20, 191-196 et XXVIII, 20, 385-392), 1989 (XXIX, 21, 153-157 et XXX, 21, 369-378), 1990 (XXXI, 22, 173-181 et XXXII, 22, 397-403), 1991 (XXXIII, 23, 197-203 et XXXIV, 23, 393-401), 1992 (XXXV, 24, 193-200 et XXXVI, 24, 399-406), 1993 (XXXVII, 25, 191-202 et XXXVIII, 25, 435-441), 1994 (XXXIX, 26, 193-203 et XL, 26, 383-390), 1995 (XLI, 27, 225-234 et XLII, 27, 395-404), 1996 (XLIII, 28, 279-285 et XLIV, 28, 603-612).

HERZIG R., LIEBENDÖRFER L., URECH M., AMMANN K., GUECHEVA M. & LANDOLT W., 1989. Passive biomonitoring with lichens as a part of an integrated biological measuring system for monitoring air pollution in Switzerland. International Journal of Environmental Analytical Chemistry 35, 43-57.

HERZIG R., URECH M., LIEBENDÖRFER L., AMMANN K., GUECHEVA M. & LANDOLT W., 1990. Lichens as biological indicators of air pollution in Switzerland: Passive biomonitoring as a part of an integrated measuring system for monitoring air pollution. I n: Element Concentration Cadasters in Ecosystems. Methods of Assessment and Evaluation (H. Lieth & B. Markert, eds), VCH Weinheim, 317-332.

HOLM E., ROOS P. & SKWARZEC B., 1992. Radioanalytical studies of fallout 63Ni. International Journal of Radiation Applications and Instrumentation. Part A, Applied Radiation and Isotopes 43, 1/2, 371-376.

HOROVITZ C.T., SCHOCK H.H. & HOROVITZ-KISIMOVA L.A., 1974. The content of scandium, thorium, silver, and other trace elements in different plant species. Plant and Soil 40, 397-403.

ILA P., 1988. Multielement analysis of lichen by instrumental neutron activation analysis. Journal of Radioanalytical and Nuclear Chemistry, Articles, 120, 2, 247-252.

ISKANDAR I.K. & SYERS J.K., 1972. Metal-complex formation by lichen compounds. Journal of Soil Science 23, 3, 255-265

INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA), 1995. Survey of reference materials. Vol.1: Biological and environmental reference materials for trace elements, nuclides and microcontaminants. IAEA-TECDOC-854.

JAAKKOLA T., 1969. Analysis of iron-55 produced by nuclear tests and its enrichment in Finnish Lapps. Annales Academiae Scientiarum. Fennicae, Series A, II. Chemica, 150, 1-64.

JAAKKOLA T., PUUMALA H. & MIETTINEN J.K., 1967. Microelement levels in environmental samples in Finland. In: Proceedings of the International Symposium on Radioecological Concentration Processes (B. Aberg & F.D. Hungate, eds), Stockholm, Sweden, April 1966, Oxford UK, Pergamon Press, 314-350.

JACKSON T.A. & KELLER W.D., 1970. A comparative study of the role of lichens and "inorganic" processes in the chemical weathering of recent hawaiian lava flows. American Journal of Science 269, 446-466.

JAMES P.W., 1973. The effect of air pollutants other than hydrogen fluoride and sulphur dioxide on lichens. In: Air Pollution and Lichens (B.W. Ferry, M.S. Baddeley & D.L. Hawksworth, eds), The Athlone Press, London, 143-175.

JENKINS D.A., 1987. Trace elements in saxicolous lichens. In: Pollutant Transport and Fate in Ecosystems (P.J. Coughtrey, M.H. Martin & M.H. Unsworth, eds), Oxford, Blackwell Scientific Publications, 249-266.

JENKINS D.A. & DAVIES R.I., 1966. Trace element content of organic accumulations. Nature 210, 1296-1297.

JOHNSEN I.B., 1981. Heavy metal deposition on plants in relation to immission and bulk precipitation. Silva Fennica 15, 4, 444-445.

JONES D., WILSON M.J. & LAUNDON J.R., 1982. Observations on the location and form of lead in *Stereocaulon vesuvianum*. The Lichenologist 14, 3, 281-286.

JONES D., WILSON M.J. & McHARDY W.J., 1981. Lichen weathering of rock-forming minerals: application of scanning electron microscopy and microprobe analysis. Journal of Microscopy 124, 1, 95-104.

JOVANOVIC S., CARROT F., DESCHAMPS C., DESCHAMPS N. & VUKOTIC P., 1995. A study of the air pollution in the surroundings of an aluminium smelter, using epiphytic and lithophytic lichens. Journal of Trace and Microprobe Techniques 13, 4, 463-471.

KANERVA T., SARIN O. & NUORTEVA P., 1988. Aluminium, iron, zinc, cadmium and mercury in some indicator plants growing in south Finnish forest areas with different degrees of damage. Annales Botanici Fennici 25, 275-279.

KANSANEN P. H.& VENETVAARA J., 1991. Comparison of biological collectors of airborne heavy metals near ferrochrome and steel works. Water, Air, and Soil Pollution 60, 337-359.

KAPU M.M., IPAYE M.M., EGA R.A.I., AKANYA H.O., BALARABE M.L. & SCHAEFFER D.J., 1991. Lichens as bioindicators of aerial fallout of heavy metals in Zaria, Nigeria. Bulletin of Environmental Contamination and Toxicology 47, 3, 413-416.

KARDISH N., RONEN R., BUBRICK P. & GARTY J., 1987. The influence of air pollution on the concentration of ATP and on chlorophyll degradation in the lichen, *Ramalina duriaei* (De Not.) Bagl. The New Phytologist 106, 4, 697-706.

KAUPPI M. & HALONEN P., 1992. Lichens as indicators of pollution in Oulu, northern Finland. Annales Botanici Fennici 29, 1-9.

KAUPPI M. & MIKKONEN A., 1980. Floristic versus single species analysis in the use of epiphytic lichens as indicators of air pollution in a boreal forest region, Northern Finland. Flora 169, 255-281.

KEINONEN M., 1992. The isotopic composition of lead in man and the environment in Finland 1966-1987: isotope ratios of lead as indicators of pollutant source. The Science of the Total Environment 113, 251-268.

KERSHAW K.A., 1985. The lichen environment: ionic criteria. In: Physiological Ecology of Lichens, Cambridge University Press, Cambridge, 60-101.

KORTESHARJU M. & KORTESHARJU J., 1989. Studies on epiphytic lichens and pine bark in the vicinity of a cement works in northern Finland. Silva Fennica 23, 4, 301-310.

KORTESHARJU J., SAVONEN K. & SÄYNÄTKARI T., 1990. Element contents of raw humus, forest moss and reindeer lichens around cement works in northern Finland. Annales Botanici Fennici 27, 3, 221-230.

KRAL R., KRYZOVA L. & LISKA J., 1989. Background concentrations of lead and cadmium in the lichen *Hypogymnia physodes* at different altitudes. The Science of the Total Environment 84, 201-209.

KUBIN E., 1990. A survey of element concentrations in the epiphytic lichen *Hypogymnia physodes* in Finland in 1985-86. In: Acidification in Finland (P. Kauppi, P. Anttila & K. Kenttämies, eds), Springer-Verlag, Heidelberg, 421-46.

KUBIN E., 1991. A survey of element concentrations in the epiphytic lichen *Hypogymnia physodes* in Northern Finland in 1986. Geological Survey of Finland, Special Paper 9, 183-194.

KYTÖMAA A., NIEMINEN S., THUNEBERG P., HAAPALA H. & NUORTEVA P., 1995. Accumulation of aluminium in *Hypogymnia physodes* in the surroundings of a finnish sulphite-cellulose factory. Water, Air, and Soil Pollution 81, 401-409.

LAAKSOVIRTA K. & OLKKONEN H., 1977. Epiphytic lichen vegetation and elements of *Hypogymnia physodes* and pine needles examined as indicators of air pollution at Kokkola, W Finland. Annales Botanici Fennici 14, 112-130.

LAAKSOVIRTA K. & OLKKONEN H., 1979. Effect of air pollution on epiphytic lichen vegetation and element contents of a lichen and pine needles at Valkeakoski, S Finland. Annales Botanici Fennici 16, 285-296.

LAAKSOVIRTA K., OLKKONEN H. & ALAKUIJALA P., 1976. Observations on the lead content of lichen and bark adjacent to a highway in Southern Finland. Environmental Pollution 11, 247-255.

LAMBINON J., 1964a. *Stereocaulon nanodes* Tuck. en Wallonie et en Rhénanie. Lejeunea, N.S., 27 (avril), 1-8.

LAMBINON J. & AUQUIER P., 1964b. La flore et la végétation des terrains Calaminaires de la Wallonie septentrionnale et de la Rhénanie aixoise. Natura Monsana 16, 4, 113-130.

LAMBINON J., MAQUINAY A. & RAMAUT J.L., 1964c. La teneur en zinc de quelques lichens des terrains calaminaires belges. Bulletin du Jardin Botanique de l'Etat à Bruxelles. 34, 273-282.

LAMY D., 1974-1994. Bibliographie bryologique et lichénologique. Revue Bryologique et Lichénologique puis Cryptogamie, Bryologie et Lichénologie.

LANE I. & PUCKETT K.J., 1979. Responses of the phosphatase activity of the lichen *Cladina rangiferina* to various environmental factors including metals. Canadian Journal of Botany 57, 1534-1540.

LAWREY J.D., 1977. X-ray emission microanalysis of *Cladonia cristatella* from a coal strip-mining area in Ohio. Mycologia 69, 855-860.

LAWREY J.D., 1980. Calcium accumulation by lichens and transfer to lichen herbivores. Mycologia 72, 3, 586-594.

LAWREY J.D., 1993. Lichens as monitors of pollutant elements at permanent sites in Maryland and Virginia. The Bryologist 96, 3, 339-341.

LAWREY J.D. & HALE Jr M.E., 1979. Lichen growth responses to stress induced by automobile exhaust pollution. Science 204, 423-424.

LAWREY J.D. & HALE Jr. M.E., 1981. Retrospective study of lead accumulation in the Northeastern United States. The Bryologist 84, 4, 449-456.

LAWREY J.D. & HALE Jr. M.E., 1988. Lichen evidence for changes in atmospheric pollution in Shenandoah National Park, Virginia. The Bryologist 91, 1, 21-23.

LAWREY J.D. & RUDOLPH E.D., 1975. Lichen accumulation of some heavy metals from acidic surface substrates of coal mine ecosystems in Southeastern Ohio. The Ohio Journal of Science 75, 3, 113-117.

LEHTIMÄKI J., LESKELÄ K., MERILÄ P., REIJONEN T. & NUORTEVA P., 1990. Observations about nickel and other metals in Finnish Lapland. Luonnon Tutkija 94, 138-141.

LEMAISTRE V., 1983. Mise au point d'une électrode à oxygène en milieu aérien. Application à l'étude de l'influence de la pollution automobile globale sur les échanges gazeux de deux lichens. Thèse de 3e cycle, Université Pierre et Marie Curie, Paris.

LEMAISTRE V., 1985. Influence of automobile exhaust and lead on the oxygen exchange of two lichens measured by a new oxygen electrode method. In: Lichen Physiology and Cell Biology (D.H. Brown, ed.), Plenum Press, New-York, 173-183.

LEMAISTRE V. & LECLERC J.C., 1986. Forte variabilité de l'activité photosynthétique dans des populations de lichens pollués par le plomb d'origine automobile. Bulletin de la Société d'Ecophysiologie 11, 1, 67-77.

LEROY L.W. & KOKSOY M., 1962. The lichen - a possible plant medium for mineral exploration. Economic Geology 57, 107-113.

LESUEUR P. & PUCKETT K.J., 1980. Effect of vanadium on the phosphatase activity of lichens. Canadian Journal of Botany 58, 502-504.

LLOYD O.L. & GAILEY F.A., 1987. Techniques of low technology sampling of air pollution by metals: a comparison of concentrations and map patterns. British Journal of Industrial Medicine 44, 494-504.

LODENIUS M., 1981. Regional distribution of mercury in *Hypogymnia physodes* in Finland. Ambio 10, 4, 183-184.

LODENIUS M., 1989. Biological monitoring of airborne mercury. In: Man and his Ecosystem (L.J. Brasser & W.C. Mulder, eds), Elsevier Science Publishers B.V., Amsterdam. In: Proceedings of the 8th World Clean Air Congress, The Hague, The Netherlands, 11-15 sept. 1989, vol.3, 159-164.

LODENIUS M., 1991. Mobilization of cadmium and mercury after artificial acidification. Geological Survey of Finland, Special Paper 9, 61-67.

LODENIUS M. & KUMPULAINEN J., 1983. Cd, Fe and Zn content of the epiphytic lichen *Hypogymnia physodes* in finnish suburb. The Science of the Total Environment 32, 81-85.

LODENIUS M. & LAAKSOVIRTA K., 1979. Mercury content of *Hypogymnia physodes* and pine needles affected by chlor-alkali works at Kuusankoski, SE Finland. Annales Botanici Fennici 16, 7-10.

LODENIUS M. & MALM J., 1990. Influence of acidification on metal uptake in plants. In: Acidification in Finland (P. Kauppi, P. Anttilla & K. Kenttämies, eds), Springer-Verlag, Berlin, Heildeberg, New-York, London, Paris, Tokyo, Hong-Kong, Barcelona, 495-503.

LODENIUS M. & TULISALO E., 1984. Environment mercury contamination around a chlor-alkali plant. Bulletin of Environmental Contamination and Toxicology 32, 439-444.

LOONEY J.H.H., WEBBER C.E., NIEBOER E., STETSKO P.I. & KERSHAW K.A., 1986. Interrelationships between concentrations of 137Cs and various stable elements in three lichens species. Health Physics 50, 1, 148-152.

LOPPI S., CHITI F., CORSINI A. & BERNARDI L., 1992. Preliminary data on the integrated use of lichens as indicators and monitors of atmospheric pollutants in central Italy. Giornale Botanico Italiano 126, 2, 360.

LOPPI S., CHITI F., CORSINI A. & BERNARDI L., 1994a. Lichen biomonitoring of trace metals in the Pistoia area (central northern Italy). Environmental Monitoring and Assessment 29, 17-27.

LOPPI S., CORSINI A. & BRUSCOLI C., 1994b. The amounts of Cd, Cr, Cu, Ni, Pb and Zn in the lichen *Parmelia caperata* growing in agricultural and suburban sites of the Pistoia area (central Italy). Micologia e Vegetazione Mediterranea 9, 1, 25-34.

LOUNAMAA K.J., 1956. Trace elements in plants growing wild on different rocks in Finland. A semi-quantitative spectrographic survey. (Lichens, pp 62-68). Annales Botanici Societatis Zoologicae-Botanicae Fennicae 'Vanamo' 29, 4, 1-196.

LOUNAMAA K.J., 1965. Studies on the content of iron, manganese and zinc in macrolichens. Annales Botanici Fennici 2, 127-137.

LÜHMANN H.J., WIETSCHORKE G.M. & KREEB K.H., 1989. Influences of combined temperature, lead and herbicide stresses on lichen fluorescence and their mathematical modelling. Photosynthetica 23, 1, 71-76.

LUPSINA V., HORVAT, M., JERAN Z. & STEGNAR P., 1992. Investigation of mercury speciation in lichens. Analyst 117, 3, 673-675.

LURIE S. & GARTY J., 1991. Ethylene production by the lichen *Ramalina duriaei*. Annales of Botany 68, 317-319.

LYON G.L., BROOKS R.R., PETERSON P.J. & BUTLER G.W., 1970. Some trace elements in plants from serpentine soils. New Zealand Journal of Science 13, 133-139.

MAQUINAY A., LAMB I.M., LAMBINON J. & RAMAUT J.L., 1961. Dosage du zinc chez un lichen calaminaire belge: *Stereocaulon nanodes* Tuck. f. *tyroliense* (Nyl.) M. Lamb. Physiologia Plantarum 14, 284-289.

MARGOT J. & ROMAIN M.T., 1976. Métaux lourds et cryptogames terrestres, synthèse bibliographique. Mémoires de la Société Royale de Botanique de Belgique 7, 25-47.

MARKERT B., 1991a. Inorganic chemical investigations in the Forest Biosphere Reserve near Kalinin, USSR. I. Mosses and peat profiles as bioindicators for different chemical elements. Vegetatio 95, 127-135.

MARKERT B. & DE LI Z., 1991b. Inorganic chemical investigations in the Forest Biosphere Reserve near Kalinin, USSR. II. The distribution of lanthanide elements in the vegetation cover. Vegetatio 97, 1, 57-62.

MARKERT B. & WTOROVA W., 1992. Inorganic chemical investigations in the Forest Biosphere Reserve near Kalinin, USSR. III. Comparison of the multielement budget with a forest ecosystem in Germany - aspects of rejection, indication and accumulation of chemical elements. Vegetatio 98, 1, 43-58.

MISZALSKI Z. & NIEWIADOMSKA E., 1993. Comparison of sulphite oxidation mechanisms in three lichen species. The New Phytologist 123, 345-349.

MOORE D.I., GOSZ J.R. & WHITE C.S., 1978. Impact of a ski basin on a mountain watershed. II. Heavy metals. Water, Air, and Soil Pollution 10, 81-93.

MOSER T.J., SWAFFORD J.R. & NASH III T.H., 1983. Impact of Mount St. Helens' emissions on two lichen species of South-Central Washington. Environmental and Experimental Botany 23, 4, 321-329.

MUELLER C.S., THOMPSON R.L., RAMELOW G.J., BECK J.N., LANGLEY M.P., YOUNG J.C. & CASSERLY D.H., 1987. Distribution of Al, V, and Mn in lichens across Calcasieu Parish, Louisiana. Water, Air, and Soil Pollution 33, 155-164.

MUKHERJEE A.B. & NUORTEVA P., 1994. Toxic metals in forest biota around the steel works of Rautaruukki Oy, Raahe, Finland. The Science of the Total Environment 151, 191-204.

NASH III T.H., 1975. Influence of effluents from a zinc factory on lichens. Ecological Monographs 45, 2, 183-198.

NASH III T.H., 1989. Metal tolerance in lichens. In: Heavy Metal Tolerance in Plants: Evolutionary Aspects (A.J. Shaw, ed.), CRC Press, Boca Raton, Florida, 119-131.

NASH III T.H. & GRIES C., 1995a. The use of lichens in atmospheric deposition studies with an emphasis on the Arctic. The Science of the Total Environment 160/161, 729-736.

NASH III T.H. & GRIES C., 1995b. The response of lichens to atmospheric deposition studies with an emphasis on the Arctic. The Science of the Total Environment 160/161, 737-747.

NASH III T.H. & SIGAL L.L., 1980. Sensitivity of lichens to air pollution with an emphasis on oxidant air pollutants. In: Proceedings of the Symposium on Effects of Air Pollutants on Mediterranean and Temperate Forest Ecosystems, June 22-27, 1980, Riverside, California, USA, 117-124.

NASH III T.H. & SOMMERFELD M.R., 1981. Elemental concentrations in lichens in the area of the four corners power plant, New Mexico. Environmental and Experimental Botany 21, 2, 153-162.

NAZAROV V.M., FRONTASYEVA M.V., PERESEDOV V.F., CHINAEVA V.P., OSTROVNAYA T.M., GUNDORINA S.F. & NIKONOV V.V., 1995. Resonance neutrons for determination of elemental content of moss, lichen and pine needles in atmospheric deposition monitoring. Journal of Radioanalytical and Nuclear Chemistry, Articles, 192, 23, 229-238.

NIEBOER E., AHMED H.M., PUCKETT K.J. & RICHARDSON D.H.S., 1972. Heavy metal content of lichens in relation to distance from a nickel smelter in Sudbury, Ontario. The Lichenologist 5, 292-304.

NIEBOER E., LAVOIE P., SASSEVILLE R.L.P., PUCKETT K.J. & RICHARSON D.H.S., 1976a. Cation-exchange equilibrium and mass balance in the lichen *Umbilicaria muhlenbergii*. Canadian Journal of Botany 54, 720-723.

NIEBOER E., PADOVAN D., LAVOIE P. & RICHARDSON D.H.S., 1984. Anion accumulation by lichens. II. Competition and toxicity studies involving arsenate, phosphate, sulphate and sulphite. The New Phytologist 96, 83-93.

NIEBOER E., PUCKETT K.J. & GRACE B., 1976b. The uptake of nickel by *Umbilicaria muhlenbergii*: a physicochemical process. Canadian Journal of Botany 54, 724-733.

NIEBOER E., RICHARDSON D.H.S., BOILEAU L.J.R., BECKETT P.J., LAVOIE P. & PADOVAN D., 1982. Lichens and mosses as monitors of industrial activity associated with uranium mining in northern Ontario, Canada - Part 3: Accumulations of iron and titanium and their mutual dependence. Environmental Pollution (Series B) 4, 181-192.

NIEBOER E., RICHARDSON D.H.S., LAVOIE P. & PADOVAN D., 1979. The role of metal-ion binding in modifying the toxic effects of sulphur dioxide on the lichen *Umbilicaria muhlenbergii*. I. Potassium efflux studies. The New Phytologist 82, 621-632.

NIEBOER E., RICHARDSON D.H.S. & TOMASSINI F.D., 1978. Mineral uptake and release by lichens: an overview. The Bryologist 81, 226-246.

NIMIS P.L., 1990. Air quality indicators and indices: the use of plants as bioindicators for monitoring air pollution. In: Proceedings of the Workshop on Indicators and Indices for Environmental Impact Assessment and Risk Analysis (A.G. Colombo & G. Premazzi, eds), JRC, Ispra, 15-16 may 1990, 93-126.

NUORTEVA P., 1988. The role of metals in the multistress disease forests in Europe. Lounais-Hämeen Luonto 75, 62-76.

NUORTEVA P., 1990. Metal distribution patterns and forest decline. Seeking Achilles' heels for metals in finnish forest biocoenoses. Publications of the Department of Environmental Conservation, Helsinki University, 11, 1-77.

NUORTEVA P., AUTIO S., LEHTONEN J., LEPISTÖ A., OJALA S., SEPPÄNEN A., TULISALO E., VEIDE P., VIIPURI J. & WILLAMO R., 1986. Levels of iron, aluminium, zinc, cadmium and mercury in plants growing in the surroundings of an acidified and a non-acidified lake in Espoo, Finland. Annales Botanici Fennici 23, 4, 333-340.

NYGARD S. & HARJU L., 1983. A study of the short range pollution around a power plant using heavy fuel oil by analysing vanadium in lichens. The Lichenologist 15, 1, 89-93.

NYLANDER M.W., 1866. Les lichens du jardin du Luxembourg. Bulletin de la Société Botanique de France 13, 364-372.

OBORN E.T., 1960. Chemistry of iron in natural water. Iron content of selected water and land plants. U.S. Geological Survey Water-Supply Paper 1459-G, 191-211.

ORSI E.V. & GLENN M.G., 1991. Lichens as microenvironment markers of air quality. Grana 30, 51-58.

PAKARINEN P., 1981. Nutrient and trace metal content and retention in reindeer lichen carpets of Finnish ombrotrophic bogs. Annales Botanici Fennici 18, 265-276.

PAKARINEN P., MÄKINEN A. & RINNE R.J.K., 1978. Heavy metals in *Cladonia arbuscula* and *Cladonia mitis* in eastern Fennoscandia. Annales Botanici Fennici 15, 281-286.

PALIOURIS G., SVOBODA J. & WEIN R.W., 1992. Cu levels in the northern boreal forest ecosystem and the effect of fire in redistributing this metal. MUSK-OX 39, 157-163.

PARR R.M. & ZEISLER R., 1994. Programs of the IAEA utilizing nuclear analytical techniques in the life sciences. Biological Trace Element Research 651-661.

PEARSON L.C. & ROPE S.K., 1987. Electron microscopy and cell membrane leakage tests as aids in monitoring air pollution with lichens. In: 14th International Botanical Congress, Berlin (West), Germany, 24 july - 01 august 1987.

PEREZURRIA E., LEGAZ M.E. & VICENTE C., 1986. The function of nickel on the urease activity of the lichen *Evernia prunastri*. Plant Science 43, 37-43.

PERSSON B.R.R., HOLM E. & LIDEN K., 1974. Radiolead (210Pb) and stable lead in the lichen *Cladonia alpestris*. Oikos 25, 2, 140-147.

PFEIFFER H.N. & BARCLAY-ESTRUP P., 1992. The use of a single lichen species, *Hypogymnia physodes*, as an indicator of air quality in northwestern Ontario. The Bryologist 95, 1, 38-41.

PIERVITTORI R., SALVADORI O. & LACCISAGLIA A., 1994. Literature on lichens and biodeterioration of stonework. I. Lichenologist 26, 2, 171-292.

PIERVITTORI R., SALVADORI O. & LACCISAGLIA A., 1996. Literature on lichens and biodeterioration of stonework. II. Lichenologist 28, 5, 471-483.

PILEGAARD K., 1978. Airborne metals and SO2 monitored by epiphytic lichens in an industrial area. Environmental Pollution 17, 81-92.

PILEGAARD K., 1979a. Heavy metals in bulk precipitation and transplanted *Hypogymnia physodes* and *Dicranoweisia cirrata* in the vicinity of Danish steelworks. Water, Air, and Soil Pollution 11, 77-91.

PILEGAARD K., 1983. Biological monitoring of airborne metal pollution around a lead-zinc mine in Greenland. In: Proceedings of the International Conference on Heavy metals in the Environment, Heidelberg, Sept. 1983, 1133-1137.

PILEGAARD K., 1985. Biological monitoring of airborne deposition around exposed mineralizations in Greenland. In: Proceedings of the International Conference on Heavy Metals in the Environment (T.D. Lekkas, ed.), Athens, Sept. 1985, 518-520.

PILEGAARD K., 1987a. Changes in heavy metal deposition around a lead-zinc mine in Maarmorilik, Greenland during the years 1979 to 1985. In: Proceedings of the International Conference on Heavy Metals in the Environment (S.E. Lindberg & T.C. Hutching, eds), New-Orleans, sept. 1987, 275-276.

PILEGAARD K., 1987b. Biological monitoring of airborne deposition within and around the Ilimaussaq intrusion, Southwest Greenland. Meddelelser om Gronland, Bioscience 24, 1-28.

PILEGAARD K., 1993. Biological monitoring of particulate pollutants during exploration work at a niobium mineralization in Greenland. Environmental Monitoring and Assessment 27, 221-232.

PILEGAARD K., 1994. Deposition of airborne metals around the lead-zinc mine in Maarmorilik monitored by lichens and mosses. Meddelelser om Gronland, Bioscience 43, 1-20.

PILEGAARD K., RASMUSSEN L. & GYDESEN H., 1979b. Atmospheric background deposition of heavy metals in Denmark monitored by epiphytic cryptogams. Journal of Applied Ecology 16, 843-853.

PRUSSIA C.M. & KILLINGBECK K.T., 1991. Concentrations of ten elements in two common foliose lichens: leachability, seasonality, and the influence of rock and tree bark substrates. The Bryologist 94, 2, 135-142.

PUCKETT K.J., 1976. The effect of heavy metals on some aspects of lichen physiology. Canadian Journal of Botany 54, 2695-2703.

PUCKETT K.J. & FINEGAN E.J., 1980. An analysis of the element content of lichens from the Northwest Territories, Canada. Canadian Journal of Botany 58, 2073-2089.

PUCKETT K.J., NIEBOER E., GORZYNSKI M.J. & RICHARDSON D.H.S., 1973. The uptake of metal ions by lichens: a modified ion-exchange process. The New Phytologist 72, 329-342.

PUEYO G..Les lichens indicateurs de la pollution atmosphérique. Revue bibliographique. Annales des Falsifications et de l'Expertise Chimique 1985 (I, 78, 841, 375-381), 1986 (II, 79, 844, 25-31 et III, 79, 847, 167-174), 1987 (IV, 80, 858, 241-246 et V, 860, 351-356), 1988 (VI, 81, 865, 57-64), 1989 (VII, 82, 880, 377-383), 1992 (VIII, 85, 910, 289-297), 1994 (IX, 87, 925, 65-74).

PUNZ W., 1979. The effect of single and combined pollutants on lichen water content. Biologia Plantarum (Praha) 21, 6, 472-474.

PURVIS O.W., 1984. The occurence of copper oxalate in lichens growing on copper sulphide-bearing rocks in Scandinavia. The Lichenologist 16, 2, 197-204.

PURVIS O.W., ELIX J.A., BROOMHEAD J.A. & JONES G.C., 1987. The occurence of copper-norstictic acid in lichens from cupriferous substrata. The Lichenologist 19, 2, 193-203.

PURVIS O.W., ELIX J.E. & GAUL K., 1990. The occurence of copper-psoromic acid in lichens from cupriferous substrata. The Lichenologist 22, 3, 345-354.

PURVIS O.W., GILBERT O.L. & JAMES P.W., 1985a. The influence of copper mineralization on *Acarospora smaragdula*. The Lichenologist 17, 1, 111-116.

PURVIS O.W. & JAMES P.W., 1985b. Lichens of the Coniston copper mines. The Lichenologist 17, 3, 221-237.

PYATT F.B., 1976. Lichen ecology of metal spoil tips: effects of metal ions on ascospore viability. The Bryologist 79, 172-179.

PYATT F.B., BEAUMONT E.H., LACY D. & STOREY D.M., 1992. Accumulation of lead by the lichen *Stereocaulon dactylophyllum*. The Environmentalist 12, 3, 207-210.

RAMELOW G.J., YUMO Z. & LIU L., 1991. Uptake of metallic ions from aqueous solution by dried lichen biomass. Microbios 66, 95-105.

RAO D.N., ROBITAILLE G. & LEBLANC F., 1977. Influence of heavy metal pollution on lichens and bryophytes. Journal of the Hattori Botanical Laboratory 42, 213-239.

RASMUSSEN P.E., MIERLE G. & NRIAGU J.O., 1991. The analysis of vegetation for total mercury. Water, Air, and Soil Pollution 56, 379-390.

RICHARDSON D.H.S., 1978. Lichens on iron cannon balls. The Lichenologist 10, 233-235.

RICHARDSON D.H.S., 1987. Lichens as pollution indicators in Ireland. In: Biological Indicators of Pollution (D.H.S. Richardson, ed.), Proceedings of a Seminar 24-25 feb. 1986, Royal Irish Academy, Dublin, 155-168.

RICHARDSON D.H.S., 1988. Understanding the pollution sensitivity of lichens. Botanical Journal of the Linnean Society 96, 31-43.

RICHARDSON D.H.S. & NIEBOER E., 1983. The uptake of nickel ions by lichen thalli of genera *Umbilicaria* and *Peltigera*. The Lichenologist 15, 1, 81-88.

RICHARDSON D.H.S., NIEBOER E., LAVOIE P. & PADOVAN D., 1979. The role of metal-ion binding in modifying the toxic effects of sulphur dioxide on the lichen *Umbilicaria muhlenbergii*. II. 14C-fixation studies. The New Phytologist 82, 633-643.

RICHARDSON D.H.S., NIEBOER E., LAVOIE P. & PADOVAN D., 1984. Anion accumulation by lichens. I. The characteristics and kinetics of arsenate uptake by *Umbilicaria muhlenbergii*. The New Phytologist 96, 71-82.

RICHARDSON D.H.S., SHORE M., HARTREE R. & RICHARDSON R.M., 1995. The use of X-ray fluorescence spectrometry for the analysis of plants, especiallly lichens, employed in biological monitoring. The Science of the Total Environment 176, 97-105.

ROPE S.K. & PEARSON L.C., 1990. Lichens as air pollution biomonitors in a semiarid environment in Idaho. The Bryologist 93, 1, 50-61.

ROUSSEL L., 1993. Diagnostique de la qualité de l'air a Chalon-sur-Saône par les lichens. 2ème partie: Bioaccumulation des métaux lourds et des éléments radioactifs. Rapport sur une étude réalisée par l'Observatoire Mycologique, le Service de Protection Sanitaire de l'Environnement de la DDASS de Saône et Loire et la Faculté de Pharmacie de l'Université de Lille, 15p.

SAEKI M., KUNII K., SEKI T., SUGIYAMA K., SUZUKI T. & SHISHIDO S., 1977. Metal burden of urban lichens. Environmental Research 13, 256-266.

SAEKI M., KUNII K., SEKI T. & SUZUKI T., 1975. A lichen (Parmelia conspersa) surviving with elevated concentrations of lead and copper in the center of Sendai city. Bulletin of Environmental Contamination and Toxicology 14, 6, 726-730.

SÄRKELÄ M. & NUORTEVA P., 1987. Levels of aluminium, iron, zinc, cadmium and mercury in some indicator plants growing in unpolluted Finnish Lapland. Annales Botanici Fennici 24, 3, 301-305.

SCHATZ A., 1962. Pedogenic (soil-forming) activity of lichen acids. Naturwissenschaften 49, 518-519.

SCHUTTE J.A., 1977. Chromium in two corticulous lichens from Ohio and West Virginia. The Bryologist 80, 279-283.

SCHWARTZMAN D., KASIM M., STIEFF L. & JOHNSON Jr J.H., 1987. Quantitative monitoring of airborne lead pollution by a foliose lichen. Water, Air, and Soil Pollution 32, 363-378.

SCOTT M.G. & HUTCHINSON T.C., 1989. Morphological and chemical studies of epiphytic lichens from high elevation cloud forests as indicators of atmospheric pollution. American Journal of Botany 76 (6 suppl.), 13-14.

SEAWARD M.R.D., 1973. Lichen ecology of the Scunthorpe heathlands. I. Mineral accumulation. The Lichenologist 5, 423-433.

SEAWARD M.R.D., 1974. Some observations on heavy metal toxicity and tolerance in lichens. The Lichenologist 6, 158-164.

SEAWARD M.R.D., 1977. Field and study note. Metal levels in lichens: a correction. The Lichenologist 9, 87.

SEAWARD M.R.D., 1980. The use and abuse of heavy metal bioassays of lichens for environmental monitoring. In: Proceedings of the 3rd International Conference on Bioindicatores Deteriorisationis Regionis (J. Spaleny, ed.), Academia, Praha, 375-384.

SEAWARD M.R.D., BYLINSKA E.A. & GOYAL R., 1981. Heavy metals content of *Umbilicaria* species from the Sudety region of SW Poland. Oikos 36, 107-113.

SEAWARD M.R.D., GOYAL R. & BYLINSKA E.A., 1978. Heavy metal content in some terriculous lichens from mineral-enriched sites in Northern England. Naturalist 103, 135-141.

SEMADI A., 1989. Effets de la pollution atmosphérique (pollution globale, fluorée et plombique) sur la végétation de Annaba (Algérie). Thèse de Doctorat d'Etat, Université Pierre et Marie Curie, Paris, 339p.

SEMADI A. & DERUELLE S., 1993. Détection de la pollution plombique à l'aide de transplants lichéniques dans la région de Annaba (Algérie). Pollution Atmosphérique 35, 140, 86-102.

SHERIDAN R.P., 1979. Impact of emissions from coal-fired electricity generating facilities on N2-fixing lichens. The Bryologist 82, 1, 54-58.

SHIMWELL D.W. & LAURIE A.E., 1972. Lead and zinc contamination of vegetation in the Southern Pennines. Environmental Pollution 3, 291-301.

SHOWMAN R.E. & HENDRICKS, 1989. Trace element content of *Flavoparmelia caperata* (L.) Hale due to industrial emissions. JAPCA, Journal of the Air Pollution Control Association 39, 317-320.

SHOWMAN R.E. & LONG R.P., 1992. Lichen studies along a wet sulfate deposition gradient in Pennsylvania. The Bryologist 95, 2, 166-170.

SIEGEL B.Z. & SIEGEL S.M., 1976. Unusual mercury accumulation in lichen flora of Montenegro. Water, Air, and Soil Pollution 5, 335-337.

SIEGEL S.M. & DALY O., 1968. Responses of *Cladonia rangiferina* to experimental stress factors. Botanical Gazette 129, 4, 339-345.

SIEGEL S.M., SIEGEL B.Z., PUERNER N., SPEITEL T. & THORARINSSON F., 1975. Water and soil biotic relations in mercury distribution. Water, Air, and Soil Pollution 4, 9-18.

SIGAL L.L. & JOHNSON W. Jr, 1986. Effects of simulated acidic rain on one species each of *Pseudoparmelia*, *Usnea*, and *Umbilicaria*. Water, Air, and Soil Pollution 27, 315-322.

SKACEL F. & PEKAREK J., 1992. Monitoring of lead, cadmium and mercury in environmental samples at the regional station of the integrated background monitoring network of GEMS in Czechoslovakia. The Science of the Total Environment 115, 3, 261-276.

SLOOF J.E., 1995a. Lichens as quantitative biomonitors for atmospheric trace-element deposition, using transplants. Atmospheric Environment 29, 1, 11-20.

SLOOF J.E., 1995b. Pattern recognition in lichens for source apportionment. Atmospheric Environment 29, 1, 333-353.

SLOOF J.E., DE BRUIN M. & WOLTERBEEK H.Th., 1988. Critical evaluation of some commonly used biological monitors for heavy metal air pollution. In: Environmental Contamination, 3rd International Conference (A.A. Orio, ed.), Venice, Sept. 1988, 296-298.

SLOOF J.E. & WOLTERBEEK B.Th., 1993a. Interspecies comparison of lichens as biomonitors of trace-element air pollution. Environmental Monitoring and Assessment 25, 149-157.

SLOOF J.E. & WOLTERBEEK B.Th., 1993b. Substrate influence on epiphytic lichens. Environmental Monitoring and Assessment 25, 3, 225-234.

SLOOF J.E. & WOLTERBEEK H.Th., 1991a. National trace-element air pollution monitoring survey using epiphytic lichens. The Lichenologist 23, 2, 139-165.

SLOOF J.E. & WOLTERBEEK H.Th., 1991b. Patterns in trace elements in lichens. Water, Air, and Soil Pollution 57-58, 785-795.

SOLBERG Y.J., 1967. Studies on the chemistry of lichens. IV. The chemical composition of some Norwegian lichen species. Annales Botanici Fennici. 4, 29-34.

SOLBERG Y. & SELMER-OLSEN A.R., 1978. Studies on the chemistry of lichens and mosses. XVII. Mercury content of several lichen and moss species collected in Norway. The Bryologist 81, 1, 144-149.

ST CLAIR L.L., RUSHFORTH S.R. & NEWBERRY C.C., 1990. Lichens as indicators of elevated levels of environmental lead in Utah Valley, Utah. American Journal of Botany (Supplement, Abstracts to Richmond Meeting) 77, 6, 3-4.

STEINNES E. & KROG H., 1977. Mercury, arsenic and selenium fall-out from an industrial complex studied by means of lichen transplants. Oikos 28, 160-164.

STONE S.F., FREITAS M.C., PARR R.M. & ZEISLER R., 1995. Elemental characterization of a candidate lichen research material - IAEA-336. Fresenius' Journal of Analytical Chemistry 352, 227-321.

STUBBS C.S. & HOMOLA R.H., 1990. Not rare. But, endangered ? Elemental profiles of three corticulous lichen species on red spruce in Maine. American Journal of Botany (Supplement, Abstracts to Richmond Meeting) 77, 6, 4.

SYERS J.K. & ISKANDAR I.K., 1973. Pedogenetic significance of lichens. In: The lichens (V. Ahmadjian & M.E. Hale, eds), New-York and London, Academic Press, 225-248.

TAKALA K. & OLKKONEN H., 1976. Lead content of the lichen *Pseudevernia furfuracea* in the urban area of Kuopio, central Finland. In: Proceeedings of the Kuopio Meeting on Plant Damages Caused by Air Pollution (L. Kärenlampi, ed.), 64-67.

TAKALA K. & OLKKONEN H., 1981. Lead content of an epiphytic lichen in the urban area of Kuopio, east central Finland. Annales Botanici Fennici 18, 85-89.

TAKALA K. & OLKKONEN H., 1985. Titanium content in Finland. Annales Botanici Fennici 22, 299-305.

TAKALA K., OLKONNEN H. & SALMINEN R., 1994. Iron content and its relations to the sulphur and titanium contents of epiphytic and terricolous lichens and pine bark in Finland. Environmental Pollution 84, 131-138.

THOMAS R.S. & IBRAHIM S.A., 1995. Plutonium concentrations in lichens of rocky flats environs. Health Physics 68, 3, 311-319.

THOMAS W., RÜHLING A. & SIMON H., 1984. Accumulation of airborne pollutants (PAH, chlorinated hydrocarbons, heavy metals) in various plant species and humus. Environmental Pollution (Series A) 36, 295-310.

THOMAS W., SIMON H. & RÜHLING A., 1985. Classification of plant species by their organic (PAH, PCB, BHC) and inorganic (heavy metals) trace pollutant concentrations. The Science of the Total Environment 46, 83-94.

THOMPSON R.L., RAMELOW G.J., BECK J.N., LANGLEY M.P., YOUNG J.C. & CASSERLY D.M.,, 1987. A study of airborne metals in Calcasieu Parish, Louisiana using the lichens, *Parmelia praesorediosa* and *Ramalina stenospora*. Water, Air, and Soil Pollution 36, 295-309.

TOMASSINI F.D., PUCKETT K.J., NIEBOER E., RICHARDSON D.H.S. & GRACE B., 1976. Determination of copper, iron, nickel, and sulphur by X-ray fluorescence in lichens from the Mackenzie Valley, Northwest Territories, and the Sudbury District, Ontario. Canadian Journal of Botany 54, 14, 1591-1603.

TUOMINEN Y., 1967. Studies on the strontium uptake of the *Cladonia alpestris* thallus. Annales Botanici Fennici 4, 1-28.

TUOMINEN Y., 1971. Studies on some concentration-distance curves of the diffusion of 137Cs and 90Sr ions in comumns composed of the thallus of *Cladonia alpestris*. Annales Botanici Fennici 8, 245-253.

TUOMINEN Y. & JAAKKOLA T., 1973. Absorption and accumulation of mineral elements and radioactive nuclides. In: The lichens (V. Ahmadjian & M.E. Hale, eds), New-York and London, Academic Press, 185-223.

TYLER G., 1972. Heavy metals pollute nature may reduce productivity. Ambio 1, 2, 52-59.

TYLER G., 1989. Uptake, retention and toxicity of heavy metals in lichens. Water, Air, and Soil Pollution 47, 321-333.

TYLER G., BALSBERG PAHLSSON A.M., BENGTSSON G., BAATH E. & TRANVIK L., 1989. Heavy metal ecology of terrestrial plants, microorganisms and invertebrates. Water, Air, and Soil Pollution 47, 189-215.

UPRETI D.K. & PANDEV V., 1994. Heavy metals of antarctic lichens. 1. *Umbilicaria*. Feddes Repertorium 105, 3-4, 197-199.

VAN DEN BERG G.J., TYSSEN T.P.M., AMMERLAAN M.J.J., VOLKERS K.J., WORONIECKA U.D., DE BRUIN M. & WOLTERBEEK H.Th., 1992. Radiocesium and lead in the lichen species *Parmelia sulcata* sampled in three regions around Chernobyl: assessment of concentrations in 1990. Journal of Environmental Radioactivity 17, 115-127.

VESTERGAARD N.K., STEPHANSEN U., RASMUSSEN L. & PILEGAARD K., 1986. Airborne heavy metal pollution in the environment of a Danish steel plant. Water, Air, and Soil Pollution 27, 363-377.

WAINWRIGHT S.J. & BECKETT P.J., 1975. Kinetic studies on the binding of zinc ions by the lichen *Usnea florida* (L.) Web. The New Phytologist 75, 91-98.

WALTHER D.A., RAMELOW G.J., BECK J.N., YOUNG J.C., CALLAHAN J.D. & MARCON M.F. 1990a. Distribution of airbone heavy metals as measured in the lichens *Ramalina stenospora* and *Parmotrema praesorediosum* in Baton Rouge, Louisiana. Water, Air, and Soil Pollution 50, 279-292.

WALTHER D.A., RAMELOW G.J., BECK J.N., YOUNG J.C., CALLAHAN J.D. & MARCON M.F., 1990b. Temporal changes in metal levels of the lichens *Ramalina stenospora* and *Parmotrema praesorediosum*, Southwest Louisiana. Water, Air, and Soil Pollution 53, 189-200.

WANNER H., AMMANN K., BERLINCOURT P., FILLIGER P., HERZIG R., LIEBENDÖRFER L., RICKLI R. & URECH M., 1986. Urban meteorology and air pollution in Biel - Bienne (Switzerland). In: Workshop on Urban Meteorology: International Symposium on Climatology, Febr. 1986, Freiburger Geografische Hefte.

WARREN H.V. & DELAVAULT R.E., 1955. Biogeochemical prospecting in northern latitudes. Transactions of the Royal Society of Canada 49, 3, 111-115.

WELLS J.M., BROWN D.H. & BECKETT R.P., 1995. Kinetic analysis of Cd uptake in Cd-tolerant popultions of the moss *Rhytidiadelphus squarrosus* (Hedw.) Warnst and the lichen *Peltigera membranacea* (Ach.) Nyl. The New Phytologist 129, 477-486.

WIERSMA G.B., BRUNS D.A., FINLEY K., McANULTY L., WHITWORTH C. & BOELCKE C., 1992. Elemental composition of lichens from a remote *Nothofagus* forest site in Southern Chile. Chemosphere 24, 2, 155-167.

WIETSCHORKE G.M., LÜHMANN H.J. & KREEB K.H., 1990. Single and combined effects of lead, herbicide and temperature on net photosynthetic rate of *Hypogymnia physodes*, a corticulous lichen. Photosynthetica 24, 1, 102-109.

WILLIAMS M.E. & RUDOLPH E.D., 1974. The role of lichens and associated fungi in the chemical weathering of rock. Mycologia 66, 648-660.

WILSON M.J. & JONES D., 1984. The occurence and significance of manganese oxalate in *Pertusaria corallina* (Lichenes). Pedobiologia 26, 373-379.

YLIRUOKANEN I., 1975. Uranium, thorium, lead, lanthanoids and yttrium in some plants growing on granitic and radioactive rocks. Bulletin of the Geological Society of Finland 47, 71-78.

ZAKSHEK E.M., PUCKETT K.J. & PERCY K.E., 1986. Lichen sulphur and lead levels in relation to deposition patterns in eastern Canada. Water, Air, and Soil Pollution 30, 161-169.