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## Bio-accumulation des Radioéléments par les Lichens

## Revue Bibliographique

## Bio-accumulation of Radioelements by Lichens

## Review

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Mots-clés : lichen ; radioéléments ; radionucléides ; bio-accumulation.
Key words : lichen ; radioelements ; radionuclides ; bio-accumulation.

RESUME : Une revue bibliographique a été réalisée sur le thème de la bio-accumulation des radioéléments par les lichens. Les articles sont présentés dans un tableau à cinq colonnes. Dans les colonnes figurent respectivement : le nom du premier auteur et l'année de la publication étudiée, le site d'étude, le type d'analyses effectué, les éléments analysés, les espèces considérées.

ABSTRACT : A bibliographical review about bio-accumulation of radioelements in lichens has been realised. The aim of this work is to provide study references to everyone interested in and/or working on these subjects. Articles are presented in a five columns table (Table 1). The first column gives the name of the first author and the year of publication. The second column presents the geographical location of the research ; no site is mentioned for laboratory studies. The third one describes the type of work : **is** stands for ''*in situ*'', **T** stands for ''Transplants'' and **L** stands for ''Laboratory study''. The fourth and the fifth columns list respectively the chemical symbols of the elements and the abbreviations of the lichens species under study. All abbreviations are explained in a second table (Table 2). For instance ''Pca,cons,su'' means that the species under study are *Parmelia caperata*, *Parmelia conspersa* and *Parmelia sulcata*.

Further work....

In order to continue and to enrich this bibliographical review, we suggest to authors publishing in languages other than english or french, to send their results, as is in the Table 1 of this article. We would appreciate to receive the whole reference of the publications. All informations will be enclosed in an updated version of the review. *Take care ! ! ! !* Results and references should be written in latin alphabet.

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INTRODUCTION :

Depuis plusieurs décennies, les lichens sont utilisés pour étudier les pollutions environnementales. Les sources de radioactivité naturelle, comme les rayons cosmiques, l'atmosphère, les mines uranifères..., et celles artificielles, dues aux activités humaines, émettent des radioéléments qui sont susceptibles d'être accumulés par les lichens. Au niveau des pollutions anthropogéniques, les essais nucléaires de l'après-guerre, les rejets des centrales et les accidents comme Tchernobyl ont libéré et répandu de grandes quantités de radioéléments dans l'atmosphère. Les lichens nous permettent de rendre compte de leur importance, de leur répartition, de leur évolution et de leur persistance dans l'environnement. Dans le cadre de nos études sur la bio-accumulation des éléments-traces et des radioéléments par les lichens et les macromycètes (JACQUIOT & DAILLANT 1997, 1998), nous abordons par la présente revue le thème des lichens et des radioéléments.

Bien que les lichens ne soient pas directement consommés par l'homme, un problème de santé publique est apparu dans certains pays. Les lichens représentent la principale source de nourriture hivernale des rennes en Laponie et les rennes celles des Lapons. La capacité des lichens à accumuler les radioéléments conduit à une grande surveillance de la contamination de la chaîne alimentaire lichen → renne → homme.

LES ARTICLES RECENSES :

La présente étude bibliographique porte sur les articles traitant des interactions entre les lichens et les radioéléments. Nous nous sommes limités aux articles écrits en français et en anglais, exceptée une publication en polonais (ICHIHASHI & al., 1998) dont les auteurs nous ont procuré les renseignements nécessaires.

Les articles étudiés traitent :
- de la bio-accumulation ou de l'exclusion de certains radioéléments par certains lichens.
- de l'effet sur les lichens d'une exposition à un rayonnement gamma artificiel.
- de la différence de réponse intergénérique, interspécifique et intraspécifique.
- de l'interaction entre les éléments (antagonisme, synergie d'accumulation, d'effets).
- des mécanismes d'adsorption, d'absorption, d'accumulation et de localisation dans le thalle.

METHODES DE PRESENTATION :

Les articles sont présentés dans un tableau à cinq colonnes (Tableau 1).

La première colonne présente le nom du premier auteur et l'année de la publication ; les références complètes pourront ainsi être retrouvées en fin d'article.

La deuxième colonne présente les indications géographiques de l'étude. Les abréviations des locations sont explicitées en début du Tableau 2. Aucun site n'est mentionnés pour les études en laboratoire.

Troisième colonne : l'étude de la bio-accumulation des radioéléments les lichens peut se faire de trois façons: la première méthode consiste à doser les éléments dans les lichens prélevés sur le lieu étudié, *in situ* (**is**). La seconde permet de déterminer les doser des spécimens provenant de zone non polluées et transplantés dans des sites pollués (**T**). Le travail en laboratoire (**L**), consiste à prélever des lichens et à les soumettre à des solutions de radioéléments ou des sources radioactives.

La quatrième colonne indique les symboles des éléments chimiques faisant l'objet de chaque travail. Le terme « Gamma » est employé lorsque les lichens ont été soumis à une source de rayons $\gamma$, dont l'origine n'est pas précisée.

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. Par exemple ''Pca,cons,su'' veut dire que les espèces étudiées sont *Parmelia caperata*, *Parmelia conspersa* et *Parmelia sulcata*.

AUTRES ETUDES :

Dans notre précédente étude sur les lichens et les métaux lourds (JACQUIOT & DAILLANT, 1997), nous avons cité des revues bibliographiques sur l'utilisaton des lichens dans l'étude de la pollution de l'environnement.

Celles-ci peuvent être consultées dans le cas des radioéléments. Nous pouvons compléter cette liste avec d'autres références : NIEBOER & RICHARDSON, 1981; RICHARDSON & al., 1985 ; SEAWARD, 1992 ; HENDERSON, 1997-1999.

KAPPEN (1973) présente les réponses des lichens aux environnements extrêmes, dont la radioactivité naturelle et artificielle.

Un lichen, *Evernia prunastri*, fait partie des matériels de référence pour la mesure des quantités de 32 métaux lourds et radioéléments par différentes méthodes (PARR & ZEIGLER, 1994 ; IEAE, 1995 ; STONE & al. ; FREITAS & al., 1995).

JACKSON & al. (1993) s'intéresse à toutes les étapes à prendre en compte dans une étude de bio-monitoring des métaux lourds et des radioéléments. WOLTERBEEK & BODE (1995) se sont attachés aux aspects d'échantillonage et de manipulation des échantillons dans une étude de bio-monitoring à grande échelle. Ils citent, entre autres des références relatives à l'utilisation des lichens dans le bio-monitoring des métaux lourds et des radioéléments.

Des études mathématiques sont utilisées pour l'études de la pollution par les lichens. SHEARD (1986b ; Tableau 1) réalise une étude statistique sur la bio-accumulation par des lichens et par d'autres végétaux. SLOOF & WOLTERBEEK (1991 ; Tableau 1) identifient des sources de pollution par leur méthode TTFA (Target Transfer Factor Analysis). Cette méthode est améliorée par la méthode de Monte-Carlo (KUIK & al., 1993a et b ; Tableau 1 ; KUIK & WOLTERBEEK, 1994).

HOLM (1977a) s'intéresse aux isotopes du plutonium dans l'environnement et surtout dans la chaîne alimentaire lichen → renne → homme. En Scandinavie, GAARE & STAALAND (1994) repère la migration des rennes, leurs habitudes et régimes alimentaires et la quantité de lichens ingérée. Ils s'intéressent aux teneurs en cesium des lichens et d'autres végétaux, ainsi qu'à celles des rennes. Ils étudient l'effet de cet intrant de césium dans la chaîne alimentaire lichens / autres végétaux → rennes → hommes / autres prédateurs.

<u>CONCLUSION</u> :

Cette revue bibliographique présentée sous forme d'un tableau à cinq colonnes donne aux personnes intéressées des informations qui leur seront utiles et de les mettre en relation avec leurs sujets d'étude selon que leur intérêt se porte sur une région à étudier, des protocoles de laboratoire, des éléments ou des espèces précis...

Cependant 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 des informations supplémentaires qui pourraient leur être communiquées et qui seraient reprises dans une mise à jour ultérieure.

D'autre part, sauf exception, 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.

<u>REMERCIEMENTS</u> :

Nous tenons à remercier tous les auteurs qui ont envoyé leurs articles et/ou le résumé de leurs articles sous forme d'un tableau à cinq colonnes.

**TABLEAU 1 : Recensement des publications étudiées.**
(Pour la légende, voir texte et Tableau 2)

| AUTEUR(S) | SITE(S) | TYPE(S) | ELEMENT(S) | ESPECE(S) |
|---|---|---|---|---|
| AKCAY 1988 | TURQUIE, Izmir, Trabzon ; FRANCE, Drôme, Col du Rousset | is | $^{144}$Ce $^{134}$Cs $^{137}$Cs $^{144}$Pr $^{106}$Rh $^{106}$Ru $^{125}$Sb | Lmu Pfur PSf |
| AKCAY 1990 | O TURQUIE, Izmir | is | $^{144}$Ce $^{134}$Cs $^{137}$Cs $^{95}$Nb $^{106}$Rh $^{103}$Ru $^{106}$Ru $^{125}$Sb | Lmu Pta,til PSf |
| AKCAY 1995 | N et O TURQUIE | is | $^{144}$Ce/$^{144}$Pr $^{134}$Cs $^{137}$Cs $^{103}$Ru $^{106}$Ru/$^{106}$Rh $^{125}$Sb | Cr Lmu Pca,ta,til PSf SQc |
| BALDINI 1987a | N ITALIE, Dolomites, Auronzo | is | $^{140}$Ba $^{141}$Ce $^{144}$Ce $^{134}$Cs $^{140}$La | USfl |
| BALDINI 1987b | N ITALIE, Dolomites, Auronzo | is | $^{11Om}$Ag $^{141}$Ce $^{144}$Ce $^{134}$Cs $^{137}$Cs $^{103}$Ru $^{106}$Ru $^{125}$Sb $^{95}$Zr-$^{95}$Nb | USfl |
| BALDINI 1989 | N ITALIE, Dolomites, Auronzo | is | $^{110m}$Ag $^{144}$Ce $^{134}$Cs $^{137}$Cs $^{106}$Ru $^{125}$Sb | USfl |
| BALDINI 1990 | ITALIE, Auronzo, Canazei | is | $^{134/137}$Cs | N.D. |
| BARCI 1987 | S FRANCE, Nice | is | $^{110m}$Ag $^{141}$Ce $^{144}$Ce $^{134}$Cs $^{137}$Cs $^{95}$Nb $^{144}$Pr $^{106}$Rh $^{103}$Ru $^{106}$Ru $^{125}$Sb $^{95}$Zr | Pfur USb |
| BARTOK 1990 | ROUMANIE ? | is | $^{134}$Cs $^{137}$Cs | Cco,fi,fu CEg,p Ep Pfur,ph,til PEc Rc USfl,h |
| BEASLEY 1966 | USA, Alaska | is | $^{210}$Po | N.D. |
| BEASLEY 1969 | USA, Alaska, Iles Aléoutiennes, Ile Amchitka | is | $^{63}$Ni | Cpa+N.D. |
| BECKETT 1982 | CANADA, Ontario | is | Pb U | C Cmi,ra |
| BENSON 1983 | CANADA | is | $^{228}$Ac $^{7}$Be $^{214}$Bi $^{144}$Ce $^{137}$Cs $^{40}$K $^{95}$Nb $^{212}$Pb $^{214}$Pb $^{226}$Ra $^{103}$Ru $^{106}$Ru $^{125}$Sb $^{228}$Th $^{208}$Tl $^{95}$Zr | Anig N.D. |
| BIAZROV 1993 | UKRAINE, région de Tchernobyl | is | $^{241}$Am $^{60}$Co $^{154}$Eu $^{155}$Eu | Ccrp,mi,u Ep Hp Psu |
| BIAZROV 1994a | UKRAINE, région de Tchernobyl | is | $^{144}$Ce $^{134}$Cs $^{137}$Cs $^{106}$Ru | Cmi Hp |
| BIAZROV 1994b | CE RUSSIE, E Oural, Chelyabinsk, Kyshtym ; UKRAINE, région de Tchernobyl | is | $^{144}$Ce $^{134}$Cs $^{137}$Cs $^{106}$Ru | Ccrp,gr,mi Hp Psu |
| BLANCHARD 1970 | USA, Alaska | is | $^{210}$Pb $^{226}$Ra | Anit+C Cce,su,u CEd,i,r Po SPg |
| BOILEAU 1982 | CANADA, Ontario | is | Fe Ni Pb Ti U | Cmi,ra ST UM |
| BOILEAU 1985a,b | | L | U | Cra |
| BRETTEN 1992 | NORVEGE, Dovre, Rondane | is | $^{134}$Cs $^{137}$Cs | N.D. |

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|---|---|---|---|---|
| CARIGNAN 1995 | E CANADA, S et CE Québec | is | Pb $^{206}Pb/^{204}Pb$ $^{206}Pb/^{207}Pb$ $^{207}Pb/^{204}Pb$ $^{208}Pb/^{204}Pb$ | Em Psu US |
| CHANT 1996 | S BIELORUSSIE, Brazin ; O RUSSIE, Novozybkov ; N UKRAINE, Ovruc | is | $^{36}Cl$ $^{137}Cs$ I $^{129}I$ | Psu ? |
| CRETE 1992 | CANADA, N Québec | is | $^{137}Cs$ Cd Hg Pb | Ao Cmi,ste CORd |
| DAILLANT 1995 | FRANCE, Saône & Loire, Mâcon | is | As Cd Co Cr Cu Hg Mn Ni Pb Zn $^{134,137}Cs$ $^{40}K$ $^{210}Pb$ $^{226,228}Ra$ | Psu Xpa |
| DAILLANT 1996 | FRANCE, Saône & Loire | is | $^{228}Ac$ $^{210}Pb$ $^{212}Pb$ $^{214}Pb$ $^{226}Ra$ $^{234}Th$ | Ct LApu Pca,su Xpa |
| DE BRUIN 1987a | NL | is | Cd $^{137}Cs$ | Lco Psu X |
| DE BRUIN 1987b | De Kempen, C frontière BELGIQUE / 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 1988 | NL et De Kempen (frontière BELGIQUE / NL) | is | Al As Br Cd Co Cr Cu Eu Fe Mn Sb Sc Se Th Zn | Psu |
| 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 |
| ECKL 1984 | AUTRICHE | is | $^{7}Be$ $^{144}Ce$ $^{137}Cs$ $^{40}K$ $^{95}Nb$ $^{238}U$ $^{95}Zr$ | Ao Cfu,mi,ra CEcu,e,i Hp LApu PEa PLg PSf STa UMc,d USfi |
| ECKL 1986 | AUTRICHE | is | $^{7}Be$ $^{144}Ce$ $^{137}Cs$ $^{40}K$ $^{95}Nb$ $^{210}Pb$ $^{226}Ra$ $^{125}Sb$ $^{238}U$ $^{95}Zr$ | Cfu,ra CEce,e,i Hp LApu Psa,su,ta PEc PLg PSf UMd |
| ELLIS 1987 | CANADA, SO New-Brunswick | is | $^{7}Be$ $^{141}Ce$ $^{144}Ce$ $^{137}Cs$ $^{95}Nb$ $^{210}Pb$ $^{103}Ru$ $^{106}Ru$ $^{95}Zr$ Pu | Cra |
| ERÄMETSÄ 1971 | FINLANDE | is | Hf Mo Nb Th U W | Cal,ar Nar STpa,s |
| ERBISCH 1973 | | L | Gamma | Csy |
| ERBISCH 1978 | USA, Wisconsin, Rhinelander, North Central Forest | is | $^{137}Cs$ Gamma | Psub |
| 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 |
| FALANDYSZ 1998 | N POLOGNE | is | Ag Al As Ba Bi Cd Ce Co Cr Cs Cu Dy Er Fe Ga Gd Hg Ho La Lu Mn Nd Ni Pb Pr Rb Sb Sm Sn Sr Tb Th Tl Tm U Y Yb Zn | Cpy,ra Ep Hp Psu PEc PSf Rfar |
| FRAITURE 1990 | BELGIQUE, Florenville et Wallonie | is | $^{134}Cs/^{137}Cs$ | Hp |

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|---|---|---|---|---|
| FRAIZIER 1977 | O FRANCE, NO Manche (NO Cotentin, région de La Hague), O Finistère (Pointe St Mathieu), NO Côtes d'Armor (Perros-Guirec) | is | $^{144}$Ce $^{137}$Cs $^{40}$K $^{238,239,240}$Pu $^{106}$Ru | LIp Rs |
| FRAIZIER 1982 | O FRANCE, Manche (NO Cotentin, région de La Hague ; Granville), O Finistère (Pointe St Mathieu) | is | $^{241}$Am $^{7}$Be $^{141}$Ce $^{144}$Ce-Pr $^{244}$Cm $^{137}$Cs $^{155}$Eu $^{40}$K $^{54}$Mn $^{238}$Pu $^{239-240}$Pu $^{103}$Ru $^{106}$Ru-Rh $^{125}$Sb $^{95}$Zr | Rs |
| FRANCE 1993 | N CANADA, Ile Ellesmere | is | $^{137}$Cs | Ao CEn UMmu |
| FREITAS 1993a | | L | Ba Ce Co Cr Cs Fe Rb Sb Sc Th Zn | Ep |
| 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 1997 | PORTUGAL | is | Al As Ba Br Ce Co Cr Cs Eu Fe Ga Hf Hg La Lu Mn Nd Rb Sb Sc Se Sm Sr Ta Tb Th Ti U V W | Psu |
| GAARE 1987 | S NORVEGE, Mt Dovre | is | $^{134}$Cs + $^{137}$Cs | Ao Cmi,ste CEn CORd STpa |
| GORHAM 1959 | NO ANGLETERRE, Lake District | is | N.D. | N.D. |
| 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 |
| GUEIDAN 1997 | CE France, NO Saône & Loire, Autun | is | As Cd Co Cr $^{134}$Cs $^{137}$Cs Cu Fe Hg $^{40}$K Mn Ni Pb $^{210}$Pb $^{226}$Ra($^{214}$Pb) $^{228}$Ra($^{228}$Ac) $^{228}$Ra+$^{228}$Th($^{212}$Pb) $^{238}$U($^{234}$Th) Zn | Psu |
| GUILLITE 1990 | BELGIQUE ; LUXEMBOURG, Mersch | is | $^{134}$Cs $^{137}$Cs | Cco,su CEg Hp Psa PEc |
| GUILLITE 1994 | CS SUEDE, Hille | is | $^{137}$Cs | Hp |
| HAKANEN 1984 | N.D. | is | $^{238}$Pu $^{239+240}$Pu $^{241}$Pu | N.D. |
| HANDL 1993 | E SUEDE, Gävle | is | $^{129}$I | N.D. |
| HANDLEY 1968 | | L | $^{137}$Cs | Rr |
| HANSON 1966 | USA, N Alaska, Anaktuvuk Pass | is | $^{110m}$Ag $^{144}$Ce $^{60}$Co $^{134}$Cs $^{137}$Cs $^{40}$K $^{22}$Na $^{226}$Ra $^{106}$Ru $^{125}$Sb $^{85}$Sr $^{90}$Sr $^{228}$Th $^{88}$Y $^{65}$Zn $^{95}$Zr/$^{95}$Nb | C+CE Cal+N.D. Cra CEcu+CEi+N.D. CEcu,d,r CORd DAa Nar |
| HANSON 1967 | USA, N Alaska, Anaktuvuk Pass | is | $^{144}$Ce $^{137}$Cs $^{54}$Mn $^{106}$Ru $^{90}$Sr | C CE CEcu CORd |
| HANSON 1968 | USA, N Alaska, Anaktuvuk Pass | is | $^{137}$Cs $^{90}$Sr | N.D. |

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|---|---|---|---|---|
| HANSON 1971 | USA, N Alaska, Anaktuvuk Pass | is | $^{137}Cs$ | N.D. |
| HANSON 1982 | USA, N Alaska, Anaktuvuk Pass | is | $^{137}Cs$ | C CE+A |
| HÄSÄNEN 1966 | FINLANDE | is | $^{137}Cs$ $^{54}Mn$ $^{106}Ru$ $^{125}Sb$ | A Cal STpa |
| HEINRICH 1989 | AUTRICHE | is | $^{228}Ac$ $^{110m}Ag$ $^{214}Bi$ $^{144}Ce$ $^{134}Cs$ $^{137}Cs$ $^{40}K$ $^{95}Nb$ $^{212}Pb$ $^{214}Pb$ $^{226}Ra$ $^{103}RU$ $^{106}Ru$ $^{125}Sb$ $^{208}Tl$ $^{95}Zr$ | Ao Cra Hp Psu PSf |
| HILL 1965 | ANGLETERRE, CANADA, LAPONIE | is | $^{210}Pb$ $^{210}Po$ | Cal CAel |
| HOFFMAN 1972 | USA, Tennesse, Oak Ridge | is,L | $^{137}Cs$ | BU Graphidaceae L Pca,car,cet,ga,h,l,per,r PER PG Rfas USst |
| HOFMANN 1993 | AUTRICHE, Salzbourg, Haute-Autriche | is | $^{137}Cs$ $^{40}K$ | Ao Car,ph,ra,sul CEcu,i,n Ep Hp PLg PSf |
| HOLM 1975, 1976 | CO SUEDE, Lake Rogen ; FINLANDE | is | $^{238}Pu$ $^{239+240}Pu$ | Cal,am,b,ra |
| HOLM 1977b | CO SUEDE, Lake Rogen | is | $^{241}Am$ $^{241}Pu$ | Cal |
| HOLM 1977c | SCANDINAVIE | is | $^{241}Pu$ | Cal |
| HOLM 1978 | C SUEDE | is | $^{241}Am$ $^{242,\ 244}Cm$ $^{238}Pu$ $^{239+240}Pu$ $^{241}Pu$ | Cal |
| HOLM 1987 | FINLANE ; ex-YOUGOSLAVIE ; SUEDE ; ISLANDE ; NORVEGE ; SPITSBERG | is | $^{137}Cs$ $^{99}Tc$ | C Cal,mi,ra,sy,u CEi |
| HOLM 1992 | CO SUEDE, Lake Rogen | is | $^{63}Ni$ Ni | Cal |
| HOLTZMAN 1966 | USA, NO Alaska, N-Hampshire ; FINLANDE, Inari | is | $^{210}Pb$ $^{210}Po$ $^{226}Ra$ | Anig,o C Cal,sy CORd N.D. |
| HOROVITZ 1974 | SO ALLEMAGNE, Tübingen | is | Ag Co Cr Cs Fe Rb Sc Th Zn | Cre |
| HUTCHINSON-BENSON 1985 | C CANADA, latitudinalement du Manitoba à Ile Ellesmere | | $^{137}Cs$ | Anig,o Cra CEcu,i,n CORd THv UMmu |
| HVINDEN 1961 | N NORVEGE | is | $^{137}Cs$ | N.D. |
| ICHIHASHI 1998 | N POLOGNE, Forêt Tucholskie | is | Ag Al As Ba Bi Cd Ce Co Cr Cs Cu Dy Er Fe Ga Gd Hg Ho La Lu Mn Nd Ni Pb Pr Rb Sb Sm Sn Sr Tb Th Tl Tm U Y Yb Zn | Hp |
| ILA 1988 | | L | Al As Br Ce Co Cr Cs Dy Eu Fe Hf La Lu Mn Sb Sc Sm Th Ti U V Yb | Te |
| JAAKKOLA 1969 | N et S FINLANDE | is | $^{137}Cs$ $^{55}Fe$ Fe | Cal |
| JAAKKOLA 1983 | S FINLANDE et Laponie | is | $^{204,\ 206,\ 207,\ 208}Pb$ | N.D. |
| JAWOROWSKI 1966 | le long du 20ème méridien de SPITZBERG à S BULGARIE | is | $^{210}Pb$ | Cal,fu,mi,r,ra,sy |
| JERAN 1988 | SLOVENIE, Zirovski vrh et N.D. | is | U | Hp Pca,sa |

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|---|---|---|---|---|
| JERAN 1989 | SLOVENIE, E Ljubljana, Paski Kozjak, Zirovski vrh | is,T | U | Ep Hp Pca,su |
| JERAN 1990 | SLOVENIE, E Ljubljana, Paski Kozjek, Zirovski vrh | is,T | U | Hp Pca,su |
| JERAN 1993 | SLOVENIE, Zirovski vrh | is | $^{210}Pb$ $^{226}Ra$ U | Hp Pca,sa,su |
| JERAN 1995 | SLOVENIE, Brezovica, près de Ljubljana, Paski Korzjak, Zirovski vrh | is,T | $^{210}Pb$ $^{226}Ra$ U | Hp |
| JERAN 1996, 1998 | SLOVENIE | is | $^{134}Cs$ $^{137}Cs$ $^{40}K$ $^{210}Pb$ Th U | Hp |
| JONES 1989 | SUEDE | is | $^{137}Cs$ | Cra |
| KARLEN 1991 | E SUEDE, Harbo | is | $^{137}Cs$ | N.D. |
| KAURANEN 1969 | N et S FINLANDE, Enontekiö, Helsinki, Loppi, Pielisjärvi, Porvoo, Tuusula, Virolahti | is | $^{210}Pb$ $^{210}Po$ | Cal |
| KEINONEN 1977 | N FINLANDE, Laponie | is | $^{239}Pu + ^{240}Pu$ | N.D. |
| KEINONEN 1978 | N FINLANDE, Laponie | is | $^{239}Pu + ^{240}Pu$ | A |
| KEINONEN 1992 | N FINLANDE, Laponie | is | Pb $^{204}Pb$ $^{206}Pb$ | N.D. |
| KERSHAW 1983, 1984, 1987 | N CANADA, NWT, Keewatin District, Lone Gull Lake | is | $^{137}Cs$ Cu Fe Ni Pb Ti U | CEcu,n DAa |
| KÖSE 1994 | NE TURQUIE | is | $^{134}Cs$ $^{137}Cs$ | Pca,su |
| KUIK 1993b | NL | is | Al As Br Cd Co Cr Cs Fe Hg La Mn Ni Pb Sb Sc Se Th V W | Psu |
| KWAPULINSKI 1985a | SO POLOGNE, Sudètes, Karkonosze | is | $^{137}Cs$ | UMc,d,hi,mur |
| KWAPULINSKI 1985b | SO POLOGNE, Sudètes, Karkonosze | is | $^{226}Ra$ $^{228}Ra$ | UMc,d,hi,mur |
| LANE 1979 | | L | Ag Al Ba Co Cu Li Mo Ni Se Sr U V | Cra |
| LEROY 1962 | USA, Colorado | is | Ag Be Cr Cu Mo Ni Pb Sn Sr U V Y Zn | CAel Lr Pcons UMhy |
| LOONEY 1985 | N CANADA, NWT, Keewatin District, Lone Gull Lake | is | $^{137}Cs$ Cu Fe Ni Pb Ti U | CEcu,n DAa |
| LOONEY 1986 | CANADA, NWT | is | $^{137}Cs$ Cu Fe Ni Pb Ti U | CEcu,n DAa |
| LOWE 1978 | MALAISIE | is | $^{137}Cs$ | US-mousse |
| 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 |
| MARTIN 1991 | ESTONIE ; RUSSIE ; O SPITZBERG | is | $^{137}Cs$ $^{90}Sr$ | Ca,mi,ste CEcu,i |
| MATTSSON 1972 | CO SUEDE, Funäsdalen | is | $^{22}Na$ | Cal |

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|---|---|---|---|---|
| MATTSSON 1975a | CO SUEDE, Lake Rogen | is | $^{137}Cs$ | Cal |
| MATTSSON 1975b | CO SUEDE, Lake Rogen | is | $^{7}Be$ $^{144}Ce$ $^{137}Cs$ $^{155}Eu$ $^{54}Mn$ $^{106}Ru$ $^{125}Sb$ $^{95}Zr$ | Cal |
| McLEAN 1998 | SO ANGLETERRE, Cornwall | is | U | TRAi/mélanine |
| MIETELSKI 1996 | POLOGNE, Blackownia Slaska, Gzolo, Gruszki, Hala Gasienicowa, Janow Lubelski, Lichwin, Przewiez, Sernetki | is | $^{241}Am$ $^{7}Be$ $^{134}Cs$ $^{137}Cs$ $^{154}Eu$ $^{155}Eu$ $^{40}K$ $^{210}Pb$ $^{238}Pu$ $^{239/240}Pu$ | Car/sy Hp PSf |
| 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 |
| NEDIC 1995 | N.D. | is,L | $^{134}Cs$ $^{137}Cs$ | CEi |
| NEDIC 1998 | N.D. | is,L | $^{137}Cs$ | CEi |
| NEDIC 1999 | | L | $^{137}Cs$ | CEi |
| NIFONTOVA 1977 | RUSSIE, S Yamal, S Oural, Baïkal, Kanty-Mansi, Tuva | is | $^{137}Cs$ $^{90}Sr$ | Cal,am,ra,sy CEcu THv USd,g,l |
| NIFONTOVA 1989 | | L | $^{137}Cs$ $^{90}Sr$ Gamma | Cam,ar,ste PEc TR TRe ; mycobionte de Pca ; acide usnique de Car,ste |
| NIFONTOVA 1992 | N UKRAINE, autour de Tchernobyl, Chereback, Kopachi, Pitomnik | is | $^{134,137}Cs$ $^{90}Sr$ | Car,mi Hp PEc |
| NIFONTOVA 1995a | N RUSSIE, Péninsule de Yamal | is | $^{137}Cs$ $^{90}Sr$ | Cam,ar,e,mi,ra,ste,sy,u CEchr,h,i,l STt THv |
| NIFONTOVA 1995b | | L | Gamma ($^{60}Co$) | Car CEi Hp PEa |
| NIFONTOVA 1996 | N UKRAINE, autour de Tchernobyl, Chereback, Kopachi, Pitomnik ; RUSSIE, Yamal | is | $^{137}Cs$ $^{90}Sr$ | Cam,ar,e,mi,ra,ste,sy,u CEchr,h,i,l STt THv |
| NIFONTOVA 1997 | RUSSIE, 60 km autour de Ekaterinburg | is | $^{137}Cs$ $^{90}Sr$ | Car,ra,ste Hp ; mousse-lichen |
| NIFONTOVA 1998a | N RUSSIE, Ourals-Sibérie | is | $^{137}Cs$ $^{90}Sr$ | Cam,ar,ra,ste,u CEcu,d,i,n PEc STpa ; mousse-lichen |
| NIFONTOVA 1998b | RUSSIE, 60 km autour de Ekaterinburg | is | $^{137}Cs$ $^{90}Sr$ | Hp ; mousse-lichen |
| PAAKKOLA 1963 | FINLANDE | is | $^{137}Cs$ $^{90}Sr$ | Af+Aj C Cal STpa |
| PAATERO 1998 | FINLANDE | is | $^{241}Am$ $^{144}Ce$ $^{242}Cm$ $^{134}Cs$ $^{137}Cs$ $^{238}Pu$ $^{239,240}Pu$ $^{106}Ru$($^{106}Rh$) | C ; épiphytes N.D. |
| PALIOURIS 1995 | CANADA, S NWT, Parc Wood Buffalo | is | $^{137}Cs$ | Hp USs |
| PAPASTEFANOU 1989 | N GRECE | is | $^{110m}Ag$ $^{144}Ce$ $^{134}Cs$ $^{137}Cs$ $^{40}K$ | ANc Ccon,fu,r CO Ep Pph,til PH Rfr Xpa |

| | | | | |
|---|---|---|---|---|
| | | | $^{106}Ru$ $^{125}Sb$ | |
| PAPASTEFANOU 1992 | N GRECE | is | $^{137}Cs$ | ANc Ccon,fu,r CO Ep Pph,su,til PEc PH Rfr Xpa |
| PERSSON 1968 | CANADA, FINLANDE, SUEDE, ex-YOUGOSLAVIE | is | $^{134}Cs/^{137}Cs$ | N.D. |
| PERSSON 1969 | CANADA, N FINLANDE, POLOGNE, SUEDE, ex-YOUGOSLAVIE | is | $^{55}Fe$ | N.D. Cal,ra,sy CEi,n STpa |
| PERSSON 1971 | CO SUEDE, Lake Rogen | is | $^{90}Sr$ | Cal |
| PERSSON 1974 | C SUEDE, lac Rogen, Musée Botanique de Lund | is | $^{210}Pb$ $^{210}Po$ Pb | C Cal |
| PILEGAARD 1985 | GROENLAND, Maarmorilik, 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 1987 | 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 |
| PLUMMER 1965 | SE USA, Georgie, Piedmont | is | $^{144}Ce$ $^{137}Cs$ $^{40}K$ $^{54}Mn$ $^{106}Ru$ $^{90}SR$ $^{95}Zr$ | Cst Pcons |
| PYATT 1988 | SO NORVEGE, Styggedalsbreen | is | Gamma | C Cpo CEi CORa LEm RHCg UM |
| RIBEIRO GUEVARA 1995 | OSO ARGENTINE, Parc National Nahuel Huapi (Bariloche, Puerto Blest) | is | Al As Br Ce Co Cr Cs Dy Eu Fe Hf Hg La Mn Rb Sb Sc Sm Sr Ta Tb Th Ti V W Zn | CANv HYb Pcu PHa USfa |
| RICKARD 1965 | NO USA, Alaska, Ogotoruk Pass | is | $^{144}Ce/^{144}Pr$ $^{137}Cs$ $^{54}Mn$ $^{106}Ru/^{106}Rh$ $^{65}Zn$ $^{95}Zr/^{95}Nb$ | C+CE COR+N.D. |
| RISSANEN 1989 | C et N FINLANDE | is | $^{137}Cs$ | A B C ST US |
| RISSANEN 1990 | C et N FINLANDE | is | $^{134}Cs$ $^{137}Cs$ | Cmi,ra,ste |
| RITCHIE 1971 | USA, Georgie, Walton County | is | $^{137}Cs$ | Cra,st,u |
| ROUSSEL 1993 | FRANCE, Saône & Loire, Chalon-sur-Saône | is | Ag As Cd Cr Cu Hg Ni Pb Zn $^{134}Cs$ $^{137}Cs$ | Psu PHt PHYg Xpa |
| SALO 1964 | N FINLANDE, Laponie, Inari | is | $^{137}Cs$ $^{90}Sr$ | Cal,am,ar,mi,sy,u Nar |
| SANTOS 1993 | BRESIL, Pocos de Caldas, Joinville | is | $^{210}Pb$ | N.D. |
| SAWIDIS 1988 | N GRECE, Thessaloniki | is | $^{134}Cs$ $^{137}Cs$ $^{40}K$ $^{103}Ru$ $^{106}Ru$ | Rfr S USar |

| | | | | |
|---|---|---|---|---|
| SAWIDIS 1992 | N GRECE | is | $^{137}$Cs | ANc Ccon,r Ep Ht Lmu NPp Psu PEc PER PLEa Rfar,fas,fr SQg Xa,pa XPta,ti |
| SAWIDIS 1997 | N GRECE, Macédoine, Grevena, Mt Hortiatis, Thessalonique, Mt Vermion + herbier Université de Thessalonique | is | $^{137}$Cs | ANc Ccon,r COc Dm Ep Hp Lmu NPp Pph,su,til PEc PLEa PSf Rfar,fas,fr SQg USh Xc,pa XPs |
| SCHWARTZMAN 1987 | USA, Ile Plummers, Great Falls, Rock Creek Park | is | $^{210}$Po Cd Pb V Zn | PSPb |
| SCHWARTZMAN 1991 | USA, Maryland, Great Falls et Plummers Island | is,L | Pb $^{210}$Pb $^{210}$Po | FPb/PSPb |
| SEAWARD 1988 | SO POLOGNE, Sudètes, Karkonosze | is | $^{144}$Ce $^{134}$Cs $^{137}$Cs $^{95}$Nb $^{106}$Rh $^{103}$Ru $^{106}$Ru | UMc,d,hi,mur,n,po,pu |
| SHAPIRO 1991 | | L | Gamma | LOp / nitrate réductase |
| SHEARD 1986a,b | CANADA, N Saskatchewan | is | $^{210}$Pb $^{210}$Po $^{226}$Ra U | Cmi,ra,ste |
| SHEPPARD 1983 | CANADA, SE Manitoba | is | U | C UMmu |
| SHEPPARD 1984 | CANADA, SE Manitoba, Nopiming Provincial Park | is | U | C UMmu |
| SIEGEL 1968 | | L | $^{60}$Co Li Gamma | Cra |
| SINGH 1988 | USA? | is | Pu Th U | N.D. |
| SLOOF 1991 | NL | is | Al As Br Cd Co Cr Cs Fe Hg La Mn Ni Pb Sb Sc Se Th V W | Psu |
| SLOOF 1992 | NL | is | $^{134}$Cs $^{137}$Cs | Lco Psu Xpa |
| SLOOF 1995 | NL | is | Al As Br Cd Co Cr Cs Fe Hg La Mn Ni Pb Sb Sc Se Th V W Zn | Psu |
| SMITH 1990 | E CANADA, N-Brunswick, Nova Scotia | is | $^{7}$B $^{134}$Cs $^{137}$Cs $^{131}$I $^{103}$Ru | Cra |
| SNYDER 1973 | USA, Georgie, Université Emory d'Atlanta | is | $^{137}$Cs Gamma | TRAo |
| STEINNES 1993 | C NORVEGE | is | $^{137}$Cs | Cste 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 |
| STRANDBERG 1994a | DANEMARK, Tisvilde Hegn | is | $^{134}$Cs $^{137}$Cs | Cpo CEi Hp |
| STRANDBERG 1994b | DANEMARK, Tisvilde Hegn | is | $^{137}$Cs | Cpo |
| SVENSSON 1965 | N et C SUEDE | is | $^{137}$Cs | Cal,sy STpa |
| SVOBODA 1979 | CANADA, NWT, Rankin Inlet, Repulse Bay, Tuktoyaktuk ; USA, Vermont, Jay Peak | is | $^{228}$Ac $^{141}$Ce $^{144}$Ce $^{137}$Cs $^{40}$K $^{95}$Nb $^{226}$Ra $^{103}$Ru $^{220}$Th $^{228}$Th $^{95}$Zr | Ab,o CE CEcu,i,t US |
| SVOBODA 1985 | CANADA, C Keewatin, Lone Gull | is | $^{137}$Cs $^{226}$Ra $^{238}$U | N.D. |

| | | | | |
|---|---|---|---|---|
| TAYLOR F.G. 1972 | USA, Tennesse, Oak Ridge | is | $^{134}Cs$ | Cst |
| TAYLOR H.W. 1979 | CANADA | is | $^{7}Be$ $^{144}Ce$ $^{137}Cs$ $^{95}Nb$ $^{226}Ra$ $^{103}Ru$ $^{106}Ru$ $^{125}Sb$ $^{228}Th$ $^{95}Zr$ | Ao/Cb/Cra/ST/N.D. |
| TAYLOR H.W. 1985 | CANADA | is | $^{137}Cs$ | An,o Cra CEcu CORd UMmu |
| TAYLOR H.W. 1988 | N CANADA, NWT, Ile Ellesmere | is | $^{134}Cs$ $^{137}Cs$ | Ao CEi,n,t STpa THv UMpr N.D. |
| THOMAS P.A. 1994 | N CANADA, NWT, Baker Lake, Snowdrift, Kasba Lake | is | $^{210}Pb$ $^{210}Po$ | Cmi CEn |
| THOMAS R.S. 1995 | USA, Colorado, Rocky Flats Plant | is | $^{238}Pu$ $^{239+240}Pu$ Ti | XP |
| THOMPSON 1987 | USA, SO Louisiane | is | Ce Co Cr Eu Fe Hg Ir Sb Sc Se Ta Th Zn | Ppr Rst |
| TOPCUOGLU 1992 | TURQUIE | is | $^{134}Cs$ $^{137}Cs$ | CEce,chl Ep Hp,t LOp,s Psu PEho,pr PSf Rfar,o USfi,h Xpa |
| TOPCUOGLU 1993 | NE TURQUIE, Ordu-Gölköy | is | $^{134}Cs$ $^{137}Cs$ | PEpr |
| TRIULZI 1991 | ANTARCTIQUE | is | $^{137}Cs$ $^{40}K$ | CANDv+LEP NRa |
| TUOMINEN 1968, 1971 | | L | $^{137}Cs$ $^{90}Sr$ | Cal |
| VAN DEN BERG 1992 | UKRAINE / BIELORUSSIE, régions Bragin, Novozybkov, Ovruc | is | $^{137}Cs$ Pb | Psu |
| VAN HALUWYN 1992 | N FRANCE, Gravelines | is | $^{228}Ac$ $^{214}Bi$ $^{137}Cs$ $^{214}Pb$ | Xpa |
| VARSKOG 1994 | S NORVEGE, Dovre, Rondave | is | $^{137}Cs$ | CEn |
| WATSON 1964 | USA, NO Alaska, Cape Thompson | is | $^{90}Sr$ | C+CE COR |
| WATSON 1966 | USA, NO Alaska, Anaktuvuk Pass, Barrow, Kotzebue, Ogotoruk Creek | is | $^{141}Ce$+$^{144}Ce$/$^{144}Pr$ $^{137}Cs$ $^{54}Mn$ $^{103}Ru$+$^{106}Ru$/$^{106}Rh$ $^{90}Sr$ $^{95}Zr$/$^{95}Nb$ | C+CE COR |
| WITKAMP 1967 | | L | $^{137}Cs$ | Cst |
| WOODWELL 1967, 1968 | E USA, Long Island | is | Gamma | ARc BACc BAEr BUc,p,s C Cat,ba,ce,ch,cl,co,crt,de,in,ma,ne,pi,py,sq,st,sub CANDc Lcae,ch,u LEan,v LEP LEPa Pau,b,ca,g,l,ph,r,su,sub PARp PERt,x PHai,m,o,s |
| YLIRUOKANEN 1975 | FINLANDE | is | Ce Dy Er Eu Gd Ho La Lu Nd Pb Pr Sm Tb Th Tm U Y Yb | Cal,ar CEi |

## 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

NL = Netherland, Pays-Bas

**ESPECES** :

A *Alectoria* spp
Ab *A. bicolor*
Af *A. fremontii*
Aj *A. jubata*
An *A. nigricans*
Anit *A. nitidula*
Ao *A. ochroleuca*

AN *Anaptychia* spp
ANc *A ciliaris*

ARc *Arthonia caesia*

B *Bryoria* spp

BACc *Bacidia chlorococca*

BAEr *Baeomyces roseus*

BU *Buellia* spp
BUc *B. curtisii*
BUp *B. polyspora*
BUs *B. stillingiana*

C *Cladonia* / *Cladina* spp
Cal *C. alpestris*
Cam *C. amaurocraea*
Car *C. arbuscula*
Cat *C. atlantica*
Cb *C. bellidiflora*
Cba *C. bacillaris*
Cce *C. cenotea*
Cch *C. chlorophaea*
Ccl *C. clavulifera*
Cco *C. coniocraea*
Ccon *C. convulata = convoluta*
Ccrp *C. crispata*
Ccrt *C. cristatella*
Cd *C. delicata*
Ce *C. elongata*
Cfi *C. fimbriata*
Cfu *C. furcata*
Cgr *C. gracilis*
Cin *C. incrassata*
Cma *C. macilenta*
Cmi *C. mitis*
Cne *C. nemoxyna*
Cpa *C. pacificia*

Cph *C. phyllophora*
Cpi *C. pityrea*
Cpo *C. portentosa*
(= *C. impexa*)
Cpy *C. pyxidata*
Cr *C. rangiformis*
Cra *C. rangiferina*
Cre *C. retipora*
Csq *C. squamosa*
Cst *C. subtenuis*
Cste *C. stellaris*
Csu *C. subulata*
Csub *C. subcariosa*
Csul *C. sulphurina*
Csy *C. sylvatica*
Ct *C. tenuis*
Cu *C. uncialis*

CAel *Caloplaca elegans*

CANv *Candelariella vitellina*

CANDc *Candelaria concolor*
CANDv *C. vitellina*

CE *Cetraria* spp
CEce *C. cetrarioides*
CEchl *C. chlorophylla*
CEchr *C. chrysantha*
CEcu *C. cucullata*
CEd *C. delisei*
CEe *C. ericetorum*
CEg *C. glauca*
CEh *C. hipatison*
CEi *C. islandica*
CEl *C. laevigata*
CEn *C. nivalis*
CEp *C. pinastri*
CEr *C. richardsonii*
CEt *C. tilesii*

CO *Collema* spp
COc *C. cristatum*

COR *Cornicularia* spp
CORa *C. aculeata*
CORd *C. divergens*

Dm *Dermatocarpon miniatum*

DAa *Dactylina arctica*

Em *Evernia mesomorpha*
Ep *E. prunastri*

FPb *Flavoparmelia baltimorensis*

Hp *Hypogymnia physodes*
Ht *H. tubulosa*

HYb *Hypotrachyna brevirhiza*

L *Lecanora* spp
Lcae *L. caesiorubella*
Lch *L. chloroterae*
Lco *L. conizaeoides*
Lmu *L. muralis*
Lr *L. rubina*
Lu *L. uliginosa*

LApu *Lasallia pustulata*

LEan *Lecidea anthracophila*
LEm *L. macrocarpa*
LEv *L. varians*

LEP *Lepraria* spp
LEPa *L. aeruginosa*

LIp *Lichina pygmaea*

LOp *Lobaria pulmonaria*
LOs *L. scrobiculata*

Nar *Nephroma arcticum*

NPp *Neuphuscelia/Neofuscelia pulla*

NRa *Neuropogon antarcticus*

Pau *Parmelia aurulenta*
Pb *P. borreri*
Pca *P. caperata*
Pcar *P. caroliniana*
Pcet *P. cetrata*

Pch *P. chlorochroa*
Pcons *P. conspersa*
Pcu *P. cunninghamii*
Pfur *P. furfuraceae*
Pg *P. glabratula*
Pga *P. gabina*
Ph *P. hypotropa*
Pl *P. livida*
Po *P. omphalodes*
Pper *P. perforata*
Pph *P. physodes*
Ppr *P. praesorediosa*
Pr *P. rudecta*
Psa *P. saxatilis*
Psu *P. sulcata*
Psub *P. subaurifera*
Pta *P. taractica*
Ptil *P. tiliacea*

PARp *Parmeliopsis placorodia*

PEa *Peltigera aphthosa*
PEc *P. canina*
PEho *P. horizontalis*
PEpr *P. praetextata*

PER *Pertusaria* spp
PERt *P. trachythallina*
PERx *P. xanthodes*

PG *Phaeographis* spp

PH *Physcia* spp
Pha *P. adscendens*
PHai *P. aipolia*
PHm *P. millegrana*
PHo *P. orbicularis*
PHs *P. stellaris*
PHt *P. tenella*

PHYg *Physconia grisea*

PLg *Platismatia glauca*

PLEa *Pleurosticta acetabulum*

PSf *Pseudevernia furfuracea*

PSPb *Pseudoparmelia baltimorensis*

Rc *Ramalina calicaris*
Rfar *R. farinacea*
Rfas *R. fastigiata*
Rfr *R. fraxinea*
Ro *R. obtusata*
Rr *R. reticulata*
Rs *R. scopulorum*
Rst *R. stenospora*

RHCg *Rhizocarpon geographicum*

S *Sticta* spp

SPg *Spaerophorus globosus*

SQc *Squamarina cartilaginea*
SQg *S. gypsacea*

ST *Stereocaulon* spp
STa *S. alpinum*
STpa *S. paschale*
STs *S. saxatile*
STt *S. tomentosum*

Te *Trypethelium eluteriae*

THv *Thamnolia vermicularis*

TR *Trebouxia* (algue de Car)
TRe *T. erici* (algue de Ccr)

TRAi *Trapelia involuta*
TRAo *T. ornata*

UM *Umbilicaria* spp
UMc *U. cylindrica*
UMcr *U. crustulosa*
UMd *U. deusta*
UMhi *U. hirsuta*
Umhy *U. hyperborea*
UMle *U. leiocarpa*
UMly *U. lyngei*
UMmu *U. muhlenbergii*
UMmur *U. murina*
UMn *U. nylanderiana*
UMpo *U. polyphylla*
UMpr *U. proboscidea*
UMpu *U. pustulata*

US *Usnea* spp
USar *U. articulata*
USb *U. barbata*
USd *U. dasypoga*
USfa *U. fastigiata*
USfi *U. filipendula*
USfl *U. florida*
USg *U. globrescens*
USh *U. hirta*
USl *U. longissima*
USst *U. strigosa*

X *Xanthoria* spp
Xa *X. aureola*
Xc *X. calcicola*
Xpa *X. parietina*

XP *Xanthoparmelia* spp
XPs *X. somloensis*
XPta *X. taractica*
XPti *X. tinctina*

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