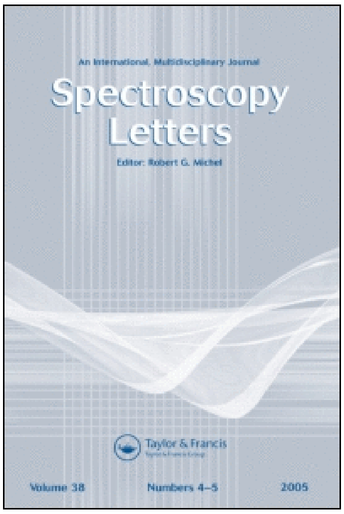

Spectroscopy Letters
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597299

Determination of Heavy Metals in Lichens Growing on Different Ecological Habitats in Schirmacher Oasis, East Antarctica

D. K. Upreti[a]; Vivek Pandey[b]
[a] Lichenology Lab & National Botanical Research Institute, Lucknow, India [b] Stress Physiology National Botanical Research Institute, Lucknow, India

To cite this Article Upreti, D. K. and Pandey, Vivek(2000) 'Determination of Heavy Metals in Lichens Growing on Different Ecological Habitats in Schirmacher Oasis, East Antarctica', Spectroscopy Letters, 33: 3, 435 — 444
To link to this Article: DOI: 10.1080/00387010009350090
URL: http://dx.doi.org/10.1080/00387010009350090

SPECTROSCOPY LETTERS, 33(3), 435–444 (2000)

DETERMINATION OF HEAVY METALS IN LICHENS GROWING ON DIFFERENT ECOLOGICAL HABITATS IN SCHIRMACHER OASIS, EAST ANTARCTICA

Key words: Lichens, Antarctica, ecological habitats, heavy metals.

D. K. Upreti[a]* and Vivek Pandey[b]

[a] Lichenology Lab & [b] Stress Physiology
National Botanical Research Institute, Rana Pratap Marg, Lucknow - 226 001, *India*

Abstract

Twelve lichen species growing on different ecological habitats in East Antarctica were analyzed for Cr, Cu, Fe, Pb and Zn. All the species had consistently higher amounts of Fe and Cu, as their substrata were iron and copper mineralized rocks. The foliose and fruticose lichens had a greater concentration of heavy metals than the crustose ones. Significantly, lead was not detected in any sample indicating that the area is still free from pollution.

1. INTRODUCTION

Lichens are one of the most widely distributed group of organisms in world, ranging from Arctic to Antarctic and from rocky shores of sea to near the summits of the highest mountains. Lichens are efficient accumulators of chemical elements which are taken up from substrate solutions, deposited aerosols, water vapour and rain. Their thalli particularly those with soredia or isidia provide effective surface for uptake [1]. Recent studies suggest that there is global contamination of air, water and soil by trace metals [2]. Several workers have suggested the possible role of lichens in pollution monitoring and biogeochemical studies [3,4].

Until now, mainly foliose or fruticose lichen species, in particular epiphytes and terricolous ones, have been utilized as biomonitors of heavy metals [4]. Furthermore, most of the studies took place in the northern hemisphere and generally in countries with a humid climate. A smaller number of publications exist on the accumulation of airborne heavy metals in lichens growing in arid or semi-arid zones.

Lichens are the major component of the Antarctic terrestrial flora, growing luxuriantly on rocks, boulders, moraine, and decaying cushions of moss (*Bryum* species) tufts in ice-free areas. Data on heavy metal distribution in the Antarctic lichens are very scanty, although some analyses have been done for heavy metals

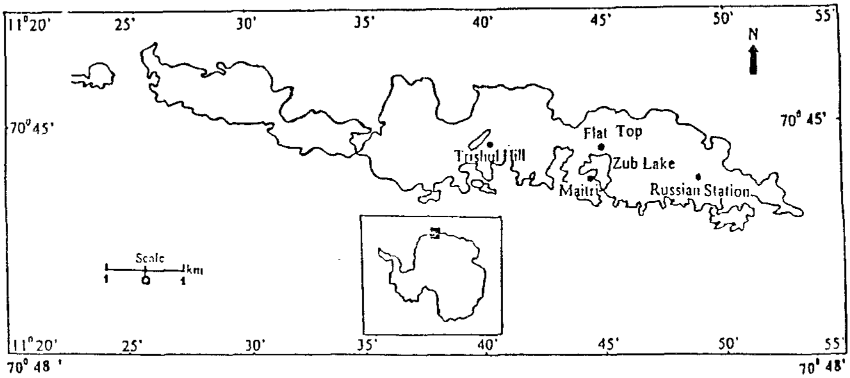

Fig. 1: Localities for Lichen collection in Schirmacher Oasis, East Antarctica

of snow, ice cores [5,6,7], and lichens [8]. The present study will provide a comparative account of metal content of different lichen thalli growing on different ecological habitats, in and around Maitri Station of the Shirmacher Oasis, East Antartica.

2. MATERIALS AND METHODS

The lichen samples were collected from eleven localities in and around the Maitri area, Schirmacher Oasis (area about 34 sq. km.) (Fig. 1). Their substrate and thallus characteristics are given in Table 1. Samples were analysed to determine the concentration of five metals (Cr, Cu, Fe, Pb, and Zn). Whole thalli were collected and transported in hard brown-paper packets. The lichens were

TABLE 1. Source of Lichen Species, their Substrate and Thallus Characteristics

Site	Species	Substrate	Thallus characteristics
	Crustose		
Around Zub lake	1. *Acarospora gwynii* Dodge & Rudolph	Moraine	Thallus squamulose to substipitate, areolate, scattered to continuous, centrally attached, upper surface rugose or smooth to fissured, thick amorphous layer of colourless hyphae on the lower surface.
Near 'Shivling' Nunatak	2. *A. gwynii* Dodge & Rudolph	Rock	
At base of Trishul hill	3. *Buellia grimmae* R. Filson	Moss	Crustose areolate thallus forming granular verruculose mass on moss cushions.
Before Trishul hill	4. *B. pallida* Dodge & Baker	Rock	Flattened to stipitate areolate thallus, forming an umbilicate mass.
North of Zub lake	5. *Lecanora expectans* Darb.	Moss	Granulose, rugose areolate thallus on top of moss tuft.
Near Russian station	6. *L. fuscobrunnea* Dodge & Baker	Rock	Crustose, adnate to substipitate, to squamulose areolate thallus, with well developed erect to prostrate stipes.
Behind flat top	7.*Lecidea cancriformis* Dodge & Baker	Rock	Adnate to substipitate irregularly areolate thallus, with up to 2 mm high stipes, eroded by weathering as it preferably grows on dry, exposed rocks at hill tops on coarse granite boulders.
North of Zub lake	8. *L. siplei* Dodge & Baker	Loose sand or sand-stone	Matty stipitate, areolate crustose thallus on loose sand-stone.
South of Maitri near stream	9. *Rhizocarpon flavum* Dodge & Baker	Rock	Continuous or scattered areolate, minutely verruculose, thallus on rock in dry, as well as, wet places.
Near Russian Station	10. *Rinodina olevaceobrunnea* Dodge & Baker	Moss	Subsquamulose thallus abundantly growing on undulating tuft of *Bryum*.
	Foliose		
east of Maitri	11. *Physcia caesia* (Hoffm.) Hampe	Moss & Moraine	Thallus adpressed, with imbricate overlapping lobes, with black scattered tuft of branhed rhizinate underside.
	Fruticose		
South Walthat mountain area	12. *Usnea antarctica* Du Rietz.	Rock	Thallus erect to subprostrate, with irregularly branched, dense, compactly arranged branches forming a cushion or felt like structure on the rock.

sorted and any particulate matter adhering to it was carefully removed under dissecting microscope. Then samples were washed three times in deionized water by shaking for 15 min. After that they were air dried for 15 hrs. The material was then oven dried to a constant weight at 90 °C. The dried lichen samples (three replicates) were powdered (0.5 g) and digested in mixture of concentrated HNO_3 and $HClO_4$ (V/V 3:1). Residues were filtered and diluted to 100 ml with double distilled water. Metal content in the solution was analysed by using a Perkin-Elmer 2380 Atomic Absorption Spectrophotometer.

3. RESULTS AND DISCUSSION

As indicated in the Table 2, all lichen species collected in and around the Maitri area have consistently higher amounts of iron and copper because of the substratum which is an iron and copper mineralized rock. Substratum play a major role in determining the metal content of lichens[9,10]. It is interesting to note that the levels of iron in muscicolous (moss inhabiting) and cushion forming species of *Lecidea siplei* and *Rinodina olivaceobrunnea* are 17510 ppm and 14240 ppm, respectively. While according to some wokers the presence of a thick mossy mat blocks the direct contact of thalli with soil and hence affected metal availability [11]. The other moss inhabiting species of *Lecanora* and *Buellia* accumulated more metals than their saxicolous (rock inhabiting) species. There could be two reasons for this: i) the dry climate of East Antarctica , and ii) dry nature of rocks

TABLE 2: Heavy Metal Content of Different Lichen Species

Species	Heavy metal content (μg g^{-1} dry wt.)			
	Cr	Zn	Cu	Fe
1. *Acarospora gwynii*	19.28^{e}	12.42^{k}	36.36^{h}	6420$^{d, e}$
2. *A. gwynii*	97.87^{b}	69.09^{d}	124.84^{d}	8560^{c,d,e}
3. *Buellia grimmae*	57.75^{c}	71.83^{c}	395.38^{a}	11290^{b,c}
4. *B. pallida*	54.76^{c,d}	51.05^{g}	138.88^{d}	10070^{b,c,d}
5. *Lecanora expectans*	60.38^{c}	37.44^{i}	53.29^{g}	9420^{c,d}
6. *L. fuscobrunnea*	25.35^{e}	15.86^{j}	59.95^{g}	9820^{b,c,d}
7. *Lecidea cancriformis*	20.72^{e}	44.71^{h}	75.41^{f}	4950^{e}
8. *L. siplei*	56.12^{c,d}	55.44^{f}	237.41^{b}	17510^{a}
9. *Rhizocarpon flavum*	51.08^{c,d}	67.12^{e}	96.56^{e}	10040^{b,c,d}
10. *Rinodina olivaceobrunnea*	46.01^{d}	71.44^{c}	82.33^{f}	14240^{a,b}
11. *Physcia caesia*	106.66^{b}	74.66^{b}	100^{e}	10350^{b,c,d}
12. *Usnea antarctica*	122.39^{a}	111.97^{a}	166.66^{c}	8840^{c,d,e}

Any two means in the column having a common letter are not significantly different at the 5% level of significance [17].

on which lichens were growing. Very high concentration of Fe and Cu have been reported in *Acarospora sinopica* and *Rhizocarpon oederi* growing on the 400 year old hills of slag in smelting works. Same species growing on substrata poorer in metals accumulated smaller contents of those metals, reflecting the concentration of the associated sites[12].

The patterns of metal localization within the different thallial components (rhizinae, medulla, and phycobiont) have been studied and it has been demonstrated that the rhizinae and medulla play an important role in metal accumulation and translocation, especially at higher metal concentration, when the metal uptake capacity of the upper thallial surface is reduced [13]. In the present study, the accumulation of Zn was less, probably due to the fact that some heavy metals (e.g. Zn and Mn) appear to be more mobile and their concentration may not necessarily be in direct relationship with the atmospheric deposition rates [13,14].

In the present study foliose (*Physcia caesia*) and fruticose (*Usnea antarctia*) species accumulated higher quantities of metals than the crustose ones. The possible factor favouring the greater accumulation of metals in these two species, are the formation of felt-like structure on the substratum and the spongy nature due to dense subprostrate thallus lobes or due to dense irregularly branched thallus. Out of the twelve species analysed, only *Physcia caesia* had tufts of branched rhizinae on the whole lower surface. It has been reported that the rhizinae play an important role in determining the accumulation within the thallus by an increase in rhizinal density and acting as a metallic reservoir [13].

Several authors have extensively documented the metal content of terricolous lichen thalli from different ecological situations[3,15,16]. In the present study, the difference in metal accumulation in two samples of same species of *Acarospora gwynii* is probably due to their different habitat. The moraine inhabiting samples have very high levels of metals in comparison to the sample from rocks in slopes.

It is interesting to note that in the present study lead was not detected in all the twelve samples while in an earlier documentation of the heavy metal contents of *Umbilicaria aprina* Nyl. and *U. decussata* (Will.) Zahlbr. collected near the bank of Russian lake, the lead content was quite high [8]. This suggests that the area in and around Maitri station is relatively free from pollution.

ACKNOWLEDGEMENTS

The Senior author is grateful to the Secretary, Department of Ocean Development, New Delhi, to the Director, National Botanical Research Institute, Lucknow for providing this opportunity to work in Antarctica.

REFERENCES

[1] M.R.D. Seaward, Lichens, Silent Witnesses of the Chernobyl Disaster, Inaugural lecture - University of Bradford, 3 March 1992, pp. 1-14.

[2] J.O. Nriagu and J.M. Pacyna, Quantitative assessment of worldwide contamination of air, water and soils by trace metals. Nature, 333 (1988) 134-139.

[3] Y. Tuominen and T. Jaakkola, Absorption and accumulation of mineral elements and radioative nuclides. in V. Ahmadjian and M.E. Hale (Eds), The Lichens. Academic Press, New York, 1973, pp 185-223.

[4] J. Garty, Lichens as biomonitors of heavy metal pollution, in B. Markert (Ed.), Plants as Biomonitors: Indicators for Heavy Metals in the Terrestrial Environment, VCH Verlagsgesellschaft mbH, Germany, 1993, pp 193-263.

[5] V.N. Nizampurkar, Glaciologial studies in Antarctica. Fifth Indian Expedition to Antarctica, Scientific Report, Department of Ocean Development, Technical Publication No. 5, 1988, pp 219-224.

[6] V.N. Nizampurkar and D.K. Rao, Polar fallout of radioisotopes ^{32}Si, ^{7}Be, ^{210}Pb, ^{137}Cs and ^{239}Pu at Dakshin Gangotri, Antarctica. Fifth Indian Expedition to Antarctica, Scientific Report, Department of Ocean Development, Technical Publication No. 5, 1988, pp 181-188.

[7] A.L. Dick, D.S. Sheppard and J.E. Patterson, Mercury content of Antarctic surface snow: Initial results. Atmospheric Pollution, 24A (1990) 973-978.

[8] D.K. Upreti and V. Pandey, Heavy metal contents of Antarctic lichens I. *Umbilicaria* Feddes Repertorium, 105 (1994) 197-199.

[9] I.M. Brodo, Substrate Ecology, in V. Ahmadjian and M.E. Hale (Eds), The Lichens, Academic Press, New York, 1974, pp 401-441.

[10]J.H.H. Looney, K.A. Kershaw, E. Nieboer, C. Webber and P.I. Stetsko, The distribution of Uranium and companion elements in lichen health associated with undisturbed Uranium deposits in the anadian Arctic, in D.H. Brown (Ed.), Lichen Physiology and Cell Biology. Plenum Press, New York, 1985, pp 193-209.

[11]R. Goyal and M.R.D. Seaward, Metal uptake in terricolous lichens I. Metal localization within the thallus. New Phytol., 89 (1981) 631-645.

*[12]O.L. Lange and H. Ziegler, Der Shwermetallgehalt von Flechten aus dem *Acarosporetum sinopicae* auf Erzhlackenhalden des Harzes. Mitt. florsoziol Arbeits Gemeinsch, 10 (1963) 156.

[13]R. Goyal and M.R.D. Seaward, Metal uptake in terricolous lichens II. Effects on the morphology of *Peltigera canina* and *Peltigera rufescens*. New Phytol., 90 (1982) 73-84.

[14]K.G. Puckett, E. Nieboer, M.J. Gorzynski and D.H.S. Richardson, The uptake of metal ions by lichens : A modified ion-exchange process. New Phytol., 72 (1973) 329-342.

[15]D.N. Rao, G. Robitaille and F. LeBlanc, Influence of heavy metal pollution on lichens and bryophytes. J. Hattori Bot. Lab., 42 (1977) 213-239.

[16]M.R.D. Seaward, R. Goyal and E.A. Bylinska, Heavy metal contents of some terricolous lichens from mineral-enriched sites in northern England. Naturalist, 103 (1978) 135-141.

---

* not seen in original

[17]K.A. Gomez and A.A. Gomez, Statistical Procedures for Agricultural Research, John Wiley and Sons, Inc., New York, 1984.

Date Received: February 20, 1999
Date Accepted: August 20, 2000