Current Research in Environmental & Applied Mycology 8(2): 282–289 (2018) ISSN 2229-2225

www.creamjournal.org

Article

Doi 10.5943/cream/8/2/11

Heavy metals accumulation by epiphytic foliose lichens as bio-monitors of air quality in Srinagar city of Garhwal hills, Western Himalaya (India)

Singh P[1], Singh PK[2], Tondon PK[3] and Singh KP[1]

[1]*Botanical Survey of India, Central Regional Centre, Allahabad 211 002((India)*
[2]*Environment Science Division, School of Applied Science, Babu Banarasi Das University, Lucknow 226008(India)*
[3]*Department of Botany, Lucknow University, Lucknow 226001(India)*

Singh P, Singh PK, Tondon PK, Singh KP 2018 – Heavy metals accumulation by epiphytic foliose lichens as biomonitors of air quality in Srinagar city of Garhwal hills, Western Himalaya (India). Current Research in Environmental & Applied Mycology 8(2), 282–289, Doi 10.5943/cream/8/2/11

Abstract

The research aims to assess the degree of accumulation of six heavy metals *e.g.,* iron (Fe), chromium (Cr), copper (Cu), zinc (Zn), lead (Pb) and nickel (Ni) by epiphytic foliose lichen species(*Canoparmelia texana, Pyxine subcineria* and *Phaeophyscia hispidula*) in a polluted area of Srinagar city and its surroundings in the Garhwal hills of the Western Himalaya. Srinagar city is one of the largest towns situated in Garhwal hills through which National highway 58 (NH58) passes and ends at Mana pass that cause atmospheric pollution due to emissions from heavy vehicular traffic activity throughout the year. Results indicated that *Canoparmelia texana* was least accumulated to Fe, Zn, Cr and Cu than the *Pyxine subcineria* and *Phaeophyscia hispidula* where heavy metals were significantly increased due to exposure of pollutants while *Pyxine subcineria* showed maximum accumulation. Pb and Ni were not detected in *Canoparmelia texana.* Heavy metal concentrations were ranked in order to Fe > Zn > Cu > Cr > Pb > Ni in the studied lichen species. *Canoparmelia texana*,a foliose lichen was sensitive and found in Kandolia forest area where minimum exposure of pollution was found while *Phaeophyscia hispidula* and *Pyxine subcineria* were tolerant species that accumulated significantly different level of heavy metals as per exposure of pollution level. Thus, foliose lichens indicated air quality levels in different areas of Srinagar city.

Key words – Air Pollution – Bioindicator – Concentration – Lichen

Introduction

Heavy metal pollution is a very severe environmental problem due to persistent and non-biodegradable properties of these contaminants in any medium. Lichens are slow growing symbiotic organisms which have been widely used as long term bio-monitors of air quality since 1866 (Kricke & Loppi 2002) and highly sensitive to environmental changes especially to air pollution. The luxuriant growth of foliose lichens in the area clearly indicates that area is free from pollution. Epiphytic foliose lichens have different sensitivity to specific pollutants, only tolerant species may persist in polluted environment, whereas sensitive species would disappear. Such

Submitted 20 February 2018, Accepted 1 April 2018, Published 5 April 2018
Corresponding Author: Singh P.K. – e-mail – singh_p_kumar@rediffmail.com

species are valuable indicators of air quality (Seaward 2004). Thus, biological monitoring may be very effective as an early warning system to detect environmental changes (Garty 2001).

The present study was undertaken to determine the degree of accumulation of heavy metals by foliose lichen species (*Canoparmelia texana*, *Pyxine subcineria* and *Phaeophyscia hispidula*) and to assess the contamination of these metals in atmospheric environment of Srinagar city and its surroundings in the Garhwal hills of the Western Himalaya. In India, some workers (Dubey et al. 1999, Saxena et al. 2007, Shukla & Upreti 2007a, b, 2008, 2009, Shukla et al. 2010) have reported that lichens are most useful bio-indicators of air pollution. Shukla & Upreti (2007) also studied the effects of pollution on the physiology of the lichen species- *Phaeophysia hispidula* from Srinagar.

Srinagar (Fig. 1) is one of the largest towns situated in the lap of Garhwal hills of Western Himalaya. National Highway-58 passes through Srinagar which ends at Mana pass. Atmospheric pollution has been a major environmental problem in Srinagar city (Shukla & Upreti 2007b) and its surroundings due to emissions from heavy vehicular traffic activity throughout the year which increases in the months April to September because of thousands of 'pilgrims' pass through this city to visit the holy places like Tungnath, Kedarnath, Badrinath, and Hemkund. Srinagar city is a main halt point for pilgrims to stay over here. It is one of the fastest growing cities in the Garhwal Himalaya. In the past few years, the city has expanded rapidly in terms of construction, tourism, number of automobiles, leading to the deterioration of air quality.

Fig. 1 – Map showing lichen collection sites in Srinagar city and its surrounding (Garhwal), Uttaranchal, India Red dot indicating lichen collection site and Yellow line NH 58. Site-1(Residential area), Site-2. (Garhwal University administrative area garden), Site-3 (Banswara), Site-4 (Srikot), Site- 5(on way to Srikot) and Site- 6 (Kalyasaur).

Materials & Methods

Srinagar is a largest city (30°13 N 78° 47 30.22° N 78.78° E) situated at the left bank of Alaknanda River in Pauri district of Uttarakhand. It has an average elevation of 560 m. Three different species of foliose lichen (*Canoparmelia texana, Pyxine subcineria* & *Phaeophyscia hispidula*) samples were collected from seven different sites *i.e.*, Kandolia forest area, Residential area, Garhwal University administrative area garden, Banswara, Srikot (main road), on way to Srikot (main road), Kalyasaur (main road) (Table 1). The fresh lichen samples were collected along with the substrate to prevent the damage of the thallus from non-polluted and polluted site of Srinagar and its surroundings, growing on the bark of *Aauracaria heterophylla, Mangifera indica*, *Melia azedarach* and *Ailanthus excela* where vehicular activity and human interferences were maximum The collected lichen specimens were identified and authenticated following Awasthi (2007). The voucher specimens were deposited in the lichen herbarium BSA.

Table 1 Sources of lichen material collected from different sites and exposure of traffic.

Sl. No.	**Sampling sites [m]**	**Altitude**	**Lichen species**	**Substrate**	**Site direction**
1.	Kandolia (forest)	1800 m	*Canoparmelia texana*	*Pinus roxburghii*	200 m away from road side
2.	Residential area (garden)	560 m	*Pyxine subcineria*	*Mangifera indica*	100 m away from road side
3.	Garhwal University administrative garden area	560 m	*Phaeophysia hispidula*	*Aaucaria heterophylla*	20 m away from road side
4.	Banswara (Main road)	560 m	*Phaeophysia hispidula*	*Ailanthus excelsa*	3 m away from road side
			Pyxine subcineria	*Ailanthus excelsa*	3 m away from road side
5.	On way to Srikot (main road)	560 m	*Pyxine subcineria*	*Melia azedarach*	2 m away from road side
6.	Srikot (main road)	560m	*Pyxine subcineria*	*Mangifera indica*	2 m away from road side
7.	Kalyasaur (main road)	590 m	*Pyxine subcineria*	*Mangifera indica*	2 m away from road side

Heavy metal analysis

Collected lichens (thalli) were cleaned, oven-dried at 70 ºC for 48 hrs. The dried lichen samples were ground to powdered and 0.5 g of sample was digested in a diacid mixture (HNO_3 + $HCIO_3$) in 3:1 v/v ratio on hot plate under controlled temperature for estimation of Fe, Cr, Zn, Cu, Pb and Ni (Piper 1967). Residues were filtered through filter paper Whatmann no. 42. The analysis of heavy metals concentration in digested sample of lichens was done by Atomic Absorption Spectroscopy (AAS, Model GBC Avanta-Sigma, Australia). Hollow cathode lamps (Varian) for respective metals were used at a working current ranging from 5-30 m A with 213.9-357.9 nm spectral line.

Statistical Analysis

The data analysis was subjected to one way Analysis of Variance (ANOVA) using statistical program Sigma State 3.5. Fisher LSD method followed for all pair wise multiple comparisons. The difference in mean values among the different groups were found to be significant ($P= <0.001$) and represented in the form of mean ± SEM (Standard Error Mean).

Results and Discussions

Result indicated that heavy metal contents in three different foliose lichen species *i.e., Canoparmelia texana*, *Pyxine subcineria* and *Phaeophyscia hispidula* were accumulated in order to Fe > Zn > Cu > Cr >Pb> Ni (fig.2). The concentration of Fe ranged from 1947.6 - 3543.2 µg g^{-1} dry weight (d wt) in *Pyxine subcineria* which was maximum while in *Phaeophyscia hispidula,* it was ranged from 2018.6-2831.2 µg g^{-1} d wt (Table 2) but in *Canoparmelia texana* concentration of Fe was found least (1308.6 µg g^{-1} d wt). *Canoparmelia texana* was collected from Kandolia forest where there was least exposure of air pollution while two other species collected from Srinagar and its surroundings were exposed to maximum air pollution (main road side) due to emissions from heavy vehicular traffic activity throughout the year. The accumulation of Fe was significantly variable ($P= <0.001$) as per exposure of pollutants in different sites. Similar observation regarding

Fe accumulation in lichen was also reported by some workers (Kinalioglu et al. 2006, Shukla & Upreti 2007b, Saxena et al. 2007) in different areas. Increased accumulation of Fe in thallus of lichen may be one of the tolerant mechanisms that directly affect to photosynthetic pigments. Fe showed high correlation with Cr (Table 2). Nimis et al. (2000) reported high Fe concentration in *Xanthoria parietina* and high Fe concentrations were explained on the basis of the dominance of siliceous rocks while NG et al. (2005) stated that accumulated heavy metals in lichen predominantly derived from atmosphere and was not influenced by splash or suspension of soil particulate.

Table 2 Heavy metals accumulated in *Canoparmelia texana*, *Phaeophyscia hispidula* and*Pyxine subcineria* collected from various polluted sites of Srinagar city.

Sites	**Lichen species**	**Heavy metals concentration (µg g^{-1} dry weight)**					
		Fe	**Cr**	**Cu**	**Zn**	**Pb**	**Ni**
Kandolia (forest)	*Canoparmelia texana*	1308±7.26	6.67±0.71	7.93±0.98	95.62±3.25	ND	ND
Residential area (garden)	*Pyxine subcineria*	2939.2±8.43	ND	10.38±1.42	144.81±6.64	1.12±0.30	ND
Garhwal Univ. administrative area garden	*Phaeophysia hispidula*	2018.6±8.01	ND	24.39±1.85	121.22±7.15	19.42±0.31	3.94±0.33
Banswara (Main road)	*Phaeophysia hispidula*	2831.2±8.19	13.48±1.07	14.31±0.99	163.4±5.14	6.98±0.69	ND
	Pyxine subcineria	3507.2±9.44	33.22±1.35	12.31±0.94	151.1±7.304	31.42±4.96	ND
On way to Srikot (main road)	*Pyxine subcineria*	3231.2±9.14	9.46±0.66	18.12±1.44	116.68±7.04	24.9±3.38	ND
Srikot (main road)	*Pyxine subcineria*	1947.6±7.67	1.39±0.26	20.13±1.44	107.82±4.35	21.3±2.49	0.75±0.02
Kalyasaur (main road)	*Pyxine subcineria*	3543.2±10.1	10.21±0.5	18.12±1.35	262.24±6.06	17.02±2.10	ND
LSD$_{(\alpha= 0.05)}$		**25.68**	**2.19**	**3.85**	**18.07**	**7.43**	**NS**

ND = Not detected; NS= Non significant; ± showed standard error mean (SEM); All statistically significant difference (P<0.001)

Cr content was not detected in *Pyxine subcineria* and *Phaeophyscia hispidula* from residential and Garhwal University administrative area garden while in other areas Cr was significantly variables in all lichen samples. The highest Cr uptake was determined from *P. subcineria* species at Banswara site. Cr accumulation in thalli of different samples of lichen ranged from 1.39 – 33.22 µg g^{-1} d wt. That was agreement with Saxena et al. 2007, Shukla & Upreti 2007b, Aslan et al. 2011. Cr was showed highest correlation with Zn (Table 3).

Concentration of Cu was ranging from 7.93 – 24.39 µg g^{-1} d wt. Least Cu concentration was observed in *Canoparmelia texana* while in other species of lichens Cu was significantly variable as exposure of pollutants. Cu showed high correlation with Ni. Concentration of Zn was ranging from 95.62-262.24 µg g^{-1} d wt which was agreement with Shukla & Upreti 2007. Least Zn concentration was observed in *Canoparmelia texana* while in other species of lichen Zn was significantly variable as per exposure of pollutants. According to Harte et al. (1991) Zn level may be elevated near motorways due to tyre wear.

Leaded petrol and diesel contain high level of lead (Pb) while the unleaded pertrol emission contains lead in a lesser level (Aslan et al. 2011). The combustion of leaded petrol released Pb into the atmosphere where it could cause lead poisoning. Therefore, Pb is the main pollutant from traffic activities. The concentration of Pb in the lichen samples collected from the sample sites ranged from 1.12- 31.42 µg g^{-1} d wt. The highest Pb (up to 31.42 µg g^{-1} d wt) uptake was found in *Pyxine*

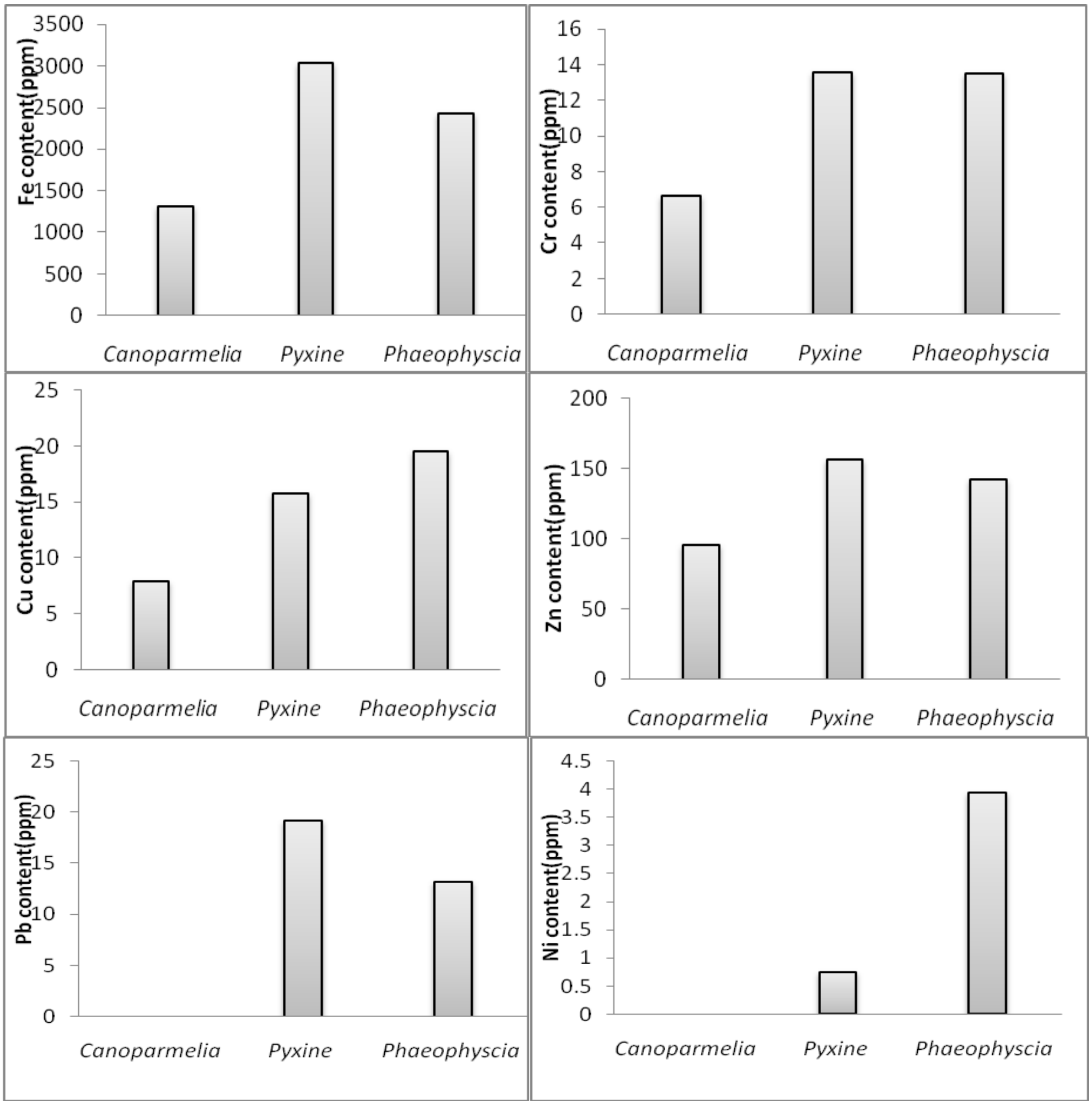

Fig. 2 – Average heavy metal contents in different species of foliose lichens exposed in different areas of Srinagar city, Garhwal hills.

Table 3 Pearson correlation coefficients between element pairs.

	Fe	Cr	Cu	Zn	Pb	Ni
Fe	1	0.527*	-0.0479	0.762**	0.429	-0.483
Cr		1	0.0723	0.515*	0.347	-0.588
Cu			1	0.299	0.275	0.517*
Zn				1	0.0714	-0.343
Pb					1	0.234
Ni						1

Note; *high correlation ** very high correlation *subcineria* at Banswar site while concentration of Pb was not detected at Kandoliya forest. The Pb concentration in the lichen samples taken from the area of Srinagar city has high as compared to Kandoliya forest due to the deposition of Pb from the exhaust of vehicles. Lead is listed by Goyer & Clarkson (2001) as a major toxic metal that causes multiple effects in human beings. Constant and excessive exposure to Pb (> 5 ppm) pollution may result in chronic or neuropathy especially in children (WHO 2001). Metal contents in lichens are with agreements of other workers (Allen-Gil et al. 2003, Di Lella et al. 2004). Ni was not detected except in Garhwal University administrative area garden (3.94 μg g^{-1} d wt) and Srikot main road (0.75 μg g^{-1} d wt). One of the sources of emission of Pb and Zn is motor vehicles. Zn exists as alloys in accumulators of motor vehicles or in carburetors and released as combustion product. The body of motor vehicle is galvanized and Zn oxides are also released by wear and tear on car tyres (Bereket & Yücel 1990, Bloemen et al. 1995). Elevated concentrations of these elements may therefore have been caused by effects of high traffic density (Kutbay & Kilinc 1991, Turkan et al. 1995)

The normal level of Fe, Zn, Cu, and Pb in lichens growing in uncontaminated areas have been reported to vary in ranges 50-250 μg g^{-1} d wt, 20-100 μg g^{-1} d wt, 5-20 μg g^{-1} d wt and 2-10 μg g^{-1} d wt respectively (Markart 1992, 1994, Aksoy & Öztürk 1996). Taking these values into account, the result of present study showed that the area is polluted by Pb, Zn, Fe, Cu and Cr which was higher than the reported values. Pandey et al. (2002) stated that thallus play an important role in determining the accumulation of heavy metals. Kinalioglu et al. (2006) reported three genera of foliose lichen i.e., *Collema, Dermatocarpon and Xanthoria* are best accumulator of heavy metal as compared to other species. McCune (1997) also stated that these genus are heavy metal tolerant which is agreement with our study that *Pyxine subcineria* and *Phaeophyscia hispidula* can be used as biomonitoring.

Conclusion

The results represent the first study of heavy metals in epiphytic lichens growing in and around Srinagar city near the roadside where the high traffic density take place throughout the year. The present survey showed that the concentrations of all six elements Pb, Zn, Fe, Cu, Ni and Cr in foliose lichens to accumulate varying degree of heavy metals due to emissions from heavy road traffic in the city. The concentration of these heavy metals was analyzed. The maximum values of Fe, Zn and Pb were reported from the lichen samples in the study area. The heavy metals accumulation in the lichen samples collected from the roadside of National Highway 58 have high concentration of Pb, Zn, Fe, Cu and Cr as compared to Kandoliya forest. The results of the study showed the high concentration of Fe metal at sample sites originates from various anthropogenic activities including vehicular traffic, construction and fossil fuel burning. Due to high traffic pollution only two foliose species *viz*. *Pyxine subcineria* and *Phaeophyscia hispidula* were resistant and found growing on the bark of *Mangifera india, Melia azedarach, Ailanthus excelsa*, *Aurucaria heterophylla* where as none of the lichen species were found on the bark of *Pinus roxburghii* which were dominant there. *Pinus* has an acidic bark and good substrata for epiphytic lichen species. Kandoliya forest about 40 km away from Srinagar city are dominated with trees of *Pinus roxburghii* and harbors luxuriant growth of epiphytic lichens. Present study also showed that traffic pollution affects the bark of trees that influence epiphytic lichen composition and most of the sensitive lichen species are unable to survive in such severe conditions. The present study revealed that the area is polluted by Fe, Pb, Zn and Cu elements and foliose lichen species *Pyxine subcineria* and *Phaeophyscia hispidula* were the most excellent accumulator of heavy metals. The result of this work will be useful for future studies of lichens to determine atmospheric pollution in the study area and other areas as well.

Acknowledgments

The authors are thankful to Director, Botanical Survey of India, Kolkata for providing facilities. Two of the authors, KPS and PS are thankful to the NASI and Science and Engineering

Research Board (SERB), New Delhi under N-PDF scheme (PDF/2016/002035) respectively for their financial assistance.

References

Aksoy A, Öztürk M. 1996 – *Phoenix dactylifera* L. as bio monitor of heavy metal pollution in Turkey. Journal of Trace and Microprobe Technology 14, 605–614.

Allen-Gil SM, Ford J, Lasorasa BK, Monetti M, Vlasova T, Landers DH. 2003 – Heavy metal contamination in the Taimyr Peninsula, Siberian Arctic. Sci. Total Environ. 301, 119–138.

Aslan A, Çiçek A, Yazici K, Karagöz Y et al. 2011 – The assessment of lichens as bioindicator of heavy metal pollution from motor vehicles activities. African Journal Agriculture Research 6, 1698–1706.

Awasthi DD. 2007 – A compendium of the Macrolichens from India, Nepal and Sri Lanka. Bishen Singh Mahendrapal Singh, Dehradun.

Bereket G, Yücel E. 1990 – Monitoring of heavy metal pollution of traffic origin in Eskischer. Turkey Journal of Chemistry 14, 266–271.

Bloemen ML, Markert B, Leith H. 1995 – The distribution of Cd, Cu, Pb and Zn in top soils of Osnabruck in relation to landuse. Science Total Environment 166, 75–82.

Di Lella LA, Frati L, Loppi S, Protano G, Riccobono F. 2004 – Environmental distribution of Uranium and other trace elements at selected Kosovo sites. Chemosphere 56, 861–865.

Dubey AN, Pandey V, Upreti DK, Singh J. 1999 – Accumulation of lead by lichens growing in and around Faizabad, UP, India . Journal of Environmental Biology 20, 223–225.

Garty J. 2001 – Biomonitoring atmospheric heavy metals with lichens: theory and application. Critical Review of Plant Science 20, 309–371.

Goyer RA, Clarkson TW. 2001 – Toxic effects of metal In: CS Klaassen (eds), Casarett and Doull’s Toxicology: The Basic Science of Poisons, McGraw-Hill Medical Public Division, New York, pp 811–867.

Harte J, Holdren C, Schneider R, Christine S. 1991 – Toxics A to Z A guide to everyday pollution hazards Berkeley University of California Press.

Kinalioglu K, Horue A, Kutbay HG, Bilgin A, Yalcin E. 2006 – Accumulation of some heavy metals in lichens in Giresun city Turkey. Ekologia (Bratis lava) 25 (3), 306–313.

Kricke R, Loppi S. 2002 – Bioindication: The IAP Approach. In PLNimis, C Scheidegger and PA Wolseley (eds), Monitoring with lichens 21–37. NATO Science Series IV,vol 7 Dordrecht. Kluwer Academic Publishers.

Kutbay H G, Kilinc M. 1991 – Heavy metal pollution in plants growing along motor roads. In Ozturk, MA Erdem U, Gork G (eds) Urban Ecology, Ege University Press, Izmir pp. 62–66.

Markart B. 1992 – Presence and significance of naturally occurring chemical elements of the periodic system in plant organism and consequences for future investigations on inorganic environmental chemistry in ecosystem. Vegetation103, 1–30.

Markart B. 1994 – Plant as biomonitors-Potential advantage and problems. In Adriano DC, Chen ZS, Yang SS(ed) Biogeochemistry of trace elements. Science and Technology, Letters, North wood pp. 601–603.

McCune B, Dey J, Peck J, Heiman K, Will-Wolf S. 1997 – Regional gradients in lichen communities of the south east United States. Bryologist 100, 145–158.

NG OH, Tan BC, Obbard JP. 2005 – Lichens as bioindicators of atmospheric heavy metal pollution in Singapore. Environmental Monitoring Assessment 123, 63–74.

Nimis PL, Lazzarin G, Lazzarin A, Skert N. 2000 – Biomonitoring of trace elements with lichens in Veneto (NE Italy). Science Total Environment 255, 97–111.

Seaward MRD. 2004 – The use of lichens for environmental impact assessment. Symbiosis 37: 293–305.

Saxena S, Upreti DK, Sharma N. 2007 – Heavy metal accumulation in lichens growing in north side of Lucknow city, India. Journal of Environmental Biology 28, 49–51.

Pandey V, Upreti DK, Pathak R, Pal A. 2002 – Heavy metal accumulation in lichens from the Hetauda industrial area Narayani zone Makwanpur District, Nepal. Environmental Monitoring Assessment 73, 221–228.

Piper CS. 1967 – Soil Plant analysis. Asia Publishing House, Bombay.

Shukla V, Upreti DK. 2009 – Polycyclic aromatic hydrocarbon (PAH) accumulation in lichen, *Phaeophyscia hispidula* of Dehradun city, Garhwal Himalayas. Environmental Monitoring Assessment 149, 1–7

Shukla V, Upreti DK. 2007a – Physiological response of the lichen *Phaeophyscia hispidula* (Ach.) Essl., to the urban environment of Pauri and Srinagar (Garhwal), Himalayas, India. Environ Pollution 150 (3), 295–299.

Shukla V, Upreti DK. 2007b – Heavy Metal Accumulation in *Phaeophyscia hispidula* En Route to Badrinath, Uttaranchal, India. Environmental Monitoring Assessment 131, 365–369.

Shukla V, Upreti DK. 2008 – Effect of metallic pollutants on the physiology of lichen, *Pyxine subcinerea* Stirton in Garhwal Himalayas. Environmental Monitoring Assessment 141, 237–243.

Shukla V, Upreti DK, Patel DK, Tripathi R. 2010 – Accumulation of polycyclic aromatic hydro carbons in some lichens of Garhwal Himalayas, India. International Journal of Environment Waste Management 5, 104–113.

Turkan I, Henden E, Celik U, Kivilcin S. 1995 – Comparison of moss and bark samples as a biomonitors of heavy metals in a highly industrialized area in Izmir, Turkey Science Total Environment 166, 61–67.

WHO. 2001 – Air Quality Guidelines for Europe. http://www.euro.who.int/document/e71922.pdf