

Heavy metal accumulation in lichens growing in north side of Lucknow city, India

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Abstract: Accumulation of Pb, Fe, Cr, Zn, Cd, Ni, Cu and Hg metals in six common lichen species growing on *Mangifera indica* trees in mango orchard surrounding the north side of the Lucknow city, were analyzed. The study revealed the higher concentration of Pb (3.3 – 15.6 $\mu\text{g g}^{-1}$), Cr (25.6 – 137.5 $\mu\text{g g}^{-1}$), Zn (49.4 – 219.7 $\mu\text{g g}^{-1}$), Cu (10.2 – 66.6 $\mu\text{g g}^{-1}$) and Fe (1748 – 19374 $\mu\text{g g}^{-1}$).

Key words: Lichens, Heavy metals, Lucknow, India

Introduction

Lichens are used as terrestrial biomonitors and bioindicators of air pollution worldwide and are recognized as more sensitive to pollution than other plants (Nimis *et al.*, 2002). The mechanism of the high accumulation of metals in lichens involves a physicochemical process occurring in the cell walls of mycobiont, which does not normally disturb the metabolism of the lichens. This would explain why lichens could tolerate elevated metal contents (Tuominen and Jaakola, 1973).

Only a few reports regarding metal accumulation in Indian lichens are available (Das *et al.*, 1986; Dubey *et al.*, 1999). With increasing industrial and atmospheric pollution in the urban areas, it is important to document information on the concentration of heavy metals in lichens occurring around major cities of the country. In the present study the level of eight heavy metals Pb, Fe, Cu, Cr, Cd, Zn, Ni and Hg were determined in six lichen species in the north of Lucknow city.

Materials and Methods

Six epiphytic lichen species *Arthopyrenia nidulans* Mull. Arg. (Coll.no.01-76837), *Bacidia submedialis* (Nyl.) Zahlbr. (Coll.no. 01-76842), *Lecanora leprosa* Fée (Coll.no. 01-76850, 01-76851), *Phaeophyscia orbicularis* (Neck) Moberg (Coll.no. 01-76831), *Pyxine cocoes* (Swartz) Nyl. (Coll.no. 01-76825, 01-76830) and *Sphinctrina anglica* Nyl. (Coll.no.76852), were collected in the month of December, 2001 on *Mangifera indica* (a common tree, bearing lichens) at 8 sites, with in 15 km of Lucknow city (Fig. 1). Collected lichen samples were identified using colour tests, microcrystallography, thin layer chromatography (Walker and James, 1980), morphological and anatomical characteristics. A voucher specimen of each species was deposited in the lichen herbarium of National Botanical Research Institute, Lucknow.

The collected lichens were sorted and any adhering particulate matter was carefully removed. The material was oven

dried to a constant weight at 90°C. The dried lichen samples were digested in a mixture of conc. HNO₃ and HClO₄ (v/v 9:1) in glass beakers on a hot plate. The solution was filtered through Whatman filter paper No. 42. The digested solution was diluted to 25 ml with double distilled water. Cu, Zn, Cr, Pb, Fe, Hg, Cd and Ni content of the solution were analysed with a Perkin-Elmer 2380 atomic absorption spectrophotometer.

Results and Discussion

It is evident from the Table 1 and 2 that most of the metals in the lichens originated from vehicular exhaust. *A. nidulans* accumulated higher levels of almost all the metals analyzed. The largest amount of Fe was found in *Phaeophyscia orbicularis*, followed by *A. nidulans*. Zinc, chromium and lead showed least concentration at site 2 and 8 which were away from motorway. Maximum accumulation of Zn occurred at site 5, near motorway in *A. nidulans* followed by *B. submedialis*. Cadmium and nickel showed least variation in concentration between the lichen species. Cadmium was not detected or only present in traces (0.47 and 0.36 $\mu\text{g g}^{-1}$) in *P. cocoes* and *L. leprosa* at sites 2 and 4, respectively.

Maximum nickel occurred at sites 3 and 2 in *Phaeophyscia orbicularis* and *P. cocoes* followed by *L. leprosa*. Cu content was maximum in *A. nidulans* growing on the roadside trees followed by *B. submedialis*. Hg showed least variation in most of the species and its concentration was quite low in lichens collected from sites away from motorway.

The epiphytic lichen genera analyzed for their metals exhibited different morphology. *P. cocoes* and *P. orbicularis* have leafy thalli while *A. nidulans*, *B. submedialis*, *L. leprosa* and *S. anglica* were crustose. The crustose forms again varied in their morphology. The thallus of *Arthopyrenia* and *Lecanora* was areolate whereas *Bacidia* has granular and *Sphinctrina* has smooth thallus. The thallus lobes of *Pyxine* were compactly

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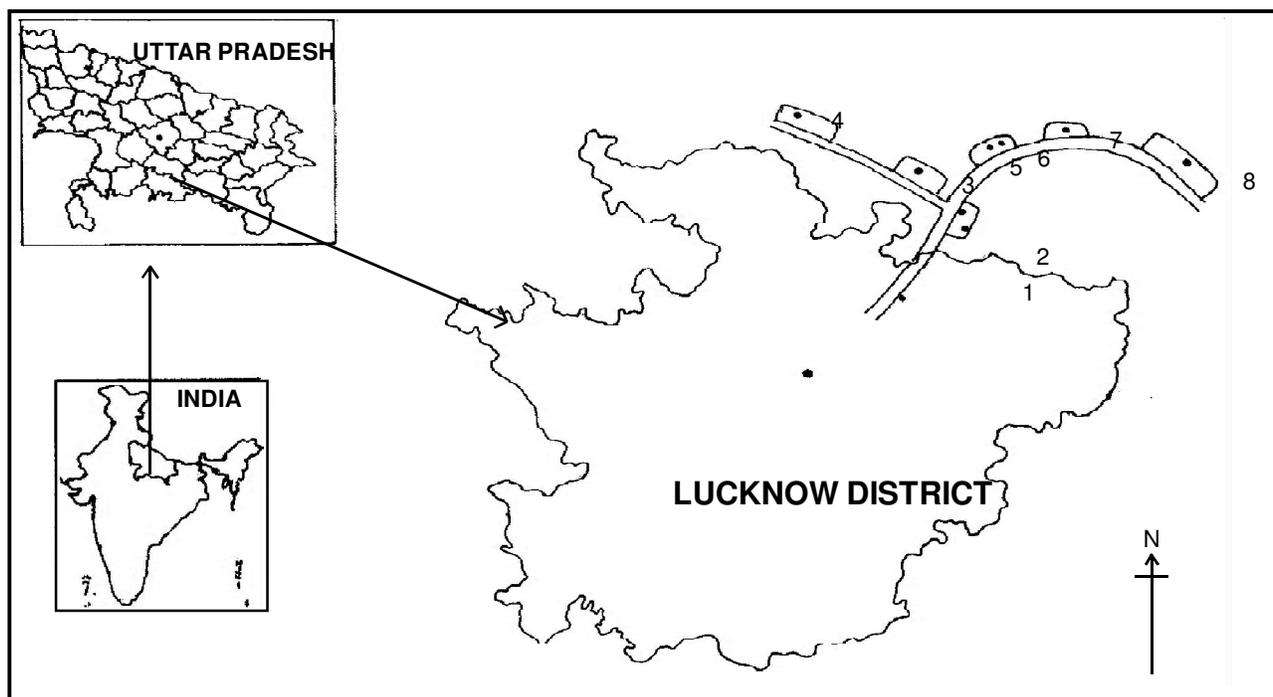


Fig. 1: Map showing lichen collection in the surrounding areas of Lucknow; 1. Palka, field facing, 2. Palka, road facing, 3. Palka, just inside from the main road, 4. 4 km inside from the main road of Palka, 5. & 6. Behta, near road side, 7. Seiva Village, 8. Kaul Foundation Research Centre

addressed to the substratum while the *Phaeophyscia* has dense rhizinal growth on the lower side.

According to Goyal and Seaward (1982) morphological and histological characteristics especially of the rhizinae and medulla affect metal accumulation within the thallus. In the present study *P. orbicularis* exhibited high level of Fe ($19374 \mu\text{g}\text{g}^{-1}$). These values are in perfect agreement with Pandey *et al.* (2002) for Fe accumulation in *P. hispidula* ($23035 \mu\text{g}\text{g}^{-1}$) of Hetauda industrial area of Narayani Zone, Nepal. The particulate uptake enhancement may be attributed to its morphology. The dense network of rhizinae on the whole lower surface may play an important role in determining the accumulation by acting as trap for metal rich particles. *P. orbicularis*, which grows near the base of mango trees, may be effective at accumulating airborne particles of soil.

Lichens also have a great affinity for binding soluble Fe (Puckett *et al.*, 1973). All the lichen species in the present study accumulated high quantities of Fe ranging from 1570 - $19374 \mu\text{g}\text{g}^{-1}$ probably both as soluble ions and particulate.

The combustion of fuel, pesticides, tetraethyl and tetramethyl lead together with battery manufacturing units, sewage effluents, cables, paints, glazing of ceramic, PVC industries are the main source of lead contamination in the environment. The concentration of Pb in most of the species of the area showed the least variation ranging from 3.1 - $6.0 \mu\text{g}\text{g}^{-1}$. A slightly higher (10 - $15.8 \mu\text{g}\text{g}^{-1}$) concentration of Pb was found in *A. nidulans*, *P. coccoides* and *L. leprosa* growing at site near motorways where generator sets operated water pumps for irrigation of orchards were used. In the present study Pb

concentration of *P. coccoides* (3.3 - $10.6 \mu\text{g}\text{g}^{-1}$) shows close similarity with *D. confluens* (0.90 - $6.00 \mu\text{g}\text{g}^{-1}$) in and around Faizabad, U.P., India as reported by Dubey *et al.* (1999). *Dirinaria* and *Pyxine*, both lichen genera have more or less similar morphology.

According to Nriagu and Pacyna (1988) chromium and copper are emitted in the atmosphere due to the oil combustion by generator sets, diesel vehicles and coal combustion. In the study area the Cr and Cu content were also higher at sites near motorways and orchards. Crustose lichens accumulated higher levels of Cr than foliose one. The Zn content in most of the lichens along motorways was higher, maximum concentration of Zn ($219.7 \mu\text{g}\text{g}^{-1}$) was found in *A. nidulans* growing on small young mango trees in the vicinity of a motorway. According to Ward and Brooks (1988) the main source of zinc in and around road soil is the oil brake pads and particles emitted by automobile tires.

Cadmium and nickel are released to the environment through vehicular exhausts and industrial activity. Since the area is devoid of industry, the concentration of both metal contents is quite low. The Cadmium content of *L. leprosa* and *P. coccoides* ranged from 0.3 - $0.4 \mu\text{g}\text{g}^{-1}$.

The maximum nickel contents were found in the foliose lichen, *P. orbicularis* and *P. coccoides* but the metal was not detected in most of the crustose forms.

Hg levels of lichen specimens of the area showed least variation between the species. Both foliose and crustose form accumulates the similar amount of Hg contents ranging from 1.1 - $7.5 \mu\text{g}\text{g}^{-1}$. *A. nidulans* and *B. submedialis* both crustose

Table -1: Sources of lichen material for heavy metal estimation in North side of Lucknow city, Uttar Pradesh

S.No.	Site	Lichen taxa	Site direction
1.	Palka village	<i>Pyxine cocolos</i> (Sw.) Nyl	50m away from motorway facing agricultuel field
2.	Palka village	<i>Pyxine cocolos</i> (Sw.) Nyl.	10 m away from motorway
3.	Palka village	<i>Phaeophyscia orbicularis</i> (Necker) Moberg	10 m away from motorway
4.	Palka village	<i>Lecanora leprosa</i> Fée	4 km away from motorway inside mango orchard
5.	Behta	<i>Arthopyrenia nidulans</i> Müll Arg.	10 m away from motorway
6.	Behta	<i>Sphinctrina anglica</i> Nyl.	10 m away from motorway
7.	Seiva village	<i>Bacidia submedialis</i> (Nyl.) Zahlbr.	Inside mango orchard 6 km away from motorway
8.	Kaul science foundation Research Station	<i>Lecanora leprosa</i> Fée	3 km away from motorway

Table - 2: Metal contents of six lichens ($\mu\text{g g}^{-1}$ dry weight) collected from the north side of Lucknow city

Localities	Lichen taxa	Pb	Cr	Zn	Cd	Ni	Fe	Cu	Hg
Palka village (Field facing)	<i>Pyxine coces</i>	3.3	34.4	63.4	ND	ND	5183	21.7	5.9
Palka village (Road facing)	<i>Pyxine coces</i>	10.6	ND	57.6	0.4	9.6	3255	10.2	2.1
Palka village (just inside the main road)	<i>Phaeophyscia orbicularis</i>	4.8	62.2	70.9	ND	10.7	19374	18.3	3.4
4 km. inside from main road of Palka	<i>Lecanora leprosa</i>	12.8	ND	66.0	0.3	5.4	1573	8.3	3.1
Behta: Near road side	<i>Arthopyrenia nidulans</i>	15.6	137.5	219.7	ND	ND	5183	21.7	5.9
Behta : Near road, Lucknow	<i>Sphinctrina anglica</i>	3.1	50.7	49.4	ND	3.8	3251	25.8	3.9
Seiva village	<i>Bacidia submedialis</i>	5.9	127.4	96.7	ND	ND	5283	66.6	7.5
Kaul Science Research Center	<i>Lecanora leprosa</i>	6.0	25.6	53.2	ND	2.2	1748	13.2	1.1

ND = Not detected

lichens accumulated higher level of Hg, 7.17 and 7.51 $\mu\text{g g}^{-1}$ respectively.

The present level of pollutants will be a useful baseline for future studies on the state of the ambient air in Lucknow City. The crustose lichen *A. nidulans* and the foliose lichen *P. orbicularis* exhibited higher levels of most of the metals than other lichens sampled in the north of Lucknow city. The species may be useful in monitoring of air quality in the region.

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