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Monitoring Air pollution using lichens species in South Bangalore, Karnataka

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Abstract: This paper roprts the results of a biomonitoring survey carried out in the urban areas of south Bangalore using the biodiversity of epiphytic lichens as indicator of air pollution . Sampling was performed at four different locations(Koramangala, Madivala Marker, Bannerughatta national Park and Bommasandra industrial area) in April 2009. Lichen species were from palm trees bark of 50-70 cm diameter and at the height of 0.5-0.7 meter. Soil and other extraneous material free, dried unwashed samples of litchens were digested to analyse the Concentrations of heavy metals (Cd, Cr, Cu, Fe, Ni, Pb and Zn). The general order of the concentrations of the heavy metal content was observed to be Bommasandra industrial area> Madivala Market> Koramangala> Bannerughatta national Park. *Pyxine meissnerina* growing inside the industrial area is most tolerant and has accumulated higher levels of all the heavy metals analyzed The highest total heavy metal contents were found in the *Graphis scripta (L.) Ach. in* Kramangala. The highest total heavy metal contents were found in the *Chrysothrix candelaris* (L.) in Madivala The highest total heavy metal contents were found in the *Foraminella ambigua in Bommasandra.* The highest total heavy metal Iron was found in the *Chrysothrix candelaris* (L.) in Bannerughatta National park. The sensitivity of lichens to polluted air and their ability to accumulate heavy metals and retain them for a long period in their thalli has become a beneficial tool in biomonitoring of various heavy metal pollutants

Key words: Air pollution; Heavy metals ; Litchens ; Biomonitors.

Introduction

The growth of the human population, the use of natural resources and the growth in technology has altered the major biogeochemical cycles, and also perished many species of genetically distinct populations in this of Earth's ecosystems[1]. Many of these changes are substantial and reasonably well quantified by driving global climatic changes and also causing irreversible losses of biological diversity .Lichens are unusual organisms because they consist of fungal threads and microscopic green alga living together and functioning as a single organism. The main body of a lichen is called a thallus and does not resemble either the fungal or algal parts. Both components receive some benefit from this symbiotic association. Simply, the algae within the thallus manufacture sugars that the fungus can live off of and in return, the fungus provides protection for the alga. Lichens do not have roots, stems and leaves so they must receive their nutrients from rainfall. Lichens are the most studied bioindicators of air quality[2,3]. They have been defined as “permanent control systems” for air pollution assessment As bioindicators, the presence/absence of sensitive species is used to look for distribution patterns that reflect pollutant deposition. They grow slowly, have a large-scale dependence upon the environment for their nutrition, and – differently from vascular plants – they do not shedpartsduringgrowth. Particles of various elements become embedded in the lichen thallus in the algal and/or fungal layer under moist or dry conditions. Lichens accumulate substances from their environment by a variety of mechanisms, including particulate trapping, ion exchange, extracellular electrolyte sorption, hydrolysis, and intracellular uptake.Lichens are supplied with mineral nutrients and heavy metals from precipitation, through , dustfall, and the underlying substrate from both natural and anthropogenic sources. Natural sources of metals include marine aerosols, leachates from foliage and bark, and suspended particulates derived from local and remote soils and rock. Lichens show varying sensitivity to metals, are good accumulators, and have been used to indicate deposition levels.Epiphytic lichens (or epiphytes), i.e. lichens growing on bark of trees, are characterized with the most sensitivity among all ecological groups of lichens. Study of these species in large cities of the world revealed a number of general patterns: the more industrialized the city is, the fewer species of lichens are found; the less the total area of the tree trunk is covered with lichens, the lower the vitality of the lichens.

It has been discovered that when the level of air pollution increases, first *fruticose* lichens disappear, then *foliaceous* lichens, and the last ones to disappear are *crustose* (cork-forming) forms of lichens. Composition of lichen flora in different areas of a city (residential , in industrialized, in parks and market places) is best suited to measure the air pollution.

Materials and methods

The present study was conducted in four locations of south Bangalore, a capital of Karnataka is the principal basis for industry. Various sites consisting of palm trees for passive monitoring of air pollution by lichens were selected for this study. Tolerant lichens surviving in polluted areas accumulate substances from rain and trap airborne particles. As a result, some pollutants become concentrated in the lichen. Lichen biomonitoring studies were investigated in four urban areas (Koramangala, Madivala , Bommasandra and Bannerughatta national park) of Bangalore South. Lichen species were from palm trees bark of 50-70 cm diameter and at the height of 0.5-0.7 meter .The lichens were carefully removed from the bark snapper blade and were oven-dried to a constant weight at 80°C[7,8]. The dried lichen samples in triplicates were then powdered (0.5g) for further metal analysis[4,5]. Lichen samples were extracted with a mixture of concentrated HCl and HNO_3 (3:1) and digested to 80°C, few drops of perchloric acid is added. The mixture was filtered through Whatman filter paper No. 42. The filtrate was diluted to the desired volume with de-ionised water. The total concentrations of Cd, Cr, Cu, Fe, Ni, Pb and Zn in the filtrate were determined by atomic adsorption spectrometer[3].

Results and discussions

Their data show that in general, the variety and amount of lichens on trees increases outward and upward from the downtown core. The lichen distribution patterns suggest that the litchen species depend on pollution pattern .The heavy metal analysis of various species of lichens collected, analysed and identified. It is observed that the variation in lichen diversity in different localities. More variety of litchens and their abundance were observed obviously in Bannerughatta National park and Koramangala residential area, this may be attributed to to the presence of a non polluted atmosphere with moist and shady condition suitable for lichen[6]. Less number of litchen species were observed in Madivala market and Bommasandra industrial area.

Koramangala: The identified litchen species in palm trees of Koramangala residential area are presented in the table-2. Total metal contents in the native litchens sampled varied broadly and reached : ND -0.26 µg Cd g^{-1} DW, ND- 15.6 µgCr g^{-1}DW ,1.6- 8.5 µgCu g^{-1} DW, Ni ND- 1.6 µgNi g^{-1} DW, 124-508 µg Fe g^{-1} DW , 2.5-154 µg Pb g^{-1} DW, ND- 13.2 µgZn g^{-1} DW L The highest total heavy metal contents were found in the *Graphis scripta (L.) Ach.* The lowest metal contents were observed in Arthopyreniaceae. This area corresponded to the lower heavy metal contents in palm tree bark sampled in this locality.

Madivala : The identified litchen species in palm trees of Madivala Market area are presented in the table-3. Total metal contents in the native litchens sampled varied broadly and reached : 0.24 -2.5 µg Cd g^{-1} DW, ND- 11.6 µg Cr g^{-1}DW ,ND- 9.4 µg Cu g^{-1} DW, Ni ND- 1.6 µgNi g^{-1} DW, 124-508 µg Fe g^{-1} DW , 2.5-162 µg Pb g^{-1} DW, 2.4- 9.7 µgZn g^{-1} DW L The highest total heavy metal contents were found in the *Chrysothrix candelaris* (L.) The lowest metal contents were observed in *Parmelia caperata*. This area corresponded to the higher heavy metal contents in palm tree bark sampled in this locality. This is attributed to heavy traffic and anthropogenic sources of pollution

Bommasandra : The identified litchen species in palm trees of Bommasandra industrial area are presented in the table-4. Total metal contents in the native litchens sampled varied broadly and reached : 4.8 -9.9 µg Cd g^{-1} DW, 21.6- 50.0 µg Cr g^{-1}DW ,6.3- 11.4 µg Cu g^{-1} DW, 20.8- 79.6 µg Ni g^{-1} DW, 456- 789 µg Fe g^{-1} DW , 88.5-259 µg Pb g^{-1} DW, 42- 162 µg Zn g^{-1} DW The highest total heavy metal contents were found in the *Foraminella ambigua* The lowest metal contents were observed in *Graphis scripta (L.) Ach.*. This corresponded to the highest heavy metal contents in palm tree bark sampled in this locality.

Bennerughatta National park: The identified lichen species in palm trees of Bennerughatta National park are presented in the table-5. Total metal contents in the native litchens sampled varied broadly and reached : ND -0.24 µg Cd g^{-1} DW, ND- 2.5 µg Cr g^{-1}DW ,ND- 1.6 µg Cu g^{-1} DW, ND- 1.2 µg Ni g^{-1} DW, 224-945 µg Fe g^{-1} DW , 2.4-8.4 µg Pb g^{-1} DW, ND- 9.4 µg Zn g^{-1} DW. The highest total heavy metal Iron was found in the *Chrysothrix candelaris* (L.) The lowest metal Iron was observed in *Diploicia canescens* . This corresponded to the lowest heavy metal contents in litchens of palm tree bark sampled in this locality. The air quality of the corresponding stations is determined as-

Stations experimented	Litchen species	Air quality	Remarks
Bommasandra	Very less abundance and max. Heavy metal contents	poor	Industrial area with heavy traffic
Madivala	leafy and crustose lichen	moderate	Anthropogenic pollution and heavy traffic
Koramangala	foliose, leafy and crustose lichens present	good air	Neatly maintained residential area
Bannerughatta	foliose lichen Usnea articulata	very clean air	A National park

Table 1 Lichen biomonitoring studies in four urban areas Koramangala , Madivala , Bommasandra and Bannerughatta national park of Bangalore South.

Stations	**distance from highway (m)**	**Koramangala**	**Madivala**	**Bommasandra**	**Bannerughatta national park**
		Lichen species from various trees bark(particularly palm trees) of 50-70 cm diameter and at the height of 0.5-0.7 meter			
1	*2*	*Graphis scripta (L.) Ach., Laundon Diploicia, Parmelia capera.*	*Parmelia caperata, Xanthoria parietina*	*Evernia prunastri, Lecidella elaeochroma*	*Chrysothrix candelaris (L.), Laundon Diploicia ,canescens Lepraria incana*
2	*4*	*Graphis scripta (L.) Ach., Parmeli caperata, Xanthoria parietina.*	*Chrysothrix candelaris (L.) Laundon*	*Foraminella ambigua,*	*Hypogymnia physodes, Lepraria incana Parmelia capera Graphis scripta (L.) Ach.,*
3	*6*	*L. perplexa Brodo Xanthoria parietina*	*Graphis scripta (L.) Ach., Laundon Diploicia*	*Lecanora chlarotera, Graphis scripta (L.) Ach. Foraminella ambigua*	*.Xanthoria parietina, Hypogymnia physodes*
4	*8*	*Usnea subfloridana, Laundon Diploicia*	*Graphis scripta, Xanthoria parietina*	*Ramalina farinacea, Foraminella ambigua*	*Lecanora dispersa, Hypogymnia physodes Parmelia capera*
5	*10*	*Parmelia perlata Lecidella elaeochroma*	*Bryoria fucescens, Xanthoria parietina*	*Chrysothrix candelaris (L.) Laundon*	*Haematomma puniceum, Parmelia capera*
6	*12*	*Degelia plumbea, Usnea subfloridana*	*Physconia distorta, Parmelia caperata*	*Lecidella elaeochroma Parmelia caperata*	*Diploicia canescens, Parmelia capera*
7	*14*	*Ramalina fraxinea L. perplexa Brodo Xanthoria parietina*	*Opegrapha varia, Graphis scripta (L.) Ach., Laundon Diploicia*	*Evernia prunastri Foraminella ambigua, Parmelia capera*	*Lepraria incana, Parmelia caperata*
8	*16*	*Teleoschistes flavicans L. perplexa Brodo Xanthoria parietina*	*Forамininella ambigua Opegrapha varia,*	*Foraminella ambigua Lecidella elaeochroma Parmelia caperata*	*Hypogymnia physodes Hypogymnia physodes, Lepraria incana Parmelia capera*

9	*18*	*Arthopyreniaceae,* *Parmelia caperata* *L. perplexa Brodo* *Xanthoria parietina*	*Parmelia caperata ,* *Usnea subfloridana*	*Graphis scripta (L.) Ach* *Lecanora chlarotera,* *Graphis scripta (L.) Ach.* *Foraminella ambigua.* *Evernia prunastri,*	*Xanthoria parietina* *Hypogymnia physodes,* *Lepraria incana* *Parmelia capera*
10	*20*	*Usnea subfloridana,* *Parmelia caperata* *Degelia plumbea,* *Usnea subfloridana*	*Usnea subfloridana ,* *Parmelia caperata* *Graphis scripta (L.) Ach.,* *Laundon Diploicia*	*Evernia prunastri* *Parmelia caperata* *Lecanora chlarotera,* *Graphis scripta (L.) Ach.* *Foraminella ambigua*	*Xanthoria parietina,* *Usnea subfloridana,* *Parmelia caperata* *Hypogymnia physodes,* *Lepraria incana* *Parmelia capera*

Table-2 Metal Concentration (µg g^{-1}) in various litchen species from the residential area-Kormangala.

Mean metal concentrations (µg g^{-1}) in litchens	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Graphis scripta (L.) Ach.	ND	15.6	8.5	508	ND	154	ND
Parmelia caperata	ND	11.0	1.6	494	ND	124	12.5
L. perplexa Brodo	0.24	5.0	2.9	307	ND	8.4	13.2
Usnea subfloridana	0.26	5.0	2.3	310	1.1	6.9	6.8
Parmelia perlata	0.25	1.6	1.6	296	1.4	2.5	9.4
Degelia plumbea	ND	2.4	2.6	167	1.6	134	ND
Ramalina fraxinea	ND	2.5	3.2	156	1.1	145	ND
Teleoschistes flavicans	ND	2.9	3.2	154	1.5	159	5.4
Arthopyreniaceae	ND	ND	2.4	124	ND	34.5	2.4

Table-3 Metal Concentration (µg g^{-1}) in various litchen species from the heavily traffic and market area-Madivala

Mean metal concentrations (µg g^{-1}) in litchens	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Parmelia caperata	2.3	7.8	9.4	508	ND	116	3.2
Chrysothrix candelaris (L.) Laundon	2.5	11.6	9.4	494	ND	162	3.2
Graphis scripta (L.) Ach.	0.24	5.9	ND	307	ND	8.4	2.4
Graphis scripta	0.26	8.5	5.4	310	1.1	6.9	5.8
Bryoria fucescens	0.25	ND	2.4	296	1.4	2.5	9.5
Physconia distorta	1.5	5.7	ND	167	1.6	134	9.7
Opegrapha varia	1.6	2.5	6.8	156	1.1	145	9.4
Foramininella ambigua	0.25	2.4	9.4	154	1.5	159	5.4
Parmelia caperata	0.25	1.6	ND	124	ND	4.5	2.2

Table-4 Metal Concentration (μg g^{-1}) in various litchen species from the industrial area-Bommasandra

Mean metal concentrations (μg g^{-1}) in litchens	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Parmelia capera	4.8	23.5	9.8	600	41.59	115.5	42.0
Foraminella ambigua	9.8	22.4	9.2	644	24.6	243	121
Lecanora chlarotera	5.6	25.5	9.5	656	21.5	88.8	162
Ramalina farinacea	6.4	22.6	8.5	631	51.5	92.5	145
Chrysothrix candelaris (L.) laundon	6.6	52.5	8.5	631	21.8	97.5	142
Lecidella elaeochroma	8.6	28.4	10.3	601	59.6	98.6	142
Evernia prunastri	6.4	40.4	11.0	604	72.4	342	147
Foraminella ambigua	9.9	50.0	11.4	789	79.6	259	149
Graphis scripta (L.) Ach.	4.8	21.6	6.3	456	20.8	115	121

Table-5 Metal Concentration (μg g^{-1}) in various litchen species from the Bennerughatta National park

Mean metal concentrations (μg g^{-1}) in litchens	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Chrysothrix candelaris (L.) Laundon	ND	ND	ND	945	ND	2.4	ND
Parmelia capera	ND	ND	ND	527	ND	5.6	2.5
Xanthoria parietina	ND	2.4	ND	356	ND	8.4	ND
Lecanora dispersa	0.24	2.4	ND	365	1.2	6.9	ND
Haematomma puniceum	0.24	1.8	1.4	300	ND	2.5	9.4
Diploicia canescens	ND	ND	1.6	224	ND	5.6	ND
Lepraria incana	ND	ND	1.2	497	1.2	8.4	ND
Hypogymnia physodes	ND	2.5	1.5	452	1.4	5.6	3.4
Xanthoria parietina	ND	ND	1.54	234	ND	6.2	4.5

Conclusion

Most chemical compounds, having a negative impact on the flora of lichens, represent the main chemical elements and substances found in the emissions of most industrial objects. This information allows us to use lichens as indicators of the *anthropogenic* load. This study of heavy metals levels in lichens with the atmospheric deposition reflects the toxic level of heavy metals in our environment and gives evidence of a air contamination at industrial and market areas with heavy traffic. The sensitivity of lichens to polluted air and their ability to accumulate heavy metals and retain them for a long period in their thalli make them a beneficial tool in biomonitoring of various aerial heavy metal pollutants

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