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Determination of toxic heavy metals in four different lichen species of Tamil Nadu, India

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Abstract

Biomonitoring studies provide valuable information about the quantity and quality of pollutants in the atmosphere and can be very effective as an early warning system to detect environmental changes. The present study was undertaken to determine the heavy metal concentration in lichens from Velachery, Tiruvallur (Chennai) and Chithanji, Kalathur (Vellore) in Tamil Nadu, India. *Physcia* lichen was collected from Velachery and *Porina interestes* lichen was collected from Tiruvallur, the pollution rich zones. *Buellia disciformis* lichen was collected from Chithanji and *Lecanora allphona* lichen was collected from Kalathur, the unpolluted zones. The residue was used for the analysis of heavy metals like Lead, Chromium, Zinc, Copper, Nickel and Iron using atomic absorption spectrophotometer (AAS). The results obtained showed the lichens in the respective places have absorbed the heavy metal which is most prone in the area. From the present study it is inferred that the heavy metal levels in lichens with the atmospheric deposition reflects the toxic level of heavy metals in our environment and gives evidence of air contamination at industrial and market areas with heavy traffic.

Key words : lichen, heavy metals, pollutants, atomic absorption spectrometer.

INTRODUCTION

Industrialization and urbanization in Chennai, has led to a variety of environmental hazards. Several pollutants are released into the atmosphere from different sources in the form of nitrogen oxide, sulphur oxide, unburned hydrocarbons, pesticides, herbicides, suspended particulates and heavy metals. Out of these, the heavy metals are emitted into the atmosphere from industrial and many other anthropogenic sources [1]. These pollutants cause negative impact on vegetation, animal life, climate, materials like buildings and monuments and also on the entire structure of the ecosystem directly or indirectly. Biomonitoring studies provide valuable information about the quantity and quality of pollutants in the atmosphere and can be very effective as an early warning system to detect environmental changes. Lichens possess a number of characteristics that make them suitable biomonitors of air pollution particularly heavy metals and radionucleotides [2-4] They possess remarkable ion exchange properties and also accumulate metal rich particulate so that they collect and retain airborne metals. The tolerance of lichens to most of the heavy metals and their slow growth rate, are among the main factors that make them good indicators or monitors of metal pollution [5]. In this respect, the present study is aimed to assess the concentrations of heavy metals in atmospheric environment through the biological indicators, the lichens as authenticated biomonitors of heavy metal pollution in air. In this regard, this paper reports the results of a comparative study of Atomic Absorption Spectrophotometer (AAS) for the determination of heavy metal contamination in the environment of Chennai and Vellore cities, due to urbanization and vehicular activity.

MATERIALS AND METHODS

Study Area: The study area chosen for the study includes Velachery and Tiruvallur in Chennai and Kalathur and Chithanji in Vellore district. Velachery and Tiruvallur are pollution rich zones of 13.0081 latitude and 80.2194 longitude and 13.05083 latitude and 79.9170 longitude. Similarly, Chithanji and Kalathur situated in Vellore district, Tamilnadu of 12.93983 latitude and 79.36648 longitude and 12.93970 latitude and 79.36642 longitude were taken as the control zones.

Samples: The lichen samples collected for the study are *Physcia* lichen (foliose lichen), *Porina interestes, Buelia disciformis* and *Lecanora allophona* (crustose lichens). *Physcia lichen* was collected from Velachery (Chennai), *Porina interestes* from Tiruvallur (Chennai) the heavy traffic zones and *Buellia disciformis* from Chithaji and *Lecanora allophona* from Kalathur (Vellore) the non polluted zones. The concentration of Copper, Cromium, Zinc, Lead, Nickle and Ferric was analyzed from the samples collected.

Methodology: The lichen samples collected were removed from the bark of the host with a bark snapper blade and taken in brown paper packets. The samples were washed with distilled water three times and kept in a shaker for 15 minutes. After this the samples were air dried. The initial weight was noted and oven dried at 90 C for 15 hours. The dried lichen samples were ground with the help of a mortar and pestle. 0.5 gm of powder was weighed and digested in a digestion rack with a mixture of concentrated Nitric acid (HNO_3) & Per chloro acetic acid (conc. $HClO_4$) in the ratio of 3:1 for 2 hours till pale green color appeared. Residue were filtered through Whatmann Filter paper No:42 and diluted to 20 ml with double distilled water. Analysis of heavy metals like Lead, Zinc, Chromium, Copper, Iron and Nickel was analyzed using Atomic Absorption Spectrophotometer (AAS).

RESULTS

All the species collected had consistently higher amounts of iron, copper and zinc. *Buellia disciformis* accumulated highest amount of Iron of 3.0 ppm and *Lecanora allophona* with the lowest (1.01 ppm) from the control zones. Zinc was found to be higher with 0.22 ppm and 0.223 ppm and Copper of 0.064 ppm and 0.079 ppm. Surprisingly, these pollutant levels were

Table 1 : Place of collection and it's pollution level

S.No.	Name of lichen sample	Site Name	Remarks	Distance from city centre	Pollution level
1.	***Physcia Lichen***	Velachery	Industrial area with heavy traffic	5 km	Very High
2.	***Porina interestes***	Tiruvallur	Industrial area with heavy traffic	40 km	High
3.	***Buellia disciformis***	Chithanji	Unpolluted area	100 km	Low
4.	***Lecanora allophona***	Kalathur	Unpolluted area	104 km	Very Low

Table 2 : Name, kind and the host plant

S.No.	Lichen name	Family	Name of the host plant	Type of lichen
1.	***Physcia Sp.***	Physciaceae	*Pulmaria sp.*	Foliose
2.	***Porina interestes***	Telochistaceae	*Pongamia*	Crustose
3.	***Buellia disciformis***	Caliciaceae	*Cassia auriculata*	Crustose
4.	***Lecanora allophona***	Lecanorales	*Pongamia*	Crustose

Table 3 : Heavy metal content of lichens

S.No.	Name of the lichen and area of the collection	Metal Concentration in ppm					
		Copper	Chromium	Zinc	Lead	Nickel	Iron
1.	*Physcia lichen* (Velachery)	0.058	0.873	0.175	0.684	0.02	0.756
2.	*Porina interestes* (Tiruvallur)	0.003	0.693	0.108	0.196	0.029	0.859
3.	*Buellia disciformis* (Chithanji)	0.064	0.604	0.22	ND	ND	3.0
4.	*Lecanora allophona* (Kalathur)	0.079	0.831	0.223	0.009	0.028	1.01

ND-Not Detected

definitely higher than the pollution rich zones. *Buellia disciformis* did not detect lead and nickle. *Lecanora allophona* detected very low levels of lead (0.009 ppm). *Physcia* lichen from Velachery, the very high pollution zone, accumulated highest amount of lead (0.684 ppm) and chromium (0.873) among the four species collected. *Porina interestes* detected high levels of lead (0.196 ppm) and lowest levels of copper of 0.003 ppm.

DISCUSSION

Both areas of Chennai and Vellore chosen for the study are avenues with medium to high density traffic. The heavy metals accumulated are likely to be emitted into the atmosphere by the wearing of engines and tyres of vehicles in traffic and may be present in fuel composition or exhausted by vehicles. Quevauviller [6] has reported that all the elements are found on roads with medium to high traffic density. It is observed that though Chennai and Vellore exhibits variation in lichen diversity, heavy metal pollution is more or less similar. This might be because of meteorological conditions existing between the area of emission and the receptor. The pollutants disperse in both vertical and horizontal ways in the atmosphere after emission [7].

Although situated away from Industrialization and urbanization areas, *Buellia disciformis* and *Lecanora allophona*, collected from Chithanji and Kalathur, which are the low and very low pollution zones, surprisingly accumulated high amounts of Ferric. This could be due to the dusty gravel roads, frequent movement of heavy vehicles and the dry climate of Vellore. Similarly, highest concentration of Zn was recorded from Chithanji and Kalathur (Vellore) being on the main bypass road to Chennai, may be due to the wear and tear of tyres of heavy vehicles. The presence of Zinc particles may originate from wear of automobile tyres, lubricating oils and brake pads [8].

According to Aksoy et al [9] the heavy metals like Copper show an increase in their content with increased urbanization. Kabata Pendias and Piotrowska [10] have reported that the normal

content of Cu in plants ranges from 2 to 20 ppm, but in most plants the normal Cu content is in a narrower range of 4-12 ppm. Even though, the study areas fall under the urbanized zone Copper was found to be in minimal quantities in all the areas irrespective of their pollution level, hence is well less within the normal tolerant range.

Chromium concentration was high in Velachery and Kalathur, followed by Tiruvallur and Chithanji showing no difference between polluted and non-polluted zones. Chettri et al [11] have reported that Chromium concentration in clean environment is very poor. Streit and Stumm [12] reports that uptake of this metal occurs as hexavalent chromate, which is rapidly reduced to Cr^{3+} in soil. This is absorbed minimally by its roots and later translocated to the other parts. Kalathur, the control zone with clean environment showed high Chromium accumulation. This may be due to the deposits of total suspended particles of chromium over the lichen surface as reported by Streit and Stumm [12]. Hence, this clearly indicates that all the study areas whether polluted or unpolluted are contaminated with chromium. According to Markert [13], Chromium is a common additive in unleaded petrol, a component of antifreeze and part of automobile bodies and clearly depicts that this was due to high traffic and industrial pollution. Velachery being a high traffic zone and Kalathur with dusty gravel roads and frequent movement of heavy vehicles could have accumulated chromium.

The source of lead pollution is mainly automobiles and petrol. Near bus stops and petrol stations, ethylene dibromide found in fuels converts lead into a volatile compound Lead bromide [14]. Takala and Okkonen [15] and Dubey *et al* [16] have correlated lead content with traffic volume. In the present study also, *Physcia lichen* and *Porina interestes* from Velachery and Tiruvallur (very high and high pollution zones) recorded highest levels indicating their traffic volume. But, it is interesting to note that *Buellia disciformis* from Vellore, the low pollution zone, which detected highest levels of Iron, did not detect any lead or nickel while *Lecanora allophona* detected negligible amounts of lead (0.009 ppm). This can be suggested that the two species *Buellia disciformis* and *Lecanora allophona* were not able to detect lead and nickel.

The metal concentration of Nickle in Chennai and Vellore had no variation and was more or less similar. According to Nriagu and Pacyna [17], the main anthropogenic emission of Ni are coal and oil combustion, copper-nickel and lead production, mining, steel and iron and cement industries. Hence Ni is detected at these areas where a number of vehicle-repair garages and heavy activity of automobiles happen. Being a control zone, *Lecanora allophona* from Kalathur has accumulated Nickle. Although away from the main city by 104 km, the contamination of Nickle, Copper, Chromium, Zinc, Iron and traces of Lead been detected has depicting that the surrounding villages of Chennai are being contaminated at an alarming rate.

CONCLUSION

It is clear from the study that air pollution due to industrialization and urbanization has been released from traffic volume, frequent movement of heavy vehicles, vehicle exhausts, dusty roads and vehicle-repair garages has started to contaminate the nearby areas at an alarming rate. Sinks of air pollution, the Lichens like *Physcia lichen, Porina interestes and Lecanora allophona* are seen to accumulate all the heavy metals, showing that they are highly resistant and toxitolerant. The present paper reflects the level of heavy metals pollution and the lichen species for conducting future studies.

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REFERENCES

1. Balabanova, Biljana and Baceva, Katerina and Stafilov, Trajče and Sajn, Robert. *Lichens as biomonitors for atmospheric pollution with heavy metals in copper mine vicinity.* 10th International Symposium and CEEPUS Summer School on Bioanalysis Graz, 18-28 September, 2011.

2. Chaparro MAE, Lavornia JM, Cha parro MAE, Sinito AM. Biomonitors of urban air pollution: Magnetic studies and SEM observations of corticolous foliose and microfoliose lichens and their suitability for magnetic monitoring. Environmental Pollution. 2013:172:61-9.

3. James P W. The effect of air pollutants other than hydrogen fluoride and sulphur dioxide on lichens. Athlone Press, London, 1973.p.143-175.

4. Seaward M R D. Lichen ecology of the Scunthorpe heathlands. I. Mineral accumulation. *Lichenologist.* 1973:5:423-433.

5. Vertica Shukla and Upreti D K. Heavy metal accumulation in *Phaeophyscia hispidula* en route to Batrinath, Uttaranchal, India. Environ Monit Assess. 2007:131:365-369.

6. Quevauviller Ph, Herzig R and Muntau H. Certified reference material of lichen (CRM 482) for the quality control of trace element biomonitoring. Science of the Total Environment. 1996:187(2):143-152.

7. LeBlanc F and De Sloover J. Relation between industrialization and the distribution and growth of epiphytic lichens and mosses in Montreal. Can J Bot. 1970:48:1485-1496.

8. Harte J, Holdren C, Schneider R and Christine S. Toxics A to Z, A guide to everyday pollution hazards, University of California Press, Berkeley. 1991.p.77-80.

9. Aksoy A, Celik A, Ozturk M and Tulu M. Roadside plants as possible indicators of heavy metal pollution in Turkey. *Chemia I Inzynieria Ekologiczna.* 2000a:7:1152-1162.

10. Kabata Pendias A, and Piotrowska M. Zanieczyszczenie Gleb I Roslin Uprawnych Pierwiastkami Sladowymi. CBR opracowanie problemowe, Warsazawa, Poland. 1984.p.28.

11. Chettri M K, Sawidis T and Karataglis S. Lichens as a tool for biogeochemical prospecting. Ecotoxicology and Environmental Safety 38:1997b:322-335.

12. Streit B and Stumm W. Chemical properties of metals and the process of bioaccumulation in terrestrial plants. In: Market, B.(ed), *Plants as Biomonitors,* VCH Publisher, Weinheim. 1993.p.29-62.

13. Markert B. Instrumental analysis of plants. In plants as biomonitors - Indicators for Heavy Metals in the Terrestrial environment.VCH Publishing. New York, 1993.p.65-104.

14. Susana Calvelo, Nora Baccal and Sandra Liberatore. Lichens as Bioindicators of Air Quality in Distant Areas in

Patagonia(Argentina). Environmental Bioindicators. 2009:4:123-135.

15. Takala K and Okkonen H. Lead content of an epiphytic lichen in the urban area of Kuopio, eastern central Finland. Annales Botanici Fennici. 1981:18:85-89.

16. Dubey A N, Pandey V, Upreti D K and Singh J. Accumulation of lead by lichens growing in and around Faizabad, U.P., India. Journal of Environmental Biology. 1999:20(3):223-225.

17. Nriagu J O and Pacyna J. Quantitative assessment of worldwide contamination of air, water and soil by trace metals. Nature. 1988:333:134-139.