Study on the Metal Absorption by two Mosses in Delhi Region (India)

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Abstract: Bryophytes act as precise and sensitive bioindicators as well as bioaccumulators of metal deposition in the environment. Heavy metals are ubiquitous pollutants which are persistent and get transferred from one tropic level to another. Two moss species *Physcomitrium cyathicarpum* and *Barbula constricta* growing across different regions of Delhi have been used as indicators of metal pollution. The estimation of important heavy metals like Cr, Co, Cd, Cu, Fe, Hg, Ni and Pb have been carried out in the tissues of both the moss species using atomic absorption spectroscopy, the level being highest for Fe, Ni, Cu and Cr followed by Co, Cd, Pb and Hg. The concentrations of Fe, Co, Cu and Cr was found high in both the species growing in North Delhi region followed by South and West Delhi suggesting the regions with industrial belt, vehicular traffic and heavy industries release chemical effluents. The low level of metal pollutants was observed in moss specimens collected from Central and East Delhi. Overall, Fe, Cu and Pb are responsible for causing major pollution in the studied sites and the concentration of metals in plant as well as in the substratum was found to be higher in North, South and West Delhi region. Statistical analyses also revealed that correlation exists between the metal content in mosses and degree of pollution in studied sites. [Journal of American Science 2010; 6(3):176-181]. (ISSN: 1545-1003).

Key words: *Accumulation capacity, Heavy metal uptake, Metal ions, Moss, Pollution Monitoring*

1. Introduction

The distribution of moss species in community, measurement of their growth rates and concentration of contaminants in them are reliable aspects in biomonitoring technology. The ability of bryophytes to retain potentially toxic element has lead to their use as monitors of air pollution (Rühling and Tyler, 1984, 2004). The use of mosses as indicators and biomonitors of atmospheric pollution by heavy metals is a well established aspect and bryophytes are suitable to absorb toxic metals from the environment (Rühling and Tyler, 1968). The stability of metal organic complexes and chelates and the great cation exchange capacity of the moss tissue are the primary conditions for the absorption of heavy metals (Tyler, 1970). Mosses have a close growth habit, lack protective cuticle and epidermis, making their tissues readily permeable to water and minerals including metal ions (Brown and Sidhu, 1992, Tyler, 1990a, b). Kansanen and Venetvaara (1991) found mosses and lichens as the most effective indicators for low and moderate level of metal deposition in polluted areas. The tolerant species accumulate the pollutant to some extent and retain them for a limited period of time. A large number of studies have been carried out for estimation of trace element deposition in mosses (Aceto *et.al.* 2003, Poikolainen 2004 a, b, Schintu and Diggeto, 1999; Schintu *et al.* 2005) which reveal that aquatic mosses play an important role in accumulation and uptake of metals from water bodies. However, uptake of metal ions in terrestrial environment is inconclusive because accumulation varies with season and time of collection of samples from the field (Kumar *et .al*., 1989). Analysis of the elemental content of mosses also gives the opportunity to investigate whether toxic elements might be responsible for the health effects observed in epidemiological studies (Basile *et al.* 2009). There are very few studies on uptake of metals by mosses and their role as bioindicators in urban terrestrial environment because of their narrow distribution range and less availability on account of various natural and anthropogenic reasons.

Delhi is recognized as one of the most polluted cities of India (CPCB Report, 2003). The heavy metal depositions in the city are mainly from industries such as metallurgy, forging factories, steel plants, etc. as well as automobiles, which release great amount of gases and dust containing heavy metals (Zheng *et al.* 2002).The common metal pollutants released into air, water and soil are Cd, Cu, Cr, Pb, Co, Fe and Ni. High concentrations of heavy metals have been detected in vegetation as well as in the soils of Delhi (Varshney and Aggarwal, 1992). The spatial distribution of bryophytes and their chemical analysis for metal contaminates reveal their level of toxicity, retention capacity and applicability in phytoremediation.

Keeping in view the role of mosses in metal accumulation and environmental monitors, the present study was undertaken in various regions of Delhi. The sites were chosen randomly across North, South, East, West and Central Delhi. The estimation of metals was done in two moss species, *Physcomitrium cyathicarpum* and *Barbula constricta* growing in these regions. Both are low growing highly tolerant species and have efficient trapping ability. The aim was to verify whether the correlation exist between metal content in moss species, the substratum and extent of pollution in the region.

2. Materials and Methods

The present study includes the analysis of metal content in two moss species viz. *Physcomitrium cyathicarpum* and *Barbula constricta* from different sites in Delhi (Fig. 1). The city is divided primarily into four sectors and further sub sectors on the basis of direction, location of industrial areas and forested sites, ridges and gardens. In the northern region of city there is an industrial belt and sporadic patches of green buffer; in the eastern region agricultural landscape is prominent and is densely populated, the western part have heavy industries which release the effluents (chemical, synthetic polymer, foundry and forging materials) into Nazafgarh drain which terminates into the river Yamuna and the southern central region experiences heavy traffic besides few industries amounting to high air pollution.

The plant material of both species with the substratum was collected from various localities of Delhi (Fig. 1) during September. The precise location of mosses with type of growth forms, the proximity to pollution sources and the nature of pollution sources were recorded on the spot. A population of the same species growing in the forested clean environment is taken as control. Samples were manually freed from solid litter, dust and other unwanted material. A jet of air was used to remove soil trapped on mosses. The specimens were dried in hot air oven for 24 hrs at 40°C. Five grams of material was taken and crushed with mortar and pestle. The soil and substratum to which moss species were adhered was stored in paper bags. The soil samples were oven dried, crushed and subjected to acid digestion. Estimation of the heavy metals in the plant samples as well as in the substratum was done by atomic absorption spectroscopy according to Allen (1989), using AAS ZEEnit 60/65.

Figure 1. Map of Delhi (India)

3. Results:

The assessment of the extent of deposition of toxic elements at different sites by bryophytes shows variation in content. North Delhi region adjoining Yamuna belt is found to be the most contaminated area by heavy metals (Cd, Cr, Co, Ni, Pb) vis a vis other parts of Delhi. In this region highest metal content was observed in both the species studied (Table 1). *Physcomitrium* accumulated maximum of Fe (22.90 µg/g) and *Barbula* had Fe (23.41 µg/g), Cu (15.20 µg/g) and Cr (13.12 µg/g). Pb ranged from 7.86 - 8.31 µg/g in the north zone, however in other zones Pb was in almost similar concentration in all plant samples. Co is significantly high in the north zone in both the species. Cd and Hg was found to be fluctuating in all the localities ranging from (1.92-8.61 µg/g) and (1.19-5.12 µg/g) respectively. It may be due to the Nazafgarh drain pouring into the river and different agriculture land in the adjoining areas.

Metal levels in *Physcomitrium* and *Barbula* in the central zone, which is comparatively a cleaner zone shows least Hg (1.92-5.12 µg/g) and Pb contamination (2.76-8.3 µg/g). Fe uptake is highest in this zone. East and West Delhi leads only in certain heavy metals like Hg and Ni. It is due to the presence of heavy industries and chemical runoff. This region has moderate amount of other heavy metals. The uptake of Cu and Fe is also considerably higher than the other metals as they constitute the micro/trace elements in the plant nutrition. Out of the two moss species studied, *Barbula* was found to absorb more metals as compared to *Physcomitrium.*

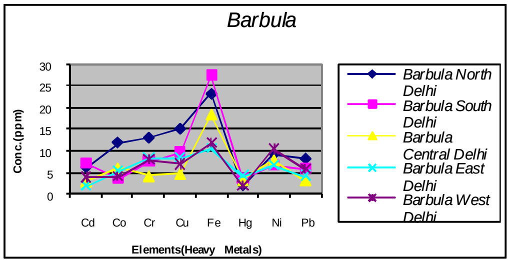

Figure 2. Graph showing metal accumulation in *Barbula* in different sites of Delhi.

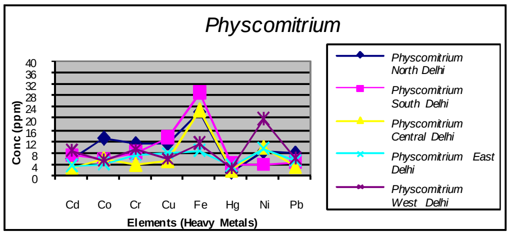

Figure 3. Graph showing metal accumulation in *Physcomitrium* in different sites of Delhi.

Table 1: Metal Concentration in the substratum and the plant samples in different sites of Delhi.

*metal concentration in plant sample, the values without star shows the metal concentration in their soil samples.

It is also found that there is variation in the metal retention by the mosses (*Physcomitrium* and *Barbula*) owing to their different degree of tolerance. *Barbula* shows its promising applicability in the phytoremediation purpose.

4. Discussion:

The present study shows the comparison of element concentration of the moss samples as well as of the substratum of different sites to expedite the accumulation of elements in two species of the same site and the pattern of emission in different locations (Table, Fig.2, 3). The pollutants in the city and from the vehicles mainly consist of heavy metal oxides and sulphates. In addition to the amount, quality and temporal development of the emission many edaphic and biological factors also regulate pollutant accumulation in the vegetation (Kozlov *et. al.* 2000). Heavy metal concentration is distinctly associated with local emission point sources and changes in emission levels (Cao *et al.* 2008). *Physcomitrium* and *Barbula* are low growing and form compact wide turfs on the ground. The wind blown particles, leaf fall and litter accumulation increases the total deposition of heavy metals in the ground mosses. The metal concentrations in mosses are influenced by many factors such as the kind of metals emitted and the chemical and physical properties of the metal-containing particles, for instance their size and acidity. The solubility of heavy metals usually

Elements	Concentration in µg/g									
	Physcomitrium					*Barbula*				
	North Delhi	South Delhi	Central Delhi	East Delhi	West Delhi	North Delhi	South Delhi	Central Delhi	East Delhi	West Delhi
Cd	*6.21	*7.52	*3.02	*3.42	*8.61	*6.11	*7.02	*2.92	*1.92	*3.96
	8.03	8.79	5.22	5.22	11.00	10.67	12.02	9.00	6.00	6.49
Co	*13.16	*6.25	*5.86	*4.15	*5.14	*12.00	*3.65	*5.88	*5.26	*4.10
	19.56	11.43	7.33	7.01	9.68	21.10	5.24	8.67	9.65	7.00
Cr	*11.04	*7.83	*3.81	*7.62	*9.41	*13.12	*7.42	*4.10	*8.10	*8.16
	15.14	7.89	4.11	9.13	10.81	16.08	9.00	5.91	10.19	10.02
Cu	*11.41	*13.26	*5.13	*8.19	*6.16	*15.20	*9.62	*4.63	*8.20	*7.02
	21.43	19.32	17.13	34.00	24.92	29.20	19.32	13.14	18.71	17.13
Fe	*22.49	*28.70	*22.9	*8.36	*11.10	*23.41	*27.60	*18.35	*10.42	*12.01
	54.33	37.23	38.56	25.36	31.08	41.41	39.10	24.50	23.33	24.54
Hg	*1.19	*3.91	*2.01	*3.16	*3.01	*1.92	*3.62	*3.15	*4.18	*2.00
	3.11	5.45	5.32	4.76	4.36	3.98	4.01	4.00	6.16	4.17
Ni	*8.64	*4.24	*9.99	*8.99	*19.50	*9.29	*6.52	*7.74	*6.49	*10.50
	9.91	5.45	16.33	17.90	31.20	19.87	6.98	8.60	12.11	18.12
Pb	*7.86	*4.52	*3.48	*5.68	*5.91	*8.18	*5.69	*3.12	*4.15	*5.78
	56.80	32.11	29.90	23.89	23.67	37.22	32.34	18.07	16.54	29.09

increases with decreasing pH. Some metals can also be substituted for others by ion exchange (Rühling and Tyler, 1970). The relative accumulation of different metals in a certain species may also vary with the total metal load (Ward *et. al.* 1977).

Major source of heavy metals in the urban areas are metallurgical processes, automobile exhaust emission, oil combustion and processing of crustal material. In our study, the concentration of Fe (8.36 – 28.70 µg/g), Ni (4.24 – 19.50 µg/g) and Cu (5.13 – 13.26 µg/g) in moss samples and Fe (25.36 – 54.33 µg/g), Pb (23.67 – 56.80 µg/g) and Cu (17.13 – 34.00 µg/g) in the substratum was found to be higher in *Physcomitrium.* Whereas, concentration of Fe (10.42- 27.60 µg/g), Cu (4.63 – 15.20 µg/g) and Cr (4.10 – 13.12 µg/g) in moss samples and Fe (23.33- 41.41 µg/g), Pb (16.54 – 37.22 µg/g) and Cu (13.14 – 29.20 µg/g) in the substratum was found to be higher in *Barbula*. The presence of these elements may seriously retard any potential colonization of polluted sites by bryophytes. Fe, Ni, Cu, and Cr was found to be in highest range in both the moss species as compared to Hg, Pb, Co and Cd, which shows likely the presence of metallurgical industries in the form of particles e.g. from electric arc furnaces, refractory brick production, combustion of coal, iron and steel industry in the nearby area of our study. In the northern region of city the total metal concentration was found to be maximum (82-89.23 µg/g), reason being the presence of many industries and sporadic patches of green buffer, whereas, lowest concentration (48.72-49.57 µg/g) of heavy metals was found in the eastern region of the city due to prominence of agricultural landscape and dense population. In the western part also metals were found to be in appreciably higher concentrations (53.53-68.84 µg/g) because of heavy industries which release the effluents (chemical, synthetic polymer, foundry and forging materials) into Nazafgarh drain which terminates into Yamuna. The southern (71.14-76.23 µg/g) and central region (49.89-56.20 µg/g) experienced high concentration of metals due to heavy traffic and few industries amounting to high air pollution. Fe uptake is maximum in the central zone, may be owing to least antagonism by heavy metals. Fe, Cu and Pb are responsible for the heavy metal pollution in both the plant sample as well in the substratum of the sites studied in the Delhi. The uptake of heavy metals in mosses may certainly be influenced by climate, especially humidity and wind velocity. Different plant species show varying resistance to air borne and soil accumulated toxic elements, which is reflected in their growth survival and occurrence along the pollution gradient. However, the actual degree of exposure to toxic elements is not the same for all the plant species growing at the same distance from an emission source because of difference in the elemental uptake mechanisms (Zechmeister *et. al.* 2003). The genetic make-up of the plant greatly influences its metal uptake potential. Huang *et al.* (1997) found that Pb accumulation varies significantly in different species grown in similar environments. The mobility and toxicity of heavy metals are strongly related to the acidity and organic matter contents of the soil (Alloway, 1990).

It is concluded that Fe, Cu and Pb are responsible for causing pollution in the studied sites and higher accumulation of heavy metal concentration was shown by *Barbula constricta* due to larger leaf surface area and more tolerance capacity as compared to *Physcomitrium cyathicarpum*. High concentration of lithogenic elements (e.g. Al and Fe) in moss is generally indicative of a high level of soil dust pollution (Bargagli, 1998). Lead is introduced into the atmosphere by exhaust fumes from vehicles, metal production and mining. The analysis of temporal and spatial trends in the heavy metal deposition is generally expressed as pollution gradient.

Conclusion:

The present study reveals the content of heavy metals (Cd, Cr, Cu, Pb, Co, Fe, Hg and Ni) in two moss species viz. *Physcomitrium cyathicarpum* and *Barbula constricta* in different sites in the polluted zones of Delhi region. It appears that these metals are present well within the tolerance range of both the species as high concentration of metal content did not show any symptoms of toxicity. The study clearly depicts that for both the species, the substratum acts as a filter to take up more toxic metals such as Pb and Hg. Hence, these are not taken up by vegetative parts and remain concentrated in the substratum.

Both the species grow successfully in the urban areas and form the dense carpet in moist and shady places especially in the winter. Our results show that both the species can accumulate large amount of metals from the substratum.

Thus, species can be used for monitoring the levels of metals in the given site and for phytoremediation.

Acknowledgments:

Authors are grateful to the University of Delhi for the financial support. Dedicated help offered by Mr Sunil Kumar Sharma (USIC, University of Delhi) in the metal analysis through AAS is greatly acknowledged.

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12/23/2009