December 2009 Volume 4 Issue 6

Trade Science Inc.

Environmental Science

An Indian Journal

Current Research Papers

ESAIJ, 4(6), 2009 [363-367]

A study on metal accumulation in two selected bryophytes

Virendra Nath[1], Sarita Sinha[2], A.K.Asthana[1,*], Vinay Sahu[1]

[1]Bryology Laboratory National Botanical Research Institute (Council of Scientific & Industrial Research, New Delhi), Lucknow- 226 001, (INDIA)

[2]Bioremediation and Ecotoxicology Laboratory, National Botanical Research Institute, Lucknow-226 001, (INDIA)

E-mail : drvirendranath2001@rediffmail.com

Received: 11th June, 2009 ; Accepted: 21st June, 2009

ABSTRACT

Bryophytes play an important role as bioindicators of atmospheric pollution. They exhibit remarkable response to it by showing visible symptoms of injury and also by accumulating a large quantity of heavy metals from atmosphere owing to the absence of cuticle in their plant body and due to the abundance of cation exchange sites on the cell walls. The present study deals with assessment and accumulation of heavy metals (Pb, Cu, Zn, Ni, and Mn) in two taxa viz., *Plagiochasma appendiculatum* Lehm. *et* Lindb. and *Mnium marginatum* (With.) P. Beauv growing in the area of frequent autovehicular movement i.e. Kempty Fall Taxi Stand and also at the Company Garden, which is an area having restricted auto-vehicular movement. Enhanced concentrations of metals have been detected in the populations of these taxa growing in polluted areas. On the basis of the results obtained in this study, we can conclude that bryophytes are efficient accumulator of heavy metals.

KEYWORDS

Metals; Accumulation. *P. appendiculatum*; *M. marginatum*; Mussoorie.

INTRODUCTION

The wide spread distribution of bryophytes and tolerance of many of its species to certain environment contaminants has led to their use as bio-monitors of pollution. Physiologically they are totally dependent on atmospheric deposition for the uptake of mineral elements due to lack of well developed root system. They have evolved efficient uptake mechanism through their general surface due to absence of cuticle, which facilitates direct absorption of metals and other nutrients in their tissue. These particular features along with abundant cation exchange sites on their cell walls make them more susceptible to air pollution. Increasing auto-vehicular movement in recent times and resulting combustion of gases from them are an important source of atmospheric pollution. Lead compounds are the main atmospheric pollutants in exhaust gases which settle down on plant and soil surfaces. Since last many years bryophytes have been frequently studied as indicators of heavy metal deposition[1-3,5,6,8-13]. The present study deals with assessment and accumulation of heavy metals (Pb, Cu, Zn, Ni & Mn) in a thalloid liverwort *Plagiochasma appendiculatum* and a moss *Mnium marginatum* growing at different locations of (Kempty Fall, Company Garden, Camel's Back Road and Lal Tibba) Mussoorie, one of the most tourist crowded hills of the country. Hence, it needs a pollution monitoring

study to protect its healthy environmental conditions.

EXPERIMENTAL

Collection of plants and site selection

Thalloid liverwort *Plagiochasma appendiculatum* Lehm. *et* Lindb. has been collected from the polluted sites viz. Kempty Fall Taxi Stand (KT), Camel's Back Road (CB), Wood Stock College (WS) and less polluted sites viz. On way to Kempty Fall (KF-2), near Kempty Fall (KF-1), Lal Tibba (LT) and Company Garden (CG-1 & CG-2) of Mussoorie (30-27^0 N and 78.06^0 E), whereas, moss *Mnium marginatum* (With.) P. Beauv. was collected from Company Garden (CG-1 and CG-2) and Camel's Back Road (CB). The voucher specimens of the plants investigated have been deposited in Bryophyte Herbarium, N.B.R.I. (LWG) Lucknow.

Plant sampling and analysis

At least three replicates of each plant sample of different species were taken. Plant samples were thoroughly washed with running tap water and rinsed with deionized water to remove any soil particles attached to the plant surfaces. The plant samples were oven dried at 80^{0}C for 24 hrs. The dried materials were grounded to powder for metal concentration analysis, 0.25 gm (dry weight) of each sample was weighed. Then plant samples were digested by HNO_3: $HClO_4$ (3:1) until no brown fumes of nitrogen dioxide were given off. The digest, a clear pale yellow liquid was allowed to cool, filtered and the volume made up to 15 ml with de-ionized water. The concentrations of Pb, Cu, Zn, Mn and Ni were determined by Atomic Absorption Spectrophotometer (GBC Avanta Σ) and mean values were calculated from triplicates.

Soil sampling and analysis

Soil samples were composite mixtures of soils from the rhizosphere of each thallus. The soil samples were air dried at room temperature, then grounded into the powder and sieved through 0.25 mm sieve, 0.5gm soil samples were digested by HNO_3: $HCIO_4$ (3:1). The digest was allowed to cool, filtered and volume made up to 15 ml with deionized water. The concentration of Pb, Cu, Zn, Ni and Mn were determined by Atomic Absorption spectrophotometer (GBC Avanta Σ) and mean values were calculated from triplicates.

TABLE 1 : Metal accumulation (μg g^{-1} dw) in *P. appendiculatum* at different sites of Mussoorie

S. No.	Sites	Metals				
		Pb	Cu	Zn	Ni	Mn
1.	KT	55.63 ± 4.28	28.86 ± 0.084	63.53 ± 0.50	5.5 ± 0.56	177.06 ± 3.39
2.	KF-1	17.95 ± 1.01	40.05 ± 0.296	107.55 ± 4.45	2.05 ± 0.35	197.52 ± 0.42
3.	KF-2	26.19 ± 2.41	29.22 ± 2.46	84.30 ± 3.81	6.61 ± 0.82	142.38 ± 2.88
4.	WSC	24.44 ± 0.95	18.75 ± 1.06	318.75 ± 8.27	19.1 ± 1.13	351.82 ± 3.36
5.	LT	11.52 ± 2.20	20.55 ± 0.04	116.70 ± 1.27	6.93 ± 0.51	152.33 ± 1.52
6.	CG-1	12.86 ± 0.73	17.32 ± 0.30	76.65 ± 3.60	1.26 ± 0.11	116.15 ± 3.32
7.	CG-2	13.92 ± 0.30	34.23 ± 2.24	105.30 ± 1.27	19.95 ± 0.63	200.49 ± 6.6
8.	CB	48.15 ± 3.18	25.13 ± 1.96	249.70 ± 1.13	26.7 ± 2.96	113.64 ± 0.509

KT- Kempty Fall Taxi Stand; KF-1- Near Kempty Fall; KF-2-On way to Kempty Fall; WS- Wood Stock College; LT- Lal Tibba; CG-1-Company Garden site1; CG-2 Company Garden site2; CB – Camel's Back Road
(All the values are mean of three replicates ± SD)

TABLE 2 : Metal accumulation (μg g^{-1} dw) in *M. marginatum* at different sites of Mussoorie

S. No.	Sites	Metals				
		Pb	Cu	Zn	Ni	Mn
1.	CG-1	19.62 ± 0.16	34.34 ± 1.57	239.70 ± 0.42	17 ± 1.4	256.90 ± 7.67
2.	CG-2	21.28 ± 0.90	19.84 ± 0.62	239.84 ± 0.622	17.75 ± 0.35	239.54 ± 2.00
3.	CB	58.68 ± 2.96	27.92 ± 1.49	353.66 ± 1.52	13.65 ± 1.21	276.36 ± 2.05

CG-1- Company Garden site1; CG-2 Company Garden site 2; CB- Camel's Back Road
(All the values are mean of three replicates ± SD)

TABLE 3 : Metal accumulation (µg g^{-1} dw) in soil of *P. appendiculatum* at different sites of Mussoorie

S. No.	Sites	Metals				
		Pb	Cu	Zn	Ni	Mn
1.	KT	7.19 ± 0.37	11.01 ± 0.45	50.41 ± 1.77	10.7 ± 0.26	229.20 ± 13.2
2.	KF-1	11.41 ± 1.28	18.94 ± 0.84	80.79 ± 7.2	12.2 ± 0.92	262.99 ± 2.46
3.	KF-2	7.54 ± 0.39	17.92 ± 0.47	71.46 ± 2.79	15 ± 0.22	424.80 ± 3.9
4.	WSC	17.03 ± 1.16	27.45 ± 0.89	263.89 ± 2.15	30.8 ± 0.80	868.80 ± 26.4
5.	LT	8.37 ± 0.89	24.07 ± 0.27	79.08 ± 0.12	19.4 ± 1.03	411.60 ± 5.88
6.	CG-1	11.06 ± 0.52	21.93 ± 1.08	81.97 ± 1.35	13.2 ± 1.15	413.19 ± 24.6
7.	CG-2	20.13 ± 0.80	42.49 ± 0.86	424.14 ± 1.49	29.34 ± 0.84	855.60 ± 60.6
8.	CB	44.82 ± 2.04	71.32 ± 4.11	366.09 ± 2.28	45.6 ± 2.06	1917.6 ± 87

KT- Kempty Fall Taxi Stand; KF-1- Near Kempty Fall; KF-2-On way to Kempty Fall; WS- Wood Stock College; LT- Lal Tibba; CG-1-Company Garden site1; CG-2 Company Garden site2; CB – Camel's Back Road
(All the values are mean of three replicates ± SD)

TABLE 4 : Metal accumulation (µg g^{-1} dw) in soil of *M. marginatum* at different sites of Mussoorie

S. No.	Sites	Metals				
		Pb	Cu	Zn	Ni	Mn
1.	CG-1	15.72 ± 0.13	36.31 ± 2.64	251.46 ± 1.43	18.63 ± 0.84	833.19 ± 39.3
2.	CG-2	10.20 ± 0.51	18.58 ± 0.96	181.44 ± 0.64	69.15 ± 0.24	634.39 ± 3.9
3.	CB	13.23 ± 0.80	25.44 ± 0.70	157.74 ± 0.57	20.29 ± 0.16	691.80 ± 8.1

CG-1- Company Garden site1; CG-2 Company Garden site 2; CB- Camel's Back Road
(All the values are mean of three replicates ± SD)

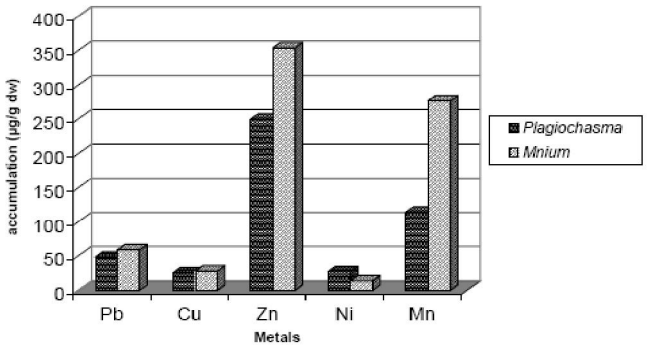
TABLE 5 : Correlation coefficient (r) between *Plagiochasma appendiculatum* and their respective soil (n = 3)

S.N	Sites	Pb	Cu	Zn	Ni	Mn
1.	KT	+0.28	+0.85	-0.54	+0.54	+0.82
2.	KF-1	- 0.65	-0.40	+0.07	+0.72	+0.68
3.	KF-2	+0.42	-0.031	-0.22	-0.99**	-0.41
4.	WSC	+0.29	+0.99**	+0.81	-0.35	-0.34
5.	LT	-1**	-0.97**	-0.046	+0.99**	+0.78
6.	CG-1	-0.98**	-0.16	+0.24	+0.95*	+0.029
7.	CG-2	+0.70	+0.72	+0.36	+0.68	-0.22
8.	CB	-0.5	+0.93*	+0.74	+0.67	+0.73

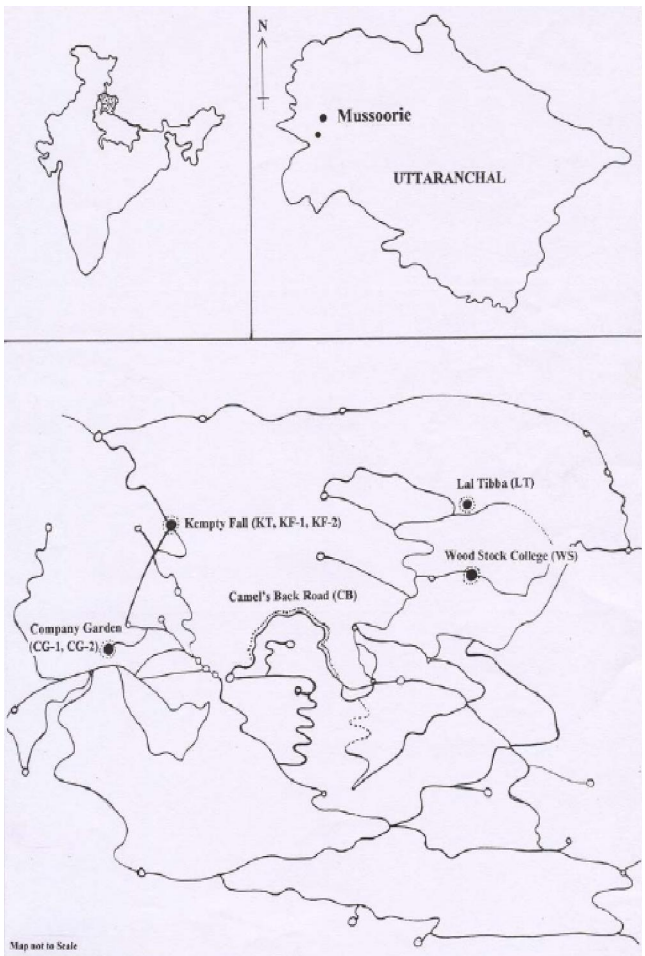
TABLE 6 : Correlation coefficient (r) between *Mnium marginatum* and their respective soil (n = 3)

S.N	Sites	Pb	Cu	Zn	Ni	Mn
1.	CG-1	-0.55	-0.50	+0.57	-0.90*	-0.93*
2.	CG-2	- 0.96**	+0.31	-0.69	+0.5	-0.86
3.	CB	+0.5	-0.14	+0.90*	-0.98**	+0.80

Significant at the level P < 0.05*
P < 0.01**



Comparative metal accumulation



Map showing sampling sites at Mussoorie (Uttaranchal)

Current Research Paper

RESULTS AND DISCUSSION

Among the two taxa *P. appendiculatum* and *M. marginatum*, former has been found widely growing at nearly all the sites surveyed, however, latter was found growing at two sites in Company Garden and at Camel's Back Road. The luxuriant growth of these plants at polluted sites exhibits their efficiency to serve as excellent accumulator of atmospheric pollutants. A preliminarily heavy metal analysis showing the range of accumulation has been provided (TABLES 1 and 2).

The accumulation of Pb in *P. appendiculatum* has been found high (55.63 $\mu g\ g^{-1}$ dw**)** in the populations of Kempty fall Taxi Stand (KT) and Camel's Back Road (CB) similarly it has also been found in comparatively higher concentration (58.68 $\mu g\ g^{-1}$ dw in *M. marginatum* at Camel's Back Road. The main reason for this is that above localities are most polluted by auto vehicular exhaust and some anthropogenic activities. A prominent decline in the level of Pb concentration has been found in the population growing at less polluted sites viz. near Kempty fall, Lal Tibba, Wood Stock College and Company Garden (TABLES 1 and 2).

The accumulation of Cu in *P. appendiculatum* and *M. margintam* showed a slight variation in the populations sampled from all the sites (TABLES 1 and 2), however, an increase in Cu concentration has been noticed at comparatively less polluted sites (near Kempty Fall) in *P. appendiculatum* and at Company Garden (site 1) in *M. marginatum*.

M. marginatum has been found as a good accumulator of Zn as compared to *P. appendiculatum*, a fair amount of Zn has been detected in the samples of Camel's Back Road, Wood Stock College, Company Garden (Site 1and 2), respectively. As such Zn is an essential element for the growth of the plants, but in higher concentration, it causes toxic effects. Tyre burning and fuel combustion are the reasons for suspension of higher concentration of Zn in atmosphere. In an experiment carried out by Ghate and Chaphekar[7], it has been found that *P. appendiculatum* is resistant to lead, Zinc and Chromium.

Nickel (Ni) is present in comparatively low concentration in both the taxa at nearly all the sites, which ranged from 10.7 to 45.6 $\mu g\ g^{-1}$ dw in *P. appendiculatum* and 13.65 to 69.15 $\mu g\ g^{-1}$ dw in *M. marginatum.*

Manganese (Mn) accumulation in *P. appendiculatum* is comparatively at higher level at Wood Stock College and Company Garden (Site 2), while *M. marginatum* showed a fair and nearly uniform level of Mn accumulation in the populations of Company Garden (sites 1 and 2) and Camel's Back Road. The rock bed is the possible source of accumulation of Mn in the above taxa[4].

Soil sample analysis of all sites has shown that the concentration of Pb was higher in plant sample as compared to the soil sample while concentration of Ni and Mn was higher in soil sample. Cu concentration was higher at Kempty fall Taxi stand, Kempty fall site-1 and Kempty fall site-2 in plant sample. In the case of Company Garden site-1, Company Garden site-2 and Camel's back road concentration of Zn was higher in soil sample as compared to plant sample.

In the present study, Correlation analysis (r) was performed in order to investigate the relationship between the soil samples and accumulation of metals in both the plants. (TABLES 5 and 6). Significant accumulation ($P < 0.01$) of Pb, Cu and Ni was recorded in *P. appendiculatum* at Lal Tibba site. Correlation data closely indicate that the accumulation of Ni and Cu was found significant. Accumulation of toxic metal (Pb) was significantly ($P < 0.01$) found in Lal Tibba and Company Garden. However, Cu was significantly ($P < 0.01$) observed at Wood Stock College. Significant ($P < 0.05$) correlation of Cu metal was found in *P. appendiculatum* at Camel's back road site. In the case of *M. marginatum* significant ($P<0.05$) correlation was found in Ni and Mn metal at Company Garden Site 1 while Pb was significantly ($P < 0.01$) observed at Company Garden Site-2. Significant ($P < 0.05$) accumulation of Zn was recorded at Camel's back road. Correlation data indicate that the accumulation of Pb was significantly found in Company Garden Site 2.

CONCLUSION

The present study and data analysis has revealed that *M. marginatum* is an efficient accumulator of heavy metals as compared to the *P. appendiculatum.* Positive and negative Correlation of all heavy metals shows that the accumulation of metals was found significant in

some localities in both the plant samples.

Excessive auto exhaust from increasing movement of tourist vehicles at Kempty fall taxi stand seems to be most probable reason for the high accumulation of Pb in the atmosphere. However, at Camel's Back Road the high Pb deposition is possibly caused by low temperature and heavy precipitation in the valley.

ACKNOWLEDGEMENT

Authors are grateful to the Director, National Botanical Research Institute, Lucknow for encouragement and providing facilities.

REFERENCES

[1] A.Ruhling, G.Tyler; Botaniska Notiser. **121**, 321-342 **(1968)**.
[2] A.Ruhling, G.Tyler; Focus. **1**, 311- 323 **(2001)**.
[3] C.D.Vincet, A.J.Lawlor, E.Tipping; Environmental Pollution. **114**, 93-100 **(2001)**.
[4] D.K.Saxena; Biomonitoring of Pb, Ni, Cr, Hg, with help of bryophytes in Nainital, in V.Nath, A.K.Asthana Eds. 'Perspectives in Indian Bryology', Bishen Singh and Mahendra Pal Singh publishers, Dehradun, India, 155-170 **(2001)**.
[5] F.Leblanc, D.N.Rao; Effect of Air pollution on Lichens and Bryophytes, in J.B.Mudd, T.T.Kozelowski, Eds. 'Responses of Plants to air pollution', Academic Press, New York, **(1975)**.
[6] F.Leblanc; The Journal of Hattori Botanical Society. **38**, 405 **(1974)**.
[7] Ghate, S.Chaphekar; Environmental Pollution. **108**, 173-181 **(2000)**.
[8] L.Folkeson; Water, Air and Soil pollution. **11**, 253-260 **(1979)**.
[9] M.Kirchhoff, H.Rudolph, C.Struck, H.Deising; Heavy metal analysis of *Sphagnum*, in J.M.Glime Ed.' Methods in Bryology', Hattori Botanical Laboratory, Nichinan, 221-226 **(1988)**.
[10] M.Singh, V.Nath, A.Kumar; Geophytology. **35(1&2)**, 75-83 **(2005a)**.
[11] M.Singh, V.Nath, A.Kumar; Proc.Nat.Acad.Sci. India. **75(B)(1)**, 41-50 **(2005b)**.
[12] M.A.S.Burton; Bot.Journ.Linn.Soc. **104**, 267-280 **(1990)**.
[13] V.Nath, A.K.Asthana, S.Sharma; Environmental studies on bryophytes of Mussoorie (Western Himalayas) in Tripathi *et al*, Eds. 'Plant response to Environmental stress', International Book Distributing Co. Lucknow, 173-178 **(2006)**.