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MARCHANTIA PALEACEA BERTOL. AS QUANTITATIVE BIOMONITOR OF ATMOSPHERIC HEAVY METALS DEPOSITION

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ABSTRACT

Bryophytes are known as good accumulators of heavy metals due to their simple morphological and physiological characteristics. The concentrations of five metals *viz.*, Zn, Mn, Pb, Cu and Ni in *Marchantia paleacea* Bertol. has been analyzed from different localities of Kumaon hills. The concentrations of the same elements were also determined in soil samples collected at the same sites to evaluate the role of soil as a potential source of metals uptake by the plant. Concentration of Pb, Cu, Ni and Zn was found higher in plant samples of disturbed sites as compared to less disturbed sites. Mn concentration was higher in soil samples as compared to plant samples. Correlation analysis (r) was also performed to investigate the relationship between the soil samples and accumulation of metals in the plant. Significant accumulation ($P<0.01$) of Pb, Cu and Ni was recorded at Bhowali taxi stand (Nainital). Present study revealed that the accumulation of toxic metals in *M. paleacea* may be used in determining the air quality of the city and can be used for future biomonitoring studies.

KEY WORDS: Bryophytes, Heavy metals, *Marchantia paleacea*, Kumaon hills.

INTRODUCTION

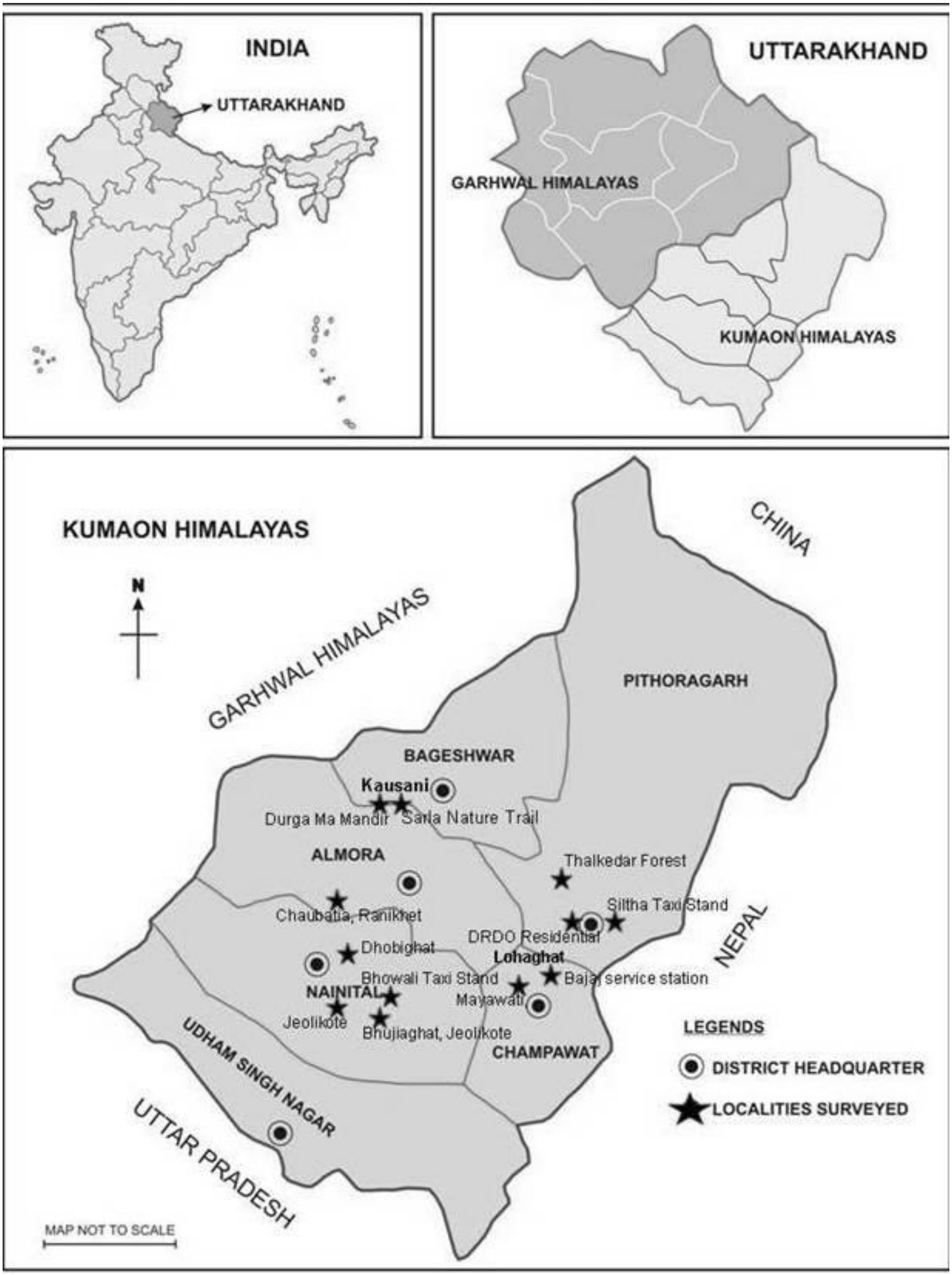
Due to environmental pollution, number of pollutants including heavy metals released in the atmosphere cause adverse effects on the health of living beings. Bryophytes possess a counter-gradient mechanism by which they accumulate metal ions. The high metal accumulating capacity of the bryophytes can be attributed to their high surface-to-volume ratio and lack of continuous cuticle layer. (1). Bryophytes are widely used as biosensors of environmental pollution in recent years (2-7). Their differential sensitivity to air borne pollutants makes them useful in biomonitoring studies. Biomonitoring is of great interest for those cities having fast pace of urbanization and industrialization which encounter the serious problems of pollution, especially due to heavy tourist activities. They have certain characters, which make them suitable for their use as biomonitors viz., rapid absorption rate, lack of cuticle and roots and dependence for mineral nutrition on precipitation and absorption through plant surface rather than their roots, accumulation of heavy metals in plants in their ionic state (8).

Present study has been undertaken on genus *Marchantia paleacea* (thalloid liverwort) growing at Kumaon hill of western Himalaya. Kumaon hill is famous for its beauty and large number of tourists visit this area every year. Due to heavy tourist activities in this area urbanization and vehicular movement were increased which enhanced the serious problem of pollution. The objective of the study was to find out the effect of heavy metals *viz.*, Zn, Mn, Pb, Cu and Ni in *Marchantia paleacea* Bertol. in different localities of Kumaon hills. The concentrations of the same elements were also determined in soil samples collected at the same sites to evaluate the role of soil as a potential source of metals uptake by the plant.

MATERIALS AND METHODS

Study area: The Himalayan region of the Uttarakhand constitutes two major zones, *viz*., Garhwal and Kumaon regions. Kumaon comprises, *viz*., Almora, Nainital, Pithoragarh, Champawat and Bageshwar hill districts. It lies between 20^0–43’ and 30^0–49’ N latitude and 78^0–44’ and 81^0–4’ E longitude.

Marchantia paleacea was growing at Kumaon region of western Himalaya (Map 1). The main collection sites for *M. paleacea* were **Nainital** (Bhowali taxi stand, Dhobighat, Jeolikote, Bhujiaghat-Jeolikote), **Pithoragarh** (Thalkedar Forest, DRDO residential area, Siltha taxi stand), **Lohaghat** (near Bajaj service station, near Mayawati), **Kausani** (near Durga Ma Mandir, Sarla Nature Trail), **Ranikhet** (Chaubatia road).


INDIA
UTTARAKHAND
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PITHORAGARH
BAGESHWAR
Kausani
Durga Ma Mandir
Sarla Nature Trail
ALMORA
Thalkedar Forest
Chaubatia, Ranikhet
Siltha Taxi Stand
NEPAL
DRDO Residential
Dhobighat
Lohaghat
Bhowali Taxi Stand
Bajaj service station
NAINITAL
Mayawati
Jeolikote
Bhujiaghat, Jeolikote
CHAMPAWAT
LEGENDS
DISTRICT HEADQUARTER
LOCALITIES SURVEYED
UDHAM SINGH NAGAR
UTTAR PRADESH
MAP NOT TO SCALE

The specimens collected from different areas of Kumaon hills have been deposited in the Bryophyte Herbarium, National Botanical Research Institute, Lucknow (LWG). For the proper identification of the collected *Marchantia* spp. authenticated samples of *Marchantia* spp. were obtained from different herbaria (The Natural History Museum, London, U.K. and Hattori Botanical Laboratory, Nichinan, Miyazaki, Japan).

Preparation of samples for Analytical studies

Plant samples were thoroughly washed with running tap water and rinsed with deionized water to remove any soil particles adhered to the plant surfaces. The plant samples were oven dried at 80^0C for 24 hrs. The dried materials were grounded to powder for metal concentration analysis, 0.25 gm (dry weight) of each sample was weighed. These plant samples were digested by HNO_3: $HClO_4$ (3:1, filtered and the volume made up to 15 ml with deionized water. The concentrations of Pb, Cu, Zn, Mn and Ni were determined by Atomic Absorption Spectrophotometer (GBC Avanta Σ) and mean values were calculated in triplicates.

RESULTS AND DISCUSSION

Plants of *Marchantia paleacea* have been collected from different localities of the Kumaon hills spread through Kausani, Lohaghat, Nainital, Pithoragarh, Ranikhet. Plant populations were found growing at different altitudes in terricolous habitats *viz*., on soil, rock, stony wall and wet rock (Table 1).

The concentration level of five metals *viz.,* Pb, Zn, Mn, Ni and Cu in plant samples of *M. paleacea* and soil *(i.e.,* substratum of *M. paleacea*) was analyzed from 12 localities of Kumaon hills. It was found that in plant samples, concentration of Zn was maximum at Durga Ma Mandir (Kausani), 261.60 µg/g dwt, while in soil samples maximum amount of Zn present at Bhowali taxi stand (Nainital), 129.29 µg/g dwt (Table 2-3). Christensen and Guinn (9) found that the particles emitted by automobile tyres are major source of Zn. In the case of Zn, the analysis showed significant correlation ($P<0.01$) at near Mayawati (Lohaghat) and significant accumulation of Zn ($P<0.05$) was found at Bhowali taxi stand (Nainital) and Siltha taxi stand (Pithoragarh: Table 4). It clearly indicates that the accumulation of Zn was found significant.

Mn concentration was found to be maximum at Bhowali taxi stand (Nainital), 468.90 µg/g dwt in plants of *M. paleacea* while soil sample analysis has shown that maximum amount of Mn was found at Dhobighat (Nainital), 614.40 µg/g dwt (Table 2-3). The high level of Mn in the plant samples could be accumulated from aerosols that are originally derived from eroded rocks (10). Wei *et al.* (11) found 550 mg/kg and 583 mg/kg Mn from the soil of USA and Japan respectively. In the case of Mn the analysis showed significant ($P<0.01$) correlation at Dhobighat (Nainital), while significant ($P<0.05$) correlation of Mn was found Near Durga Ma Mandir (Kausani) and DRDO rsidential area, Pithoragarh (Table 4).

Concentration of Cu was found to be maximum at Dhobighat (Nainital), 71.90 µg/g dwt in plant samples. Soil sample analysis has shown that maximum amount of Cu was found at Bajaj service station (Lohaghat), 48.18 µg/g dwt (Table 2-3). Shacklette (12) found that copper moss *Mielichhoferia macrocarpa* contained amounts higher than those present in substratum. In the case of Cu, the analysis showed significant correlation ($P<0.01$) at Bhowali taxi stand (Nainital) and Sarla Natural Trail (Kausani). Correlation data closely indicate that the accumulation of Cu was found significant (Table 4).

Concentration of Pb content in *M. paleacea* was found maximum at Bhowali taxi stand (Nainital), 82.74 µg/g dwt. Soil sample analysis has shown that maximum amount of Pb was present Near Bajaj service station (Lohaghat). The minimum amount of Pb was reported at Thalkedar Forest (Pithoragarh), 0.08 µg/g dwt, near Mayawati (Lohaghat), 0.28 µg/g dwt and DRDO residential area (Pithoragarh), 2.3 µg/g dwt because vehicular movement was very low or absent (Table 2-3). Less distance from road also the cause of Pb accumulation in *Marchantia.* Ruhling and Tyler (13) also reported similar observations. They found considerable amount of Pb in mosses *Pleurozium schreberi* and *Hylocomium splendens* and in soil within a distance of 50-100m from large roads. Flannagan *et al.* (14) also found high concentrations immediately adjacent to the road side and decline steeply with increasing distance from road edge. Sharma and Kapila (15) investigated 25 moss samples to monitor the lead pollution in various parts of Chandigarh city

Table 1: Localities description

S.N.	Localities	Substratum	Height from ground (m)	Distance from road (Km)	Distance from mid city (Km)	Sources of pollution
1	BT	Stony wall	1.0	0.01	0.0	Fossil fuel, Vehicular
2	DG	Rock	1.0-2.0	1.0 Km	5	Fossil fuel
3	JK	Rock	1.0-2.0	0.01	10	Fossil fuel, Vehicular
4	BJK	Stony wall	1.0-2.0	0.005	15	Fossil fuel, Vehicular
5	CR	Rock	0.50	0.005	1.0	Vehicular
6	DM	Wet rock	1.0-2.0	0.005	0.50	Vehicular
7	SNT	Soil	0.50	0.005	1.0	Fossil fuel, Vehicular
8	TF	Wet rock	0.25	5	25	Fossil fuel
9	DRD	Soil	0.75	0.01	5.0	Fossil fuel, Vehicular
10	STS	Rock	1.0	0.01	0.0	Fossil fuel, Vehicular
11	BSS	Rock	0.50-1.0	0.005	0.50	Vehicular
12	MY	Rock	1.0	0.01	7.0	Very less Vehicular activities

BT – Bhowali taxi stand, DG – Dhobighat, JK – Jeolikote, BJK – Bhujiaghat Jeolikote (Nainital); CR – Chaubatia road (Ranikhet); DM – Near Durga Ma Mandir, SNT – Sarla Natural Trail (Kausani); TF – Thalkedar Forest, DRD – DRDO Residential area, STS – Siltha taxi stand (Pithoragarh); BSS – Near Bajaj service station, MY – Near Mayawati (Lohaghat).

Table 2: Metal accumulation (μg/g dw) in *M. paleacea* at different sites of Kumaon hills.

		Metals									
S.N.	Sites	Zn		Mn		Cu		Ni		Pb	
1	BT	181.13	± 5.44	468.90	± 10.21	46.90	± 2.13	40.20	± 1.67	82.74	± 8.40
2	DG	176.40	± 5.51	428.10	± 22.63	71.90	± 5.65	53.90	± 4.37	37.90	± 2.82
3	JK	138.26	± 3.29	80.54	± 2.10	29.54	± 3.29	3.22	± 2.51	9.64	± 0.50
4	BJK	113.96	± 0.84	51.88	± 1.90	20.09	± 2.49	1.24	± 1.48	12.66	± 1.04
5	CR	133.60	± 6.23	211.20	± 2.16	69.12	± 3.73	15.60	± 1.27	64.50	± 1.44
6	DM	261.60	± 5.85	48.72	± 1.56	16	± 0.72	4.96	± 0.24	11.80	± 0.25
7	SNT	251.80	± 5.44	116.84	± 0.61	40.34	± 0.99	7.86	± 0.54	11.82	± 8.40
8	TF	95.32	± 3.24	109.96	± 5.77	17.8	± 0.60	4.54	± 0.38	0.08	± 3.26
9	DRD	83.32	± 5.63	218.82	± 3.84	9.7	± 0.19	3.96	± 0.21	2.3	± 1.87
10	STS	87.86	± 5.51	84.3	± 3.26	19.88	± 1.00	5.4	± 0.37	7.66	± 2.82
11	BSS	106	± 2.12	238.34	± 7.87	32.82	± 0.43	6.24	± 0.72	7.78	± 1.02
12	MY	128.84	± 0.27	100.14	± 2.04	22.06	± 1.01	3.34	± 0.24	0.28	± 0.09

± Standard deviation

Table 3: Metal accumulation (µg/g dw) in soil of *M. paleacea* at different sites of Kumaon hills

		Metals									
S.N.	Sites	Zn		Mn		Cu		Ni		Pb	
1	BT	129.29	± 3.27	529.90	± 4.91	24.67	± 0.33	25.90	± 0.16	10.19	± 1.05
2	DG	124.82	± 0.21	614.40	± 23.15	36.88	± 0.46	37.10	± 0.65	9.38	± 0.69
3	JK	72.05	± 1.19	316.62	± 5.68	15.22	± 0.61	12.06	± 1.73	17.76	± 0.84
4	BJK	59.38	± 1.48	203.49	± 4.18	9.72	± 1.49	14.23	± 1.46	19.53	± 1.18
5	CR	81.36	± 2.29	312	± 13.65	21.13	± 0.51	20.79	± 0.94	7.61	± 0.70
6	DM	90.34	± 1.26	292	± 1.67	22.28	± 0.21	15.44	± 032	19.85	± 0.94
7	SNT	75.15	± 0.54	503.40	± 7.48	14.36	± 0.78	60.33	± 2.41	13.28	± 1.34
8	TF	63.77	± 4.44	510.77	± 0.40	14.51	± 0.19	25.49	± 0.97	2.68	± 0.12
9	DRD	56.22	± 0.90	452.58	± 3.28	17.03	± 0.57	35.25	± 3.04	14.27	± 0.28
10	STS	39.86	± 0.45	205.36	± 17.15	20.48	± 0.90	18.56	± 0.18	11.52	± 0.76
11	BSS	76.66	± 2.67	541.92	± 0.82	48.18	± 2.35	32.65	± 0.35	20.76	± 0.48
12	MY	74.85	± 0.34	547.64	± 4.52	38.39	± 1.23	39.49	± 0.72	10.20	± 0.46

± Standard deviation

Table 4: Correlation Coefficient (r) between *M. paleacea* and their respective soil (n = 3).

S.N.	Sites	Zn	Mn	Cu	Ni	Pb
1	Bhowali taxi stand (Nainital)	+0.95*	-0.52	+0.99**	-0.99**	-0.99**
2	Dhobighat (Nainital)	-0.35	-0.99**	+0.78	-0.85	-0.40
3	Jeolikote (Nainital)	+0.87	-0.58	-0.84	+0.19	+0.97**
4	Bhujiaghat, Jeolikote (Nainital)	+0.69	+0.85	+0.78	+0.57	-0.23
5	Chaubatia road (Ranikhet)	+0.31	+0.66	+0.67	-0.99**	+0.63
6	Near Durga Ma Mandir (Kausani)	+0.41	-0.90*	+0.70	+0.86	+0.72
7	Sarla Natural Trail (Kausani)	-0.07	+0.87	-0.99**	-0.95*	-0.07
8	Thalkedar Forest (Pithoragarh)	-0.22	-0.66	-0.58	-0.74	+0.97**
9	DRDO residential area (Pithoragarh)	-0.73	+0.94*	-0.30	+0.10	-0.76
10	Siltha t6xi stand (Pithoragarh)	-0.95*	-0.20	+0.69	+0.65	+0.89*
11	Near Bajaj service station (Lohaghat)	-0.81	+0.78	-0.88	+0.60	+0.67
12	Near Mayawati (Lohaghat)	+0.99**	+0.69	+0.63	+0.86	+0.65

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

and concluded that the factors responsible for efficient uptake and accumulation of Pb were the higher concentration of Pb in the substratum and the polluted air from industries and traffic exhaust. Significant accumulation (P<0.01) of Pb was recorded at Bhowali taxi stand (Nainital) and Jeolikote (Nainital) while significant (P<0.05) correlation of Pb was found at Thalkedar Forest (Pithoragarh) and Siltha taxi stand, Pithoragarh (Table 4). Correlation data closely indicate that the accumulation of Pb was found significant.

Concentration of Ni in *M. paleacea* was found to be maximum at Dhobighat (Nainital), 53.90 µg/g dwt, while maximium amount of Ni was found in soil, at Sarla Natural Trail (Kausani), 60.33 µg/g dwt. Minimum amount of Ni was reported at Bhujiaghat, Jeolikote, Nainital. Sadiq *et al.* (16) found that vehicular Ni can be discharged into the atmosphere not only by car emissions but also due to scattered tyre particles into the environment and analyzed 29 different branded tyres and surface soil samples collected from Riyadh Dharan highway in Saudi Arabia. It was found that Ni value in the tyre samples was 4µg/g and in the soil samples 11µg/g-18 µg/g respectively. Significant accumulation ($P<0.01$) of Ni was recorded at Bhowali taxi stand (Nainital) and Chaubatia road (Ranikhet), while significant correlation ($P<0.05$) of Ni was found at Sarla Natural Trail, Kausani (Table 4). It indicates that the accumulation of Ni was found significant.

CONCLUSIONS

Among all five metals, Mn accumulation in plant samples have been found higher followed by Zn, Cu, Pb and Ni and level of Mn was found higher in soil samples also. In the present study it has been found that *M. paleacea* is an efficient accumulator of heavy metals and protect itself from environmental pollution. Metal bio-monitoring with the help of naturally growing this species is a valid and useful technique in countries like India owing to its economic growth and fast pace of urbanization. Presence of metals in thallus of *M. paleacea* confirms the ability of this species to absorb metals directly from the atmosphere and have an ability to grow frequently in polluted sites. Monitoring of heavy metal accumulation by this plant not only offers a more cost efficient method but it also allows a more time efficient way to assay the concentration of metals at distinct locations.

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REFERENCES

1. Carginale, V., Sorbo, S., Capasso, C., Trinchella, F., Cafiero, G., & Basile, A. (2004). Accumulation, localization and toxic effects of Cadmium in the liverworts *Lunularia crucita.* Protoplasma 223: 53-61.
2. Rosa, L. G., & Giuseppe, B. (2009). Bioaccumulation of heavy metals in mosses from Enta Volcano and Iblei Mountains (Eastern Sicily, Italy). Cryptogamie, Bryologie 30 (1): 143-155.
3. Sun, S. Q., Wang D. Y., He, M., & Zhang, C. (2009). Monitoring of atmospheric heavy metal deposition in Chongqing, China - based on moss bag technique, Environmental Monitoring & Assessment, 148, 1–9. doi:10.1007/s10661-007-0133-1.
4. Nath, V., Sahu, V., Asthana, A. K. and Yunus M. (2009). Heavy metal indicator *Marchantia paleacea* Bertol. (Liverwort): A case study of Nainital (Uttarakhand), Proceedings National Acadamy Of Science. India, sect. B, 79: 147-152.
5. Nath, V., Sinha, S., Asthana, A. K., & Sahu, V. (2010). A study on metal accumulation in two selected bryophytes, Environmental Science - An Indian Journal 5 (1): 42-45.
6. Nath, V., Sinha, S., Sahu, V., Govind, G., Srivastava, M., Asthana, A. K. (2010). A study on metal accumulation in two mosses of Lucknow (U.P.), Indian Journal of Applied & Pure Bioliology. 25(1): 25-29.
7. Ghatge M. M, Shaikh S. D. Dongare M. (2011): Study on the metal absorbtion by two bryophytes from Koyana wild life Sanctuary (India). Journal of Experimental Sciences 2(3): 49-50.
8. Glime, J. M., & Saxena, D. K. (1991). Uses of bryophytes. New Delhi: Today and Tomorrow's Printers and Publishers.
9. Christensen, E. R., & Guinn V. P., (1979). Zinc from automobiles tyres in urban runoff, Journal of Environmental Engineering Division 105: 165-168.
10. Saxena, D. K. (2001). Biomonitoring of Pb, Ni, Cr, Hg with help of bryophytes in Nainital, In V. Nath & A. K Asthana (Eds.), Perspectives in Indian Bryology_(pp.155-170). Bishen Singh and Mahendra Pal Singh publishers, Dehradun, India.
11. Wei, F. S., Chen, J. S., Wei, Y. Y., & Zheng, G. J. (1991). Study on the background values of soil elements of China, Environment Science. 12: 12-19.
12. Schacklette, H. T. (1965). The amount of certain elements in mosses and liverworts compared with the amounts in substrate and in vascular plants (U.S.). Geological Survey Bulletin 1198: 1-21.
13. Ruhling. A., & Tyler, G. (1968). An ecological approach to the lead problem. Botaniska Notiser. 121: 321-342.
14. Flannagan, J., Wade, K. J., Currie, A., & Curtis, D. J. (1980). The deposition of lead and Zinc from traffic pollution on two roadside shrubs. Environmental Pollution, 113: 71-78.
15. Sharma, A., & Kapila, S. (2007). Mosses as bio-indicators of lead pollution in Chandigarh. Phytomorphology 57: 45-50.
16. Sadiq, M., Alam, I. EL, Mubarek, A., & Al Mohdar HM. (1989). Preliminary evaluation of metal pollution from wear to Auto tyres. Bulletin of Environment Contamination and Toxicology 42: 743-748.