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A COMPARATIVE STUDY OF LEAD AND MERCURY IN THE AMBIENT AIR IN PANTNAGAR UNIVERSITY EMPLOYING MOSS *Thuidium cymbifolium* (Dozy & Molk.) Dozy & Molk.

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ABSTRACT
An active biomonitoring of two heavy metals, Lead (Pb) and Mercury (Hg), was undertaken employing moss *Thuidium cymbifolium* (Dozy & Molk.) Dozy & Molk. for the first time in Pantnagar University. Nylon bags containing moss were installed for a period of one year (2014-15) at an interval of 4 months, for each season, *i.e.* summer (March - June), monsoon (July - October) and winter (November - February). Quantitative analysis of Pb and Hg was done using Atomic Absorption Spectrophotometer (AAS). During summer, highest level of Pb was reported near petrol pump (11.49 ±0.56 ppm) while of Hg at Nagla gate (10.10 ±0.28 ppm). Minimum Pb concentration (5.09 ±0.11 ppm) was recorded at Medicinal Research and Development Centre (MRDC) while Hg showed its least concentration (7.52 ±0.06 ppm) at Vegetable Research Centre (VRC). During monsoon maximum Pb concentration was again found at the petrol pump (4.28±0.22 ppm) and that of Hg at Beni residential area (6.76 ±0.03 ppm). Minimum concentration of Pb was found at MRDC (1.63 ±0.19 ppm) while that of Hg at Nagla farm (2.32 ±0.10 ppm). The results suggest that summer season is more prone to heavy metal pollution deposition compared to winter and rainy season which is due to the fact that in the latter two seasons the metals are leached out owing to humid conditions.

KEYWORDS: Active Biomonitoring, Lead, Mercury, *Thuidium cymbifolium.*

INTRODUCTION

Rapid and extensive industrialization aroused health concerns due to pollution amongst people worldwide. This provoked the scientists to devise pollution monitoring instruments prior to pollution control devices. Every entity is a monitor in itself towards the changes in the environment, be it plants, animals, microorganism or lifeless rocks. With the same motive, mosses were declared as efficient biomonitors of air pollution, particularly heavy metals in the air in Sweden in late 1960s (Ruhling and Tyler, 1968; Tyler, 1970). Though Lichens are considered as the best biomonitors of air pollution (Falla *et al.*, 2000; Kansanen and Venetvaara, 1991) they suffer from taxonomic identification. While others suggest mosses to be more sensitive than lichens (Taylor and Witherspoon, 1972; Matson and Liden, 1975; Folkeson, 1979b; Pakarinen, 1981; Stanislaw, 1981; Boileau *et al.*, 1982; Pakarinen and Hasanen, 1983; Roos *et al.*, 1994). Therefore, mosses have been used on varied scales to conduct monitoring of environment for air pollutants, specifically, heavy metals (Ruhling, 1994). For places where mosses do not find suitable environment to flourish, accessibility on difficult terrains is restricted and availability of expensive and power driven equipments for heavy metal monitoring is limited, active biomonitoring as introduced by Goodman *et al. (*1974) comes into play. European Union, owing to its climatic conditions (temperate) and pollution load, has been almost entirely covered under the extensive biomonitoring programme using the moss bag technique (genoni *et al.*, 2000; Fernandez *et al.*, 2004; Lucaciu *et al.*, 2004; Culicov *et al.*, 2005; Castello, 2007; Naszradi *et al.*, 2007; Mariet *et al.*, 2011).

Unlike Europe, India is largely a tropical and sub-tropical country and the moss species are majorly confined to temperate parts of the country (Himalayan belt) which comprises elevated terrains whereas industrial sectors are restricted to the plains. Therefore passive biomonitoring using mosses is not much prevalent here. The present study was aimed to detect the concentration of lead (Pb) and mercury (Hg) in the Pantnagar area of Udham Singh Nagar district for which moss bag technique (active biomonitoring) was employed.

MATERIALS & METHODS

Study area

Pantnagar University, the first and the largest farm university in India and second largest in the world, lies at the foothills of Himalayas in the Tarai region of Kumaun division of Uttarakhand stretching across latitude 28° 53' N and 29° 23' N and laterally extends between longitudes 78° 45' E and 80° 08' E having an elevation of 284 meters (932 ft.). The climate varies from Sub-tropical and sub-humid with three distinct seasons, i.e. summer, monsoon (rainy season) and winter. The maximum temperature in the district goes up to 42ºC during the summers and the minimum temperature is between 1 and 4ºC during winter.

Sampling sites

Control moss: Moss was collected from the forests of Naina peak (earlier Cheena Peak) of Nainital, Uttarakhand through random sampling. The sub-samples of the moss were mixed together for homogeneity. They were brought

to lab, cleaned from dust and other debris and 5 g (approx.) was packed into circular balls in nylon cloth.

Installed moss: Taking G.B. Pant University's clock tower as the central point, moss bags were installed in the entire campus demarcating residential, traffic, institutional and agricultural area (Fig. 1). The bags were hanged freely from trees, poles, without obstruction of air for a period of one year (2014-15) rainy season (July to October), winter season (November to February) and summer (March to June) (Fig. 2).

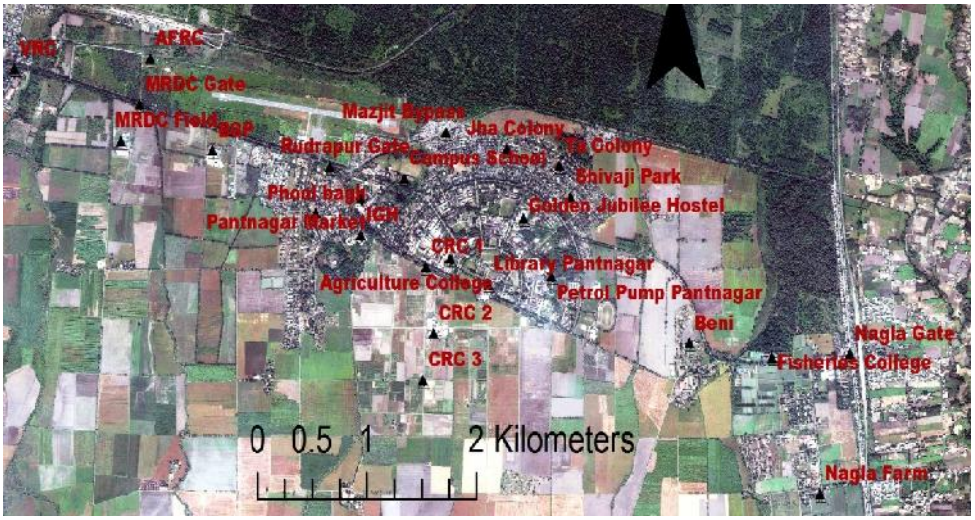
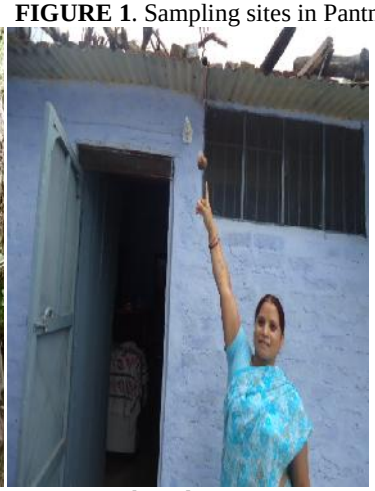


FIGURE 1. Sampling sites in Pantnagar

Moss collection at Nainital



Jha colony

Petrol pump, pantnagar

Ta Colony

Nagla Gate

FIGURE 2. moss collection and study sites

Laboratory analysis

After a period of 4 months, moss bags were brought to lab and 1 gm of plant material was digested with 5 mL of concentrated HNO_3 and with 2 mL of $HClO_4$. The digested samples were filtered using Whatman No. 42, and the solution was diluted to 50 mL with bi-distilled water and

analyzed by atomic absorption spectrophotometer (Sens-AA, GBC-Scientific equipment).

Data analysis

Samples were harvested in triplicate to conduct the statistical analysis. Value was represented as mean ± standard error (Snedecor and Cochran, 1994). Two- way ANOVA was applied to the data which revealed significant differences in the metal concentration at different sites and seasons (for $p \leq 0.01$, $p \leq 0.05$).

RESULTS & DISCUSSION

After an exposure period of 4 months during summer, maximum concentration of Pb occurred at the petrol pump (11.49 ±0.56 ppm) (Fig. 3) which is quite less compared to that reported by Saxena *et al.* (2008)(55.02 ppm) from Mussoorie. It is assumed that high concentration of Pb from this place could be because of fuel burn from the vehicles that come for re-fill (Saxena *et al.*, 2008; Vingiani *et al.*, 2015) at the gas station. While minimum concentration occurred at MRDC field crops (5.09 ±0.11 ppm) (Fig. 3) which is again quite lower than the least concentration (18.112 ppm) reported by Saxena *et al.* (2008b) in the same study. Saxena *et al.* (2014) reported seasonal trend for Pb in the order 56.32, 42.11 and 18.06 μg g^{-1} in Nainital for summer, winter and rain respectively. Here also a significant difference existed in the Pb concentration between various sites (Table 1). On the other hand mercury is reported to be highest at the Nagla gate (10.10 ±0.28 ppm) and lowest at VRC (7.52 ±0.06 ppm) (Table 1, Fig. 3). Use of pesticides, burning of fossil fuels and open incineration of sewage sludge and of pulp and paper industry wastewater sludge is held responsible for release of Hg in the air (Fernandez *et al.*, 2004; Genoni *et al.*, 2000).

TABLE 1. Lead and Mercury concentration (ppm) in the moss *Thuidium cymbifolium* Dozy & Molk, (Dozy & Molk.) in summer, monsoon and winter (2014-15)

*Maximum concentration, #Minimum concentration

Sr. No.	Location	Concentration of Lead (ppm) ± SE				Concentration of Mercury (ppm) ± SE			
		Summer	Monsoon	Winter	Mean	Summer	Monsoon	Winter	Mean
1.	Petrol pump-pantnagar	11.49±0.56*	4.28±0.22*	7.01±0.23*	7.59±0.34	8.64±0.33	5.37±0.15	6.54±0.34	6.85±0.28
2.	Golden jubilee hostel	7.30±0.59	1.89±0.11	4.20±0.39	4.50±0.36	8.30±0.09	5.95±0.23	6.46±0.11	6.90±0.15
3.	Jha colony	9.89±0.91	3.29±0.10	5.36±0.38	6.18±0.46	8.29±0.21	2.80±0.04	4.62±0.27	5.23±0.17
4.	Ta colony	7.22±0.17	2.63±0.54	3.57±0.31	4.48±0.34	8.29±0.21	3.79±0.18	5.55±0.11	5.88±0.17
5.	Shivaji park	7.49±0.22	2.05±0.04	2.90±0.16#	4.15±0.14	7.85±0.15	3.18±0.14	4.32±0.15#	5.12±0.14
6.	Maszid bypass pantnagar	8.08±0.09	3.70±0.01	3.84±0.07	5.21±0.09	8.22±0.22	3.96±0.04	4.61±0.15	5.59±0.14
7.	Library-pantnagar	6.04±0.07	1.85±0.07	3.78±0.33	3.89±0.16	7.63±0.26	3.75±0.14	5.50±0.25	5.63±0.22
8.	Agriculture college	6.07±0.05	1.89±0.11	3.74±0.16	3.90±0.11	7.78±0.11	3.15±0.20	5.20±0.05	5.38±0.12
9.	Fisheries college	7.22±0.06	1.64±0.14	3.24±0.11	4.03±0.10	8.28±0.19	3.21±0.06	5.93±0.10	5.81±0.12
10.	Crop research Centre (CRC) 1	6.89±0.10	2.45±0.67	4.40±0.48	4.58±0.45	8.37±0.15	2.40±0.01	5.77±0.20	5.51±0.12
11.	CRC 2	6.36±0.28	1.94±0.26	4.04±0.48	4.11±0.34	9.01±0.11	2.58±0.15	5.73±0.30	5.77±0.19
12.	CRC 3	6.40±0.31	2.70±0.61	4.62±0.15	4.56±0.36	8.52±0.32	2.58±0.14	5.86±0.41	5.65±0.29
13.	Pantnagar market	7.15±0.11	2.08±0.16	3.32±0.18	4.18±0.15	8.55±0.11	3.57±0.20	5.63±0.03	5.91±0.11
14.	Guest house-pantnagar	6.75±0.20	1.87±0.10	3.95±0.10	4.19±0.17	7.89±0.04	3.92±0.11	4.94±0.07	5.58±0.07
15.	Campus school-pantnagar	7.22±0.13	2.17±0.14	3.62±0.26	4.34±0.18	8.39±0.08	4.03±0.09	4.86±0.02	5.76±0.06
16.	Phoolbagh-residence	6.85±0.14	2.49±0.16	4.75±0.23	4.70±0.18	9.33±0.23	2.49±0.03	6.63±0.50	6.15±0.25
17.	Beni-residence	6.04±0.10	1.89±0.17	3.26±0.22	3.73±0.20	9.01±0.06	6.76±0.03*	5.15±0.05	6.97±0.04
18.	Nagla gate	9.89±0.12	4.05±0.12	7.12±0.13	7.02±0.12	10.10±0.28*	4.64±0.05	7.53±0.21	7.42±0.18
19.	Rudrapur gate	11.00±0.24	3.30±0.43	6.94±0.15	7.05±0.27	9.10±0.29	3.65±0.15	6.67±0.21	6.47±0.22
20.	MRDC gate	6.30±0.28	2.01±0.32	3.62±0.28	4.01±0.29	8.17±0.04	3.06±0.07	5.81±0.04	5.68±0.05
21.	MRDC-fields	5.09±0.11#	1.63±0.19#	3.24±0.04	3.32±0.11	7.68±0.07	2.58±0.13	5.06±0.07	5.11±0.09
22.	Breeder Seed Production Centre (BSP)- pantnagar	6.67±0.32	2.11±0.02	3.95±0.10	4.25±0.15	9.07±0.04	2.92±0.02	5.21±0.05	5.73±0.03
23.	Agro-forestry Research Centre (AFRC)-pantnagar	6.59±0.22	1.64±0.21	3.31±0.24	3.85±0.22	8.82±0.06	3.15±0.04	6.10±0.03	6.02±0.04
24.	Vegetable Research Centre (VRC)	6.80±0.15	1.82±0.16	3.62±0.26	4.11±0.19	7.52±0.06#	4.24±0.01	5.98±0.03	5.91±0.03
25.	Nagla farm	6.73±0.10	1.80±0.09	3.79±0.44	4.11±0.25	8.73±0.03	2.32±0.10#	7.16±0.03*	6.07±0.05
		CD at 1%	CD at 5%		SEm	CD at 1%	CD at 5%		SEm
Season		0.13	0.10		0.36	0.72	0.55		0.20
Location		0.54	0.41		0.15	0.30	0.22		0.80
Season X location		0.93	0.71		0.25	0.51	0.39		0.14

Due to leaching of the accumulated metals from the moss bags, monsoon appears to carry least amount of metals in the air. Similar results were reported in Mussoorie by Saxena *et al.* (2008). Concentration of Pb at the petrol pump (4.28±0.22 ppm), though highest in comparison to other sites in the season, is at its minimum amongst all the three seasons. Lowest levels were reported from the MRDC field crops (1.63 ±0.19 ppm) (Fig. 4). Similarly, Hg, owing to leaching, was less (6.76±0.03 ppm) as compared to that in summer. Nagla farm registered minimum concentration (2.32 ±0.10 ppm) during rainy season (Table 1, Fig. 4).

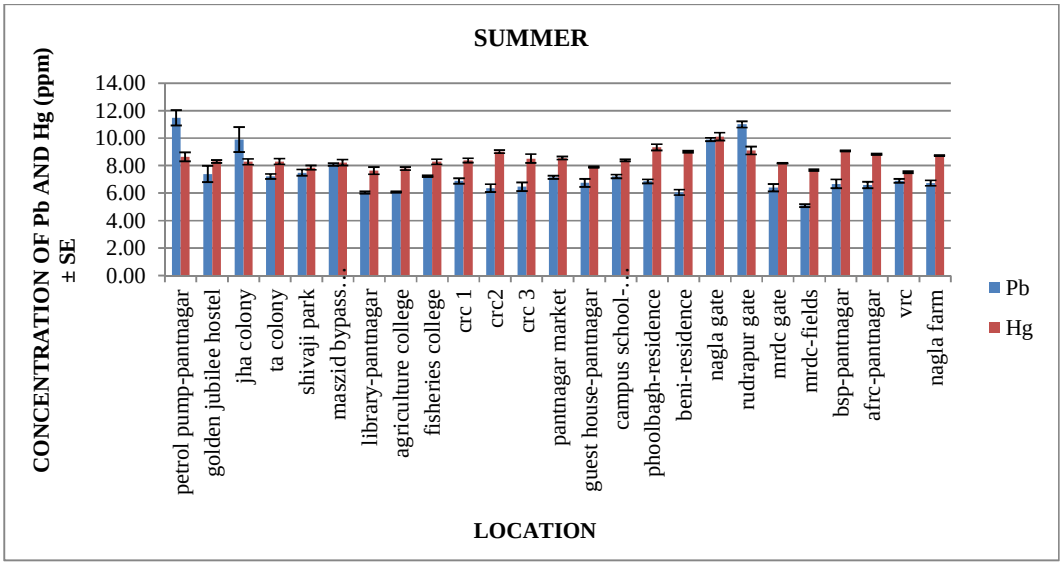


FIGURE 3. Concentration of Lead and Mercury (ppm) in summer

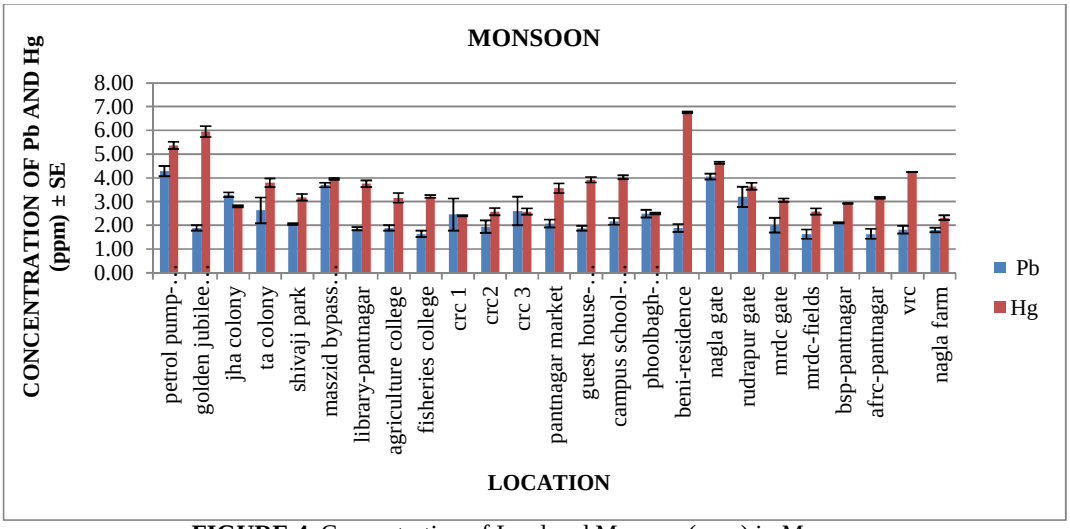


FIGURE 4. Concentration of Lead and Mercury (ppm) in Monsoon

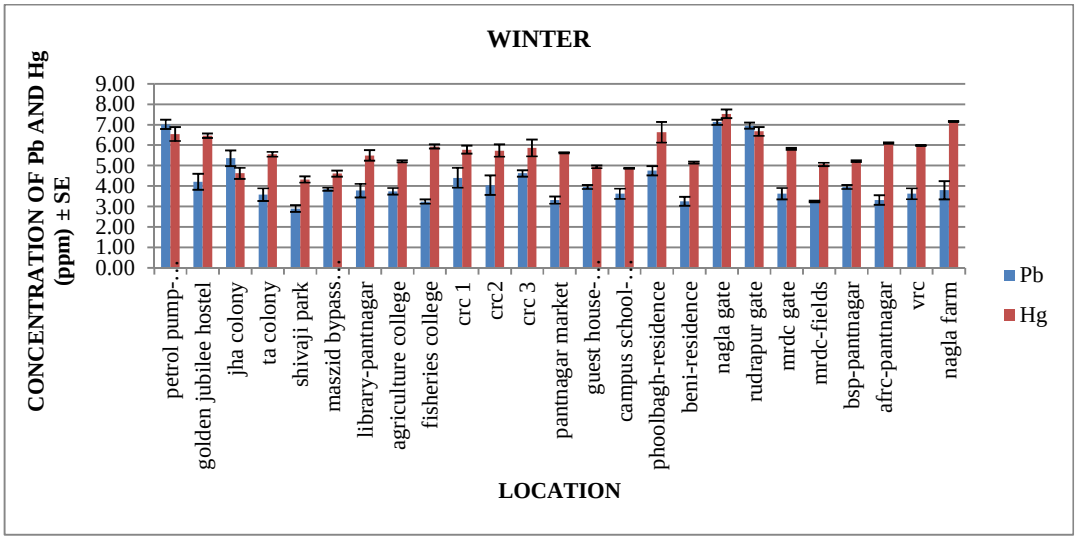


FIGURE 5. Concentration of Lead and Mercury (ppm) in Winter

Pb showed an increase in concentration at the petrol pump (7.01 ±0.23 ppm) from rainy season but less than that reported during summer (Fig. 5). Shivaji Park, a residential colony of Pantnagar, was found to hold minimum Pb concentration (2.90 ±0.16 ppm). Nagla farm recorded maximum Hg concentration (7.16±0.03 ppm) in winters while Shivaji Park held minimum Hg concentration (4.32 ±0.15 ppm). (Table 1, Fig.5). Therefore, seasonally as well as spatially, values were found to be significantly different (Fig. 6). Though the residence time of heavy metals is quite less in the air, but long enough to be detected by efficient monitor as moss.

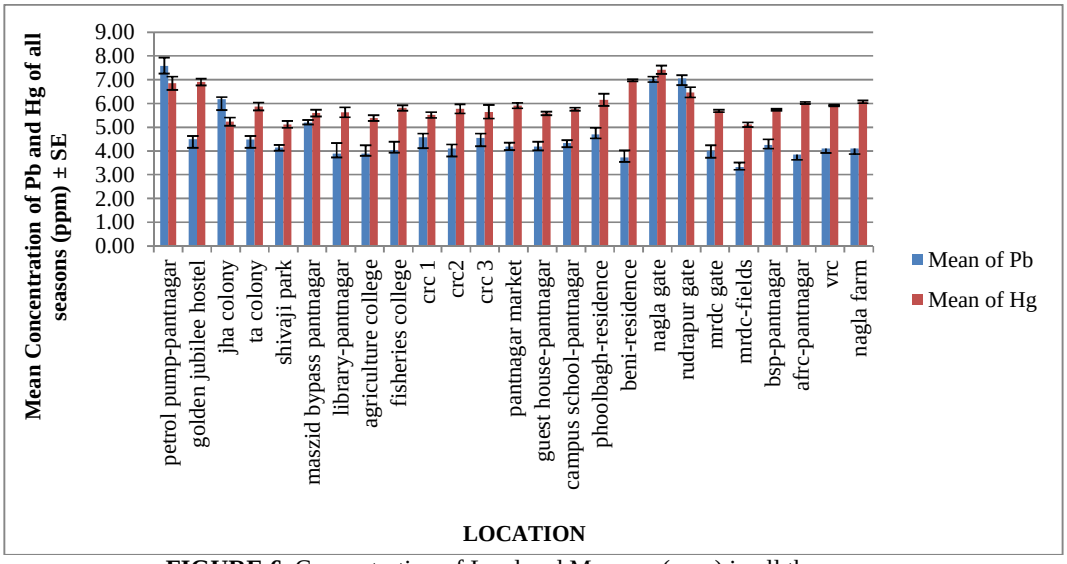


FIGURE 6. Concentration of Lead and Mercury (ppm) in all the seasons

Pantnagar University Campus, once an entirely green patch, faced industrialization after the setup of the adjoining State Industrial Development Corporation of Uttarakhand Limited (SIDCUL) in the outskirts of the university resulting in significant decline in greenery in its environs. Other than SIDCUL, pulp and paper industry located in the nearby Lalkuan town, state highway and small industries here and there exposed Pantnagar to air as well as water pollution. Thus keeping in mind the developmental activities around the town, two metals were quantified. The results clearly indicate that the concentration of Pb as well as Hg is significantly different temporally as well as spatially. Seasonally, there is a general declining pattern in their accumulation as reported by previous workers (Yurukova *et al.*, 2013; Acar, 2006; Saxena and Arfeen, 2010). This particular moss, *Thuidium cymbifolium*, was used in this study as the biomonitor owing to its year round availability from the dense forests of Nainital. Its morphology enables entrapment of metal particles for longer duration under stress conditions while maintaining its viability. Hence it proves to be an efficient biomonitor of heavy metals in future.

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