Survey on the ability to absorb elements in the polluted air of moss bags and lichen bags with non- irradiation and irradiated

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1. Introduction

Biomonitoring is a common way to study air quality and anthropogenic, and it is defined as the use of biological organisms and materials to collect certain features of the biosphere [1]. Traditional indicator species, especially leaves and needles, have recently been successfully identified by easy, rapid, cost-effective, and often non-destructive magnetic methods [2, 3]. Biomonitoring can be passive, active, or both methods. Moss and lichen bags are excellent ubiquitous bio accumulators and have been widely used in biomonitoring [4]. According to Szczepaniak and Biziuk, passive biological surveillance refers to the use of native plant species while active surveillance includes exposure of well-defined species in the form of transplants or blisters [4]. The method of exposure is particularly valuable in areas contaminated by the absence of native species (for example concretized areas, and industrial zone). Moreover, active monitoring has several advantages: the initial element concentrations and exposure times are well known [5], and they can be used to study in many different locations, conveniently without fear of being lost because they are quite discreet. As pointed out by Fernández and Carballeira [6], native vegetation can lead to an underestimation of heavy metal deposition because of the material's ability to adapt to its surroundings, and thus, to track positive is the most accurate method. This technique has been applied to both lichen and moss [7, 8].

The previous studies shown that the selection of moss in the moss bag technique depends on the degree of deformation of the moss in the study area, and the ability of moss to absorb and adapt to pollution in that area [9]. Previous studies also have used a variety of mosses and lichens to make moss bags to study the heavy metal elements present in the air [4, 10, 11]. In Vietnam, *Babular Indica* moss and *Hypogymnia physodes* lichen which have used biomonitoring, are common growth types in the areas over the country. In Vietnam, the use of moss as a biological indicator only started in the 2010s [12], all studies so far have only used natural moss to assess environmental pollution. The use of moss began with experimental research from Prof. Le Hong Khiem's group recommended that moss species is Babular indica [13-14]. As for lichens, Hypogymnia Physodes is also widely used for transplantation [15].

The aim of this study was to preliminary compare the usability and collection efficiency of moss bag and lichen bag in the monitoring of air pollutants. The bags were exposed to air pollutants at Long Thanh Airport area, Bien Hoa, Dong Nai, Vietnam, period of three months from January to March 2022.

2. Methods and Results

2.1 Study area

The study site at Long Thanh Airport (10°70'17.4"N and 107°09'31.3"E) is located in Long Thanh district, Dong Nai province. Moss bags and lichen bags were hung at Long Thanh airport before construction. The purpose is to provide data for future studies, to survey the air quality at this place before and after the airport is built and put into operation.

The places to hang the bags are 1-2 km apart. The bags of moss hanging within a radius of 1 km, around the airport, 100 m from the main road.

2.2 Bag preparation

In this research, the bag is made of cotton. The size of the mesh also needs careful consideration. The loss of moss or lichen during the research process should be considered carefully. In addition, the thickness of the mesh should also be considered. If the thickness is large, the ability of mosses to capture contaminants can be high, possibly blocking and retaining granular materials [16]. The recommended size should be from 1 - 150mm^2. Temple et al. found that bag has weight/surface area ratio of 30 mg.cm-2 is ideal for the maximum uptake [15]. Various bag shapes are used to increase the efficiency of element collection, and to homogenize samples in different directions. Commonly used bag types are cylindrical, spherical, and square or rectangular (three-dimensional) spherical and cylindrical allowing for uniform collection efficiency from all directions. It also allows collecting samples by gravity field deposition in flat or rectangular (two-dimension) moss explosives homogeneous with the atmosphere. In this work, each sample material was placed in a polyamide net (with 5mm2 mesh) and closed with a cotton thread. One part of the material was stored as a background concentration.

Babular Indica moss was collected in places that not affected by pollution, like the moss in Dung K'No mountain, in Bidoup - Nui Ba national park (Lam Dong, Vietnam). The moss sampling location has longitude 12.188447, and latitude 108.463527.

After collecting, the pretreated *Babular indica* moss as follows: moss must be handled carefully, avoiding contamination from soil or rock or other plants, to ensure the exact sampling location and to minimize the external impact on the collected moss (1). Sample after removing the roots, taking only the green part (2); then, samples were washed with water (3); and let dry in nature condition (4). After preparing the moss, put and spear natural moss collection samples in a bag, and spread evenly, ensuring the best absorption, uniformity from all directions.

Hypogymnia Physodes lichen was taken from Tả Củ Tỷ (Lào Cai), the Northern mountainous region of Vietnam. The lichen was pre-treated as the same as the moss bag preparation mentioned above).

2.3 Doses and dose rates applied in the experiments

Mosses were irradiated with various doses, ranging from 1.0 Gy to 20.0 Gy. The total number is 50 bags that were irradiated. At each dose, 5 bags of moss were copied. After irradiation, the bags were hung and observed for growth at the same natural condition.

2.4 Results

In this study, the results showed that moss irradiated from doses of 17.0 Gy to 20.0 Gy was less growing than non-irradiation moss. In this case, moss branches were dry and no longer, and less green, while in the case of irradiation from 2.0 Gy to 16.0 Gy, the moss developed better than non-irradiated ones. The moss buds are growing better and greener. Especially at doses between 14.0 Gy and 15.0 Gy, moss grows best, with green branches and roots that are not broken Figure 1.

a) Non-irradiate   b) Irradiate with optimum does

Figure 1. Comparison between moss non-irradiate and irradiate with optimum does

The bags were irradiated at 140 Gy, then hang out to evaluate the absorption of chemical elements. After 3 months of exposure, the samples were collected, treated and analyzed using TXRF technique. The results are shown in Table 1.

Table 1. The concentration of chemical elements deposited in the air through irradiated moss bag, irradiated lichen bag, un-irradiated moss bag, and un-irradiated lichen bag

No.	El.	Concentration (mg/kg) ± SD			
		1	2	3	4
1	Al	2243.25 (112.16)	561.54 (28.07)	ND	ND
2	P	418.06 (27.17)	125.69 (8.16)	16.90 (1.09)	60.00 (3.90)
3	S	1297.21 (84.32)	300.81 (19.55)	428.99 (27.88)	477.40 (31.03)
4	Cl	410.56 (26.68)	193.21 (12.55)	32.90 (2.13)	ND
5	K	668.44 (43.45)	201.32 (13.08)	484.08 (31.46)	378.95 (24.63)
6	Ca	701.56 (45.60)	178.72 (11.61)	5367.21 (348.86)	8090.75 (525.89)
7	Ti	295.76 (19.22)	88.07 (5.72)	26.16 (1.70)	21.70 (1.41)
8	V	4.95 (0.34)	1.15 (0.08)	0.24 (0.015)	0.50 (0.03)
9	Cr	5.3 (0.37)	1.3 (0.09)	0.12 (0.01)	ND
10	Mn	79.36 (5.55)	22.11 (1.54)	37.61 (2.44)	50.40 (3.52)
11	Fe	2870.43 (200.93)	718.28 (50.27)	202.34 (13.15)	176.45 (12.35)
12	Co	1.75 (0.12)	ND	ND	ND
13	Ni	2.84 (0.19)	ND	ND	ND
14	Cu	14.87 (1.04)	3.72 (0.26)	2.24 (0.14)	1.95 (0.13)
15	Zn	385.28 (26.96)	96.44 (6.75)	57.55 (3.74)	52.30 (3.66)
16	Br	3.18 (0.22)	0.8 (0.056)	ND	ND
17	Rb	2.53 (0.20)	ND	1.34 (0.08)	1.00 (0.08)
18	Sr	41.58 (3.32)	10.21 (0.81)	16.63 (1.08)	17.35 (1.38)
19	Y	6.34 (0.50)	1.59 (0.12)	541.19 (43.29)	427.65 (34.21)
20	Ag	56.47 (4.51)	14.65 (1.17)	287.44 (18.68)	64.45 (5.15)
21	Sn	86.35 (6.91)	22.72 (1.81)	32.75 (2.62)	74.20 (5.93)
22	Sb	42.15 (3.37)	11.03 (0.88)	28.40 (1.84)	64.15 (5.13)
23	Ba	41.03 (3.07)	10.32 (0.77)	5.78 (0.37)	7.60 (0.57)
24	Pb	3.75 (0.28)	0.94 (0.07)	10.71 (0.69)	15.20 (1.14)

1: Irradiated moss bag; 2: Non-irradiated moss bag; 3: Irradiated lichen bag; 4: Non-irradiated lichen bag

The results of the analysis of sedimentation of accumulated particles in the air at the long-walled airport showed that, in the case of moss radiation, 24 elements were analyzed, including Al, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Br, Rb, Sr, Y, Ag, Sn, Sb, Ba, and Pb; with moss non-irradiation, less than 3 elements are Co, Ni, and Rb. With the lichen bag, the absorption is worse than with the moss bag in terms of concentration and quantity of elements. lichen bags detected 20 elements except for Al, Co, Ni, and Br; but the non-irradiation lichen bag, has only 18 elements, except for elements including Al, Cl, Cr, Co, Ni, and Br were not determined.

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3. Conclusions

In this study, we applied the moss bag and lichen bag technique to evaluate the deposition of chemical elements in the environment at the Long Thanh airport, Dong Nai province (Vietnam), have determined maximum of 24 elements for irradiated moss bags, and only 21 elements for non-irradiated mosses. In terms of absorption, the concentration of chemical elements in irradiated mosses is higher than those of non-irradiated mosses.

Similar to lichens, in irradiated lichens, we can only measure 20 elements, while there are 18 elements are measured in the lichen without irradiation.

From the above results, the moss bags after irradiation are the most effective to apply in environmental monitoring. This is considered a friendly, economically efficient monitoring method that can be applied to environmental monitoring in developing countries.

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