# IRRADIATED MOSS BAG INTRODUCED IN ENVIRONMENTAL MONITORING

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***ABSTRACT***

*Mosses are known as alive monitoring stations in urban areas in countries around the world. They are used to monitor air quality. The moss bag technique has been widely applied to environmental monitoring in urban areas and industrial zones, where mosses rarely occur naturally. However, mosses in moss bags often grow weakly and sometimes cannot survive, making the process of absorbing chemical elements from the air less efficient, and therefore the assessment of air pollution indexes in the investigated areas can be limited and inaccurate.*

*In an attempt to overcome the above limitations, low doses irradiation was applied to stimulate the growth of moss in moss bags. Using low-energy X-rays (160 keV) to irradiate the moss bags with doses from 1.0 Gy to 17.0 Gy at an interval of 1.0 Gy and then evaluate the growth of moss, it was recognized that the optimal dose for the moss growth was 14.0 Gy.*

*Using the dose of 14.0 Gy with low-energy X-ray radiation to treat moss bags before applying for environmental monitoring. The achieved results show that the ability to absorb the chemical elements from the air of an irradiated moss bag was better than non-irradiated moss bag. This shows the effectiveness of using radiation to stimulate the growth of moss, and therefore increasing the ability to absorb chemical elements in the air.*

*Analytical results by TXRF technique obtained 24 elements deposited in the air at Long Thanh Airport (Dongnai, Vietnam). The comparison of elemental concentration deposited by 2 moss techniques showed that: the case of non-irradiated moss bag is lower than that of irradiated moss. This shows promise in the use of moss irradiation in moss bags for application as a bioindicator in environmental monitoring in places where urbanization, and where the climate is not suitable for natural moss growth.*

***Keywords:*** *X-ray, moss bag, irradiated moss, non-irradiated moss*

## 1. Introduction

The "moss bag technique" is the most common type of active biomonitoring with terrestrial mosses reported in the literature. The technique was originally introduced by Goodman and Roberts (Goodman and Roberts, 1971). Since then, it has become a useful technique in the biological monitoring of activity for contaminants, such as heavy metals and other elements. The moss bag technique is useful for executing a detailed survey of the pollution status in urban and industrial areas, where moss cannot grow naturally.

However, the disadvantage of the moss bag technique is that moss growth and development are weak when introduced into the investigated environment. Thus, the accumulation of the elements in the moss in moss bags is lower than in natural moss. Due to this lower accumulation, in some cases, the concentrations of toxic elements such as Pb, As, Cd, … in moss bags are lower than lower limit of detection, making the evaluation results become limited and not reflect the actual status.

The effects of radiation on plants have been studied around the world (Songsri et al., 2011; Shu et al., 2012; Ali et al., 2015). Radiation at high energy, and high doses can inhibit plant growth, cause cell death, or sometimes induce mutations (Ehrenberg, 1955). Low-dose radiation can cause stimulant effects on plants such as increasing the rate and shortening the time for the germination of seeds, causing the seedlings to grow faster and thereby increasing their fresh weight. Besides, low radiation doses can also increase the length and number of roots of plants (Wiendl et al., 2013; Beyaz et al., 2016; Hussain et al., 2017). Delia Marcu *et al.* showed that ionizing radiation stimulates the physiological parameters of lettuce up to certain low doses (Maffei, 2014). Maffei *et al.* described irradiations at low doses that improve morphological traits like plant height, shoot number, panicle length, and seed number per panicle (Chakraborthy and Paratkar, 2006).

Mosses belong to one of three groups of non-vascular land plants (Bryophytes), and in principle, they can be affected by radiation as other plants. The previous works showed that the selection of moss spices in the moss bag technique depends on the degree of deformation of the type of moss in the study area, and the ability of the moss to absorb and adapt to pollution in that area. The composition of chemical elements in old shoots and young buds of moss is different (Fernández et al., 2010; Adamo et al., 2011), and the absorption of the moss bags is also different from that of raw moss.

In this study, to overcome the limited growth of moss when applying the moss bag technique in environmental monitoring, a low-energy X-ray source was used for irradiation the moss bags to determine the stimulant effect of radiation on moss growth before use as a bioindicator. The purpose of this study was to demonstrate the stimulant effect of radiation on the growth of moss in the moss bags making them grow better and thereby increasing their ability to absorb chemical elements in the air. The achievements from this study can be applied in environmental monitoring, when using the moss bags irradiate technique the results are more accurate than others.

## 2. Material and method

### *2.1. Moss sample preparation*

In this work, *Babular Indica* moss was used in the experiments because the conditions were satisfied to be able to become bioindicators in environmental monitoring.

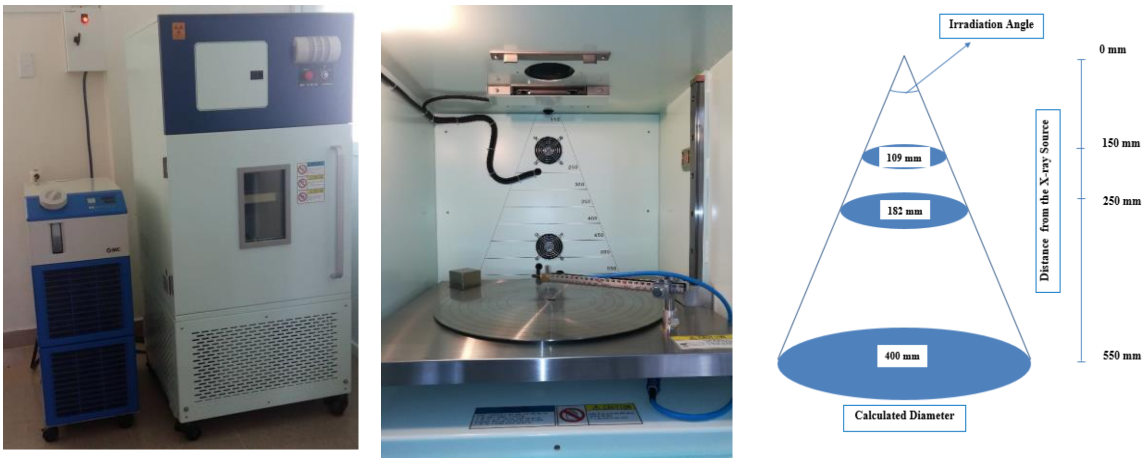
It is necessary to choose *Babular Indica* moss in an unpolluted area, to reduce the initial chemical element content in the moss and increase the absorption capacity. In this work, *Babular Indica* moss is collected less affected by pollution, like moss in the mountains of Dung K'No, belong to Bidoup Nui Ba National Park (Lam Dong, Vietnam). The location of collecting a moss sample has longitude 12.188447, latitude 108.463527.

After collecting the moss, the samples were treated. First, remove old and broken moss branches. Moss branches were chosen with a length of approximately 1.5 cm. Then, put and spear natural moss collection samples in a bag which is made of mesh bag size 7 cm x 7 cm (Figure 1), and the moss weight of about 5 g for each bag. And keep the rest of the moss in a zip bag for detected background concentration.

**Figure 1:** *Preparation of moss bag to irradiate*

### *2.2. Moss sample irradiation*

Using X-ray generation model MBR-1618R-BE (Figure 2) to irradiate moss with different X-ray doses arrange 1.0 to 17.0 Gy with 1.0 Gy per step, and unchanged dose rates of 0.5 Gy/min, with the conditions of the room.




a) X-ray machine sharp b) Irradiation room c) Irradiation angle

**Figure 2:** *MBR-1618R-BE X-ray machine and geometry irradiation*

### *2.3. Evaluation of moss growth*

After irradiating the moss bag with the above doses, hang all moss bags in the same natural conditions, at 2 meters from the ground (Figure 3). The moss bags were observed after 30 days of exposure, then determined the chlorophyll and the weight of the moss bags. As the result, the optimal dose was selected to carry out the irradiation of moss bags which were applied as a biological indicator in environmental monitoring.

**Figure 3:** *Exposure of moss bags*

### *2.4. Selecting research area*

The location chosen to hang moss bags is Long Thanh airport, Dongnai Province, Vietnam, at Latitude: 10° 58' 31.44" N and Longitude: 106° 49' 6.36" E. This research, the comparison of the efficiency of absorbing chemical elements deposited in the air by non-irradiated moss bags, irradiated moss bags. The survey period is 3 months, from January 2022 to March 2022. The moss bags were exposed at the same position which the distance from the hanging position to the main road is about 300 m. The height from the ground to the moss bag is 2 m, hanging 50 irradiated and 50 non-irradiated moss bags, each moss bag is around 5 g weight. Evaluation of the moss bag's capacity absorption elements in the atmosphere use TXRF (Bruker S2 PICOFOX spectrometer). Creating moss samples for TXRF analysis is used 1 g of dry moss (in each case: natural moss, non-irradiated and irradiated sample) to homogenize the sample with the Gallium internal standard solution is added in the sample.

## 3. Results and discussion

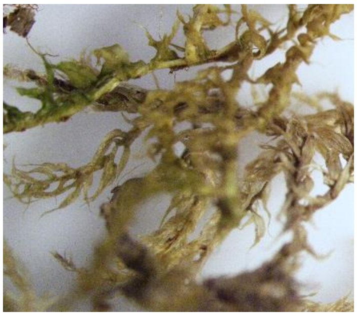
### *3.1. Investigate the effects of X-ray doses on moss growth*

Mosses were irradiated with various doses, ranging from 1.0 Gy to 17.0 Gy. The total number is 100 bags that were irradiated. At each dose, 5 bags of moss were copied. After irradiation, the moss bags were hung and observed for growth in the same natural condition. After hanging for 30 days, moss in the moss bags was taken with a microscope with a scale of 500 μm to monitor the growth. The pictures below (Figure 4) show the moss morphologies after irradiation in different irradiation cases.

Non-irradiate

1.0 Gy

2.0 Gy



3.0 Gy

4.0 Gy

5.0 Gy

6.0 Gy

7.0 Gy

8.0 Gy

9.0 Gy

10.0 Gy

11.0 Gy

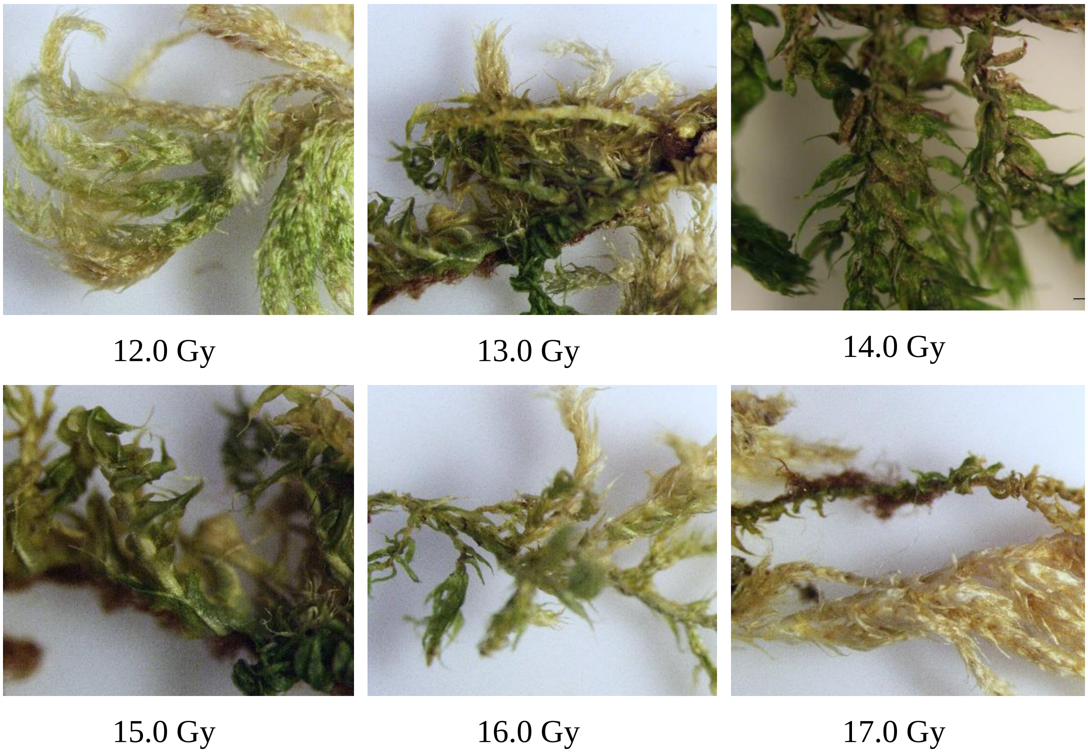



**Figure 4:** *Effects of different X-ray radiation doses on the moss survivability*

In this study, the results showed that moss that was irradiated from doses up to 16.0 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 15.0 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.

***3.2. Evaluation of the absorption of chemical elements in deposition air pollution by irradiated moss bags, and non-irradiated moss bags***

We irradiated the moss bags at 14.0 Gy, then hang out irradiated moss bags, and non-irradiated moss bags at the same site 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 bags, un-irradiated moss bags*

| No. | Elements | Concentration (mg/kg) ± SD | |
|---|---|---|---|
| | | Irradiated moss bag | Non-irradiated moss bag |
| 1 | Al | 2,643.25(132.14) | 661.54(30.76) |
| 2 | P | 618.06(40.32) | 155.69(7.15) |
| 3 | S | 1,497.21(74.56) | 374.81(16.17) |

| No. | Elements | Concentration (mg/kg) ± SD | |
|---|---|---|---|
| | | Irradiated moss bag | Non-irradiated moss bag |
| 4 | Cl | 612.56(30.54) | 153.21(6.15) |
| 5 | K | 864.44(43.76) | 216.32(11.56) |
| 6 | Ca | 801.56(41.25) | 200.72(9.13) |
| 7 | Ti | 310.71(16.32) | 78.37(4.04) |
| 8 | V | 5.11(0.31) | 1.28(0.07) |
| 9 | Cr | 5.98(0.36) | 1.50(0.08) |
| 10 | Mn | 88.32(5.71) | 22.11(1.43) |
| 11 | Fe | 2,870.43(172.87) | 718.28(33.12) |
| 12 | Co | 1.75(0.11) | ND |
| 13 | Ni | 2.84(0.17) | ND |
| 14 | Cu | 14.87(0.89) | 3.72(0.17) |
| 15 | Zn | 385.28(23.18) | 96.44(5.17) |
| 16 | Br | 3.18(0.19) | 0.80(0.11) |
| 17 | Rb | 2.53(0.15) | ND |
| 18 | Sr | 41.58(2.49) | 10.21(0.43) |
| 19 | Y | 6.34(0.38) | 1.59(0.08) |
| 20 | Ag | 56.47(3.48) | 14.65(1.24) |
| 21 | Sn | 86.35(5.71) | 22.72(3.11) |
| 22 | Sb | 42.15(2.54) | 11.03(0.23) |
| 23 | Ba | 41.03(2.46) | 10.32(0.21) |
| 24 | Pb | 3.75(0.28) | 0.94(0.08) |

(Note: ND: non-detected)

The results in Table 1 reveal that natural mosses and irradiated moss bags detected 24 chemical elements, which were analyzed by the TXRF technique in irradiated moss bags, while non-irradiation only 21 elements were determined, Co, Ni, and Rb are three elements below the lower limit of detection. Regarding the ability absorption chemical elements deposited in the air, the moss bags without irradiation is much lower than irradiated moss bags.

Consequently, irradiated moss with an optimal radiation dose can overcome the limited development of moss in the bag, which is possible to use irradiated moss in the moss bag technique as a biological indicator in assessing the deposition of elements in the atmosphere in places where natural moss does not exist or where natural moss does not grow.

## 4. Conclusion

Using biological indicators that exist in environmental monitoring areas to assess environmental effects has been implemented in many countries around the world. The moss bag technique is a method of using moss spread in bags and exposing them in sites where are lack of natural moss due to unfavorable habitats. However, the major disadvantage of bag moss is that the moss in the bag does not grow well during hanging, making the ability to absorb decline, leading to analyzing the environment being less effective.

This study used low-energy X-rays, with a dose of 14.0 Gy, to stimulate moss growth in moss bags before introducing them as a bioindicator. The process of hanging moss bags showed that the growth ability of irradiated moss was better than unirradiated moss. The growth results of irradiated moss such as mass, and especially the ability to absorb the deposit elements in the environment were better than those of non-irradiated moss. This study is effective for the application of moss bags in environmental monitoring in areas where natural moss does not grow, as well as the possibility of using moss bags as biological indicators in environmental assessment.

**REFERENCES**

Adamo P., Giordano S., Sforza A., Bargagli R. (2011). Implementation of airborne trace element monitoring with devitalised transplants of Hypnum cupressiforme Hedw.: assessment of temporal trends and element contribution by vehicular traffic in Naples city. *Environ. Pollut*, pp. 1620-1628.

Ali H., Ghori Z., Sheikh S. and Gul A. (2015). Crop Production and Global Environmental Issues. *Cham: Springer International Publishing*, pp. 27-78.

Beyaz, R., C.T. Kahramanogullari, C. Yildiz, E.S. Darcin, and M. Yildiz. (2016). The effect of gamma rays on seed germination and seedling growth of Lathyrus chrysanthus Boiss. under in vitro conditions. *Journal of Environmental Radioactivity 162-163*, p. 129-133 DOI: 10.1016/j.jenvrad. 2016.05.006.

Chakraborthy S and Paratkar G. T. (2006). Biomonitoring of Trace Element Air Pollution Using Mosses. *Aerosol and Air Quality Research*, pp. 247-258.

Ehrenberg, L. (1955). The radiation induced growth inhibition in seedlings. *Botan. Notiser*, pp.184-215.

Fernández J.A., Aboal J.R., Carballeira A. (2010). Testing differences in methods of preparing moss samples. Effect of washing on Pseudoscleropodium purum. *Environ. Monit. Assess*, pp. 669–684.

Goodman G. T., Roberts T. M. (1971). Plants and soils as indicators of metals in the air. *Nature (Lond.)*, pp. 231-287.

Hussain, F., M. Iqbal, S.Z. Shah, M.A. Qamar, T.H. Bokhari, M.Abbas and M. Younus. (2017). Sunflower germination andgrowth behavior under various gamma radiation absorbeddoses. *Acta Ecol. Sin*, pp. 48-52.

Delia Marcu, Victoria Cristea, Liviu Daraban. (2012). Dose-dependent effects of gamma radiation on lettuce (Lactuca sativa var. capitata) seedlings. *Int J Radiat Biol*. DOI: 10.3109/09553002.2013.734946.

Maffei M. E. (2014). Magnetic field effects on plant growth, development, and evolution. *Front. Plant Sci*. 5:445 10.3389/fpls.2014.00445.

Shu Q. Y., Forster B. P. and Nakagawa H. (2012). *Plant Mutation Breeding and Biotechnology.* Wallingford: CAB International.

Songsri, P., Suriharn, B., Sanitchon, J., Srisawangwong, S. and Kesmala, T. (2011). Effects of Gramma Radiation on Germination and Growth Characteristics of

Physic Nut (Jatropha curcas L.). *Journal of Biological Sciences,* pp 268-274. http://dx.doi.org/10.3923/jbs.2011.268.274.

Wiendl T. A., Wiendl F. W., Franco S. S. H., Franco J. G., Althur V. and Arthur P. B. (2013). *Ina. Int. Nucl. Atl. Conf*, pp. 24-9.

## ỨNG DỤNG TÚI RÊU CHIẾU XẠ TRONG QUAN TRẮC MÔI TRƯỜNG

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***TÓM TẮT***

*Rêu được biết đến như là trạm quan trắc sống tại các khu đô thị ở một số nước trên thế giới. Chúng được sử dụng để giám sát chất lượng không khí. Kỹ thuật túi rêu đã được áp dụng rộng rãi trong quan trắc môi trường ở các đô thị và khu công nghiệp, nơi rêu khó tồn tại trong tự nhiên. Tuy nhiên, rêu trong các túi rêu thường phát triển yếu, đôi khi không thể sống, làm cho sự hấp thụ các nguyên tố hóa học từ không khí của rêu kém hiệu quả. Vì vậy, việc đánh giá chỉ số ô nhiễm không khí tại các khu vực quan trắc bị hạn chế và thiếu chính xác.*

*Để khắc phục những hạn chế trên, phương pháp chiếu xạ rêu với liều chiếu thấp nhằm kích thích sự phát triển của rêu được áp dụng. Sử dụng tia X năng lượng thấp (160 keV) để chiếu xạ các túi rêu với liều chiếu từ 1,0 Gy đến 17,0 Gy với bước chiếu là 1,0 Gy. Kết quả cho thấy, liều chiếu xạ tối ưu để rêu phát triển là 14,0 Gy.*

*Sử dụng tia X năng lượng thấp với liều chiếu 14,0 Gy để xử lý các túi rong rêu trước khi đưa ra quan trắc môi trường. Kết quả nghiên cứu cho thấy, khả năng hấp thụ các nguyên tố hóa học trong không khí của túi rêu được chiếu xạ tốt hơn so với túi rêu không chiếu xạ. Điều này cho thấy hiệu quả của việc sử dụng bức xạ để kích thích sự phát triển của rêu, làm tăng khả năng hấp thụ các nguyên tố hóa học trong không khí.*

*Kết quả phân tích bằng kỹ thuật TXRF xác định được 24 nguyên tố lắng đọng trong không khí tại sân bay Long Thành (Đồng Nai, Việt Nam). So sánh hàm lượng nguyên tố lắng đọng bằng 2 kỹ thuật rêu cho thấy: trường hợp túi rêu không chiếu xạ thì hàm lượng thấp hơn rêu được chiếu xạ. Như vậy, triển vọng trong việc sử dụng túi rêu chiếu xạ để ứng dụng như một quan trắc sinh học trong quan sát môi trường ở những nơi đô thị hóa và những nơi có khí hậu không thích hợp cho rêu tự nhiên phát triển là khả thi.*

***Từ khóa:*** *Tia X, túi rêu, rêu chiếu xạ, rêu không chiếu xạ*