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Using Thai Native Moss as Bio-Adsorbent for Contaminated Heavy Metal in Air

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Abstract

Atmospheric particulate matter contaminated with heavy metal is harmful to the respiratory and cardiovascular system. Biomonitoring is a novel technique of using organisms or biomaterials to examine air quality. Moss was developed for using as a bioindicator to assess the concentration of heavy metal in atmosphere in many countries because of its ability to adsorb heavy metals. However; there had never been a study on native mosses in Thailand. Therefore; this research was aimed at studying the adsorption of heavy metal in polluted air by using Thai native mosses. Thai native mosses were transplanted on a tray and placed on Ratchawithi Road, Suan Sunandha Rajabhat university, Bangkok, Thailand which has heavy traffic that cause polluted air.. The results showed that Fe, Zn, Cu and Cd were found in Thai native mosses. Therefore; it could be verified that Thai mosses can adsorb heavy metal and could be used as a bio-adsorbent.

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Keywords: Heavy metal; Adsorption; Moss

1. Introduction

Air Pollution is a serious environmental problem all over the world. It is well known that air pollution affects human health. Especially, atmospheric particulate matter contaminated with heavy metal has a severe impact on respiratory and cardiovascular system (Dockery & Pope, 1994).

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Air quality assessment can indicate the human health risk. Organisms and biomaterials such as moss, lichen are commonly used to evaluate air quality (Berg, Royset & Steinnes, 1995; Bleuela et al, 2005; Boquete et al, 2013), which is called biomonitoring. Mosses are bryophyte that have no root and cuticle layer. Consequently, the adsorption process in mosses happen on their surface (Ruhling & Tyler, 1968). Heavy metal adsorption on mosses are mostly achieved from atmosphere rather than mineral uptake from soil. Mosses are capable of adsorbing heavy metals such as Cd, Co, Cu, Cr, Pb, V and Zn (Lee et al, 2005). For that reason, mosses have been developed and widely used as a bioindicator for air quality assessment in many regions e.g. Europe (Markert et al, 1996; Berg & Steinnes, 1997b; Figueira et al, 2002), North America (Groet, 1976; Barclay-Estrup & Rinne, 1979; Percy, 1982), China (Lee et al, 2005).

Many evidences from researches have been published and confirmed that moss is an excellent bioindicator for trace element in air. Furthermore; it has been verified that the concentration of heavy metals in moss tissue reflects the contamination of heavy metal in atmosphere. The recommended moss species used in Europe are *Hylocomium splendens*, *Pleurozium schreberi* (Ross, 1990), *Hypnum cupressiforme* and *Scleropodium purum*. (Bargagli et al, 1995).

Interestingly; mosses have been used for decoration in gardens and aquariums in Thailand. So far, mosses have never been studied or used for monitoring air pollution in Thailand. Hence; this study was aimed to investigate the adsorption of heavy metal in polluted air by using Thai native mosses.

2. Materials and Methods

Three types of Thai native mosses were used to conduct the experiment. All mosses were transplanted in trays and placed in a study area which has contaminated heavy metal in atmosphere to compare with unpolluted area.

2.1 Study area

The pedestrian along Ratchawithi road, Suan Sunandha Rajabhat University, Bangkok, Thailand was chosen as the study area because of the occurrence of heavy traffic on rush hour. The vehicle exhaust fume emitted the heavy metals which cause the polluted air.

2.2 Sample collection and preparation

Moss samples were collected at time course (0, 1, 2, 3, 4, 5, 6, 7, 8, 10, 14 and 18 weeks, respectively). Moss samples were cleaned with tap water to eliminate soil particles. Moss samples were dried in oven at 70 º C. Dried moss was ground to pass a 60 mesh sieve. Approximately 0.5 g of fine powder and dried moss samples were weighted and placed in tubes. Five milliliter of $HClO_4/HNO_3$ (1:2) was added to the tubes for digestion overnight. The digestion process was continued at 85±5 °C until the brown smoke disappeared. Afterward, digestion was continued at 128 ±3 °C for 3-4 hrs. Then the temperature was gradually increased to 200±20 °C until the final volume of sample was 1 ml.

2.3 Heavy metal determination

Samples from section 2.2 were analyzed for the concentration of heavy metal (Fe, Zn, Cu, Cd and Pb) by atomic absorption spectrometry (GBC, Avanta Σ system 2000/3000)

3. Results and Discussion

The analytical results of heavy metals found in all three types of Thai native mosses were shown in Table 1, 2 and 3. Fe, Zn, Cu and Cd were found in all three types of Thai native mosses while Pb was lower than limit of detection (LOD) in all three types of Thai native mosses. The comparison of heavy metals found in all three types of Thai native mosses showed the same qualitative and quantitative results as shown in Fig. 1. Fe was found in highest concentration (2.33±0.98-67.29±0.68), followed by Zn, Cu and Cd in all three types of Thai native mosses. The concentration of Zn, Cu and Cd found in mosses samples showed the same level in all three types of Thai native mosses. Zn was detected in a range of 0.01±0.00-0.26±0.00 mg/g moss in all three types of Thai native mosses (Fig. 1(b)). The concentration of Cu in all types was 0.01±0.00-0.08±0.00 mg/g moss (Fig. 1(c)). The concentration of Cd found in all types of Thai native mosses was ranging from 0.001±0.000-0.004±0.00 mg/g moss (Fig. 1(d). Moreover, the concentration of Cu and Cd found in all types showed the stable concentration throughout the time (0-18 weeks). In case of Fe and Zn, the concentration gradually increased along the time in all three types of Thai native mosses. The discovery of Zn in all three types of this study was corresponded with the investigation of air quality on Ratchawithi road, Suan Sunandha Rajabhat university, Bangkok, Thailand which atmospheric particulate matter were contaminated with Zn. (Choo-in, 2014).

Furthermore, the concentration of heavy metals found in moss samples which were placed in polluted area was compare with unpolluted area to verify the adsorption capacity of all three types of Thai native mosses. The results of heavy metals level in moss samples in unpolluted area were lower than the concentration of heavy metals found in moss samples in polluted area at the end of experimental time (18 weeks). Hence, this result can confirm their adsorption ability. This evidence verified that all three types of Thai native mosses can adsorb heavy metals in atmosphere as same as mosses in another region such as Europe (Markert et al, 1996; Berg & Steinnes, 1997b, Figueira et al, 2002), North America (Groet, 1976, Barclay-Estrup & Rinne, 1979, Percy, 1982), China (Lee et al, 2005). Therefore; the possibility to use Thai native mosses as a bio-adsorbent can be approach to relief the concentration of heavy metals in atmosphere. However, all three types of Thai native mosses should be identified into genus and species to compare with the recommended species of mosses used in other regions.

Table 1. Concentration of heavy metals in Thai native moss type I

Week	Concentration of heavy metals (mg/g of moss)				
	Fe	Zn	Cu	Cd	Pb
Polluted area					
0	21.30±3.65	0.01±0.00	0.03±0.00	0.004±0.000	<LOD
1	19.70±5.23	0.10±0.00	0.03±0.00	0.003±0.001	<LOD
2	21.15±0.15	0.18±0.01	0.03±0.00	0.004±0.001	<LOD
3	18.15±1.20	0.06±0.01	0.03±0.00	0.002±0.000	<LOD
4	27.82±1.02	0.16±0.01	0.03±0.00	0.002±0.001	<LOD
5	27.02±1.45	0.14±0.01	0.03±0.00	0.003±0.000	<LOD
6	30.18±2.91	0.16±0.01	0.04±0.00	0.001±0.000	<LOD
7	28.09±1.59	0.16±0.01	0.03±0.00	0.001±0.000	<LOD
8	27.97±1.36	0.16±0.00	0.03±0.01	0.003±0.001	<LOD
9	28.97±1.40	0.15±0.02	0.03±0.01	0.002±0.001	<LOD
10	44±07±5.75	0.19±0.00	0.05±0.00	0.005±0.000	<LOD
14	40.45±2.21	0.14±0.01	0.08±0.00	0.002±0.000	<LOD
18	59.22±0.68	0.24±0.01	0.05±0.00	0.001±0.000	<LOD
Unpolluted area					
18	16.33±1.50	0.05±0.00	0.03±0.00	<LOD	<LOD

LOD : Limit of detection

Table 2. Concentration of heavy metals in Thai native moss type II

Week	Concentration of heavy metals (mg/g of moss)				
	Fe	Zn	Cu	Cd	Pb
Polluted area					
0	15.91±0.44	0.18±0.01	0.02±0.01	0.003±0.002	<LOD
1	14.85±1.91	0.17±0.01	0.07±0.01	0.003±0.000	<LOD

2	15.75±2.61	0.27±0.00	0.06±0.00	0.002±0.000	<LOD
3	14.70±1.43	0.24±0.00	0.05±0.00	0.003±0.000	<LOD
4	15.30±0.49	0.26±0.00	0.05±0.00	0.003±0.001	<LOD
5	17.21±2.76	0.24±0.01	0.05±0.01	0.002±0.000	<LOD
6	20.91±1.55	0.26±0.00	0.04±0.00	0.002±0.000	<LOD
7	18.72±1.59	0.25±0.02	0.05±0.00	0.004±0.000	<LOD
8	21.44±0.43	0.21±0.02	0.06±0.01	0.002±0.001	<LOD
9	22.94±0.94	0.29±0.01	0.04±0.01	0.002±0.001	<LOD
10	28.74±1.04	0.17±0.03	0.03±0.01	0.004±0.000	<LOD
14	38.97±1.40	0.23±0.01	0.05±0.00	0.002±0.000	<LOD
18	49.45±4.86	0.26±0.01	0.06±0.00	0.003±0.000	<LOD
Unpolluted area					<LOD
18	4.16±1.20	0.08±0.01	0.03±0.00	<LOD	<LOD

LOD : Limit of detection

Table 3. Concentration of heavy metals in Thai native moss type III

Week	Concentration of heavy metals (mg/g of moss)				
	Fe	Zn	Cu	Cd	Pb
Polluted area					
0	2.33±0.98	0.08±0.02	0.01±0.00	0.003±0.000	<LOD
1	4.16±0.44	0.11±0.02	0.01±0.00	0.002±0.001	<LOD
2	6.02±1.04	0.20±0.00	0.03±0.00	0.004±0.000	<LOD
3	5.64±0.49	0.19±0.01	0.04±0.01	0.002±0.000	<LOD
4	11.27±1.61	0.18±0.02	0.04±0.00	0.002±0.001	<LOD
5	9.07±044	0.15±0.00	0.03±0.00	0.002±0.001	<LOD
6	18.15±5.20	0.16±0.02	0.03±0.00	0.002±0.000	<LOD
7	22.79±0.00	0.12±0.02	0.03±0.00	0.004±0.000	<LOD
8	28.09±1.59	0.13±0.02	0.04±0.01	0.001±0.000	<LOD
9	30.41±1.02	0.09±0.02	0.02±0.01	0.002±0.001	<LOD
10	44±07±5.75	0.14±0.02	0.05±0.00	0.004±0.000	<LOD
14	46.25±1.02	0.18±0.00	0.08±0.00	0.003±0.000	<LOD
18	67.29±0.68	0.19±0.01	0.09±0.01	0.003±0.000	<LOD
Unpolluted area					
18	2.85±0.58	0.08±0.02	0.03±0.00	<LOD	<LOD

LOD : Limit of detection

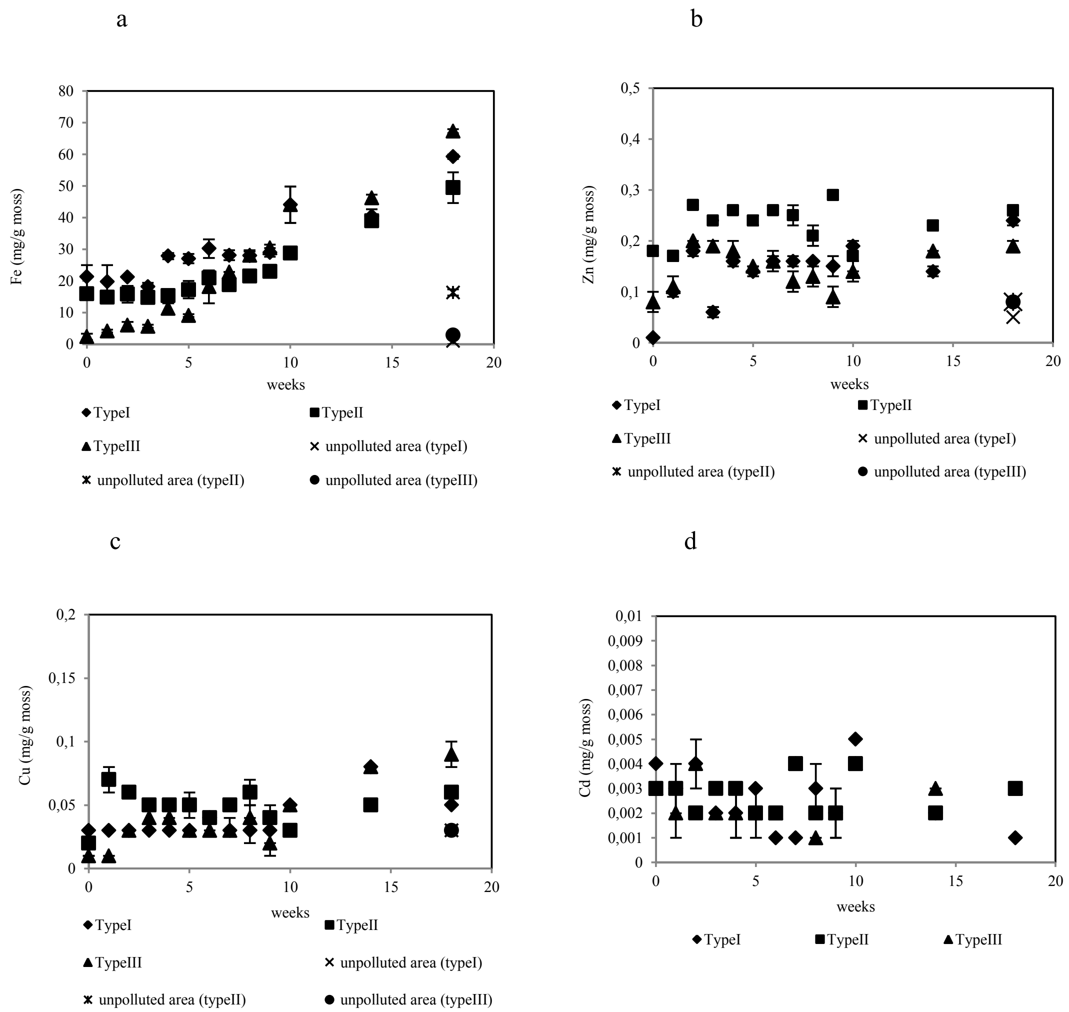

Fig.1 Heavy metals concentration in three types of Thai native mosses in polluted area and unpolluted area
(a) Fe (b) Zn (c) Cu (d) Cd

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