AENSI Journals

Australian Journal of Basic and Applied Sciences

ISSN:1991-8178

Journal home page: www.ajbasweb.com

The use of *Tillandsia usneoides* L. as biomonitor for assessment of atmospheric heavy metal accumulation: a case study in Thaksin University

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ARTICLE INFO

Article history:
Received 25 January 2014
Received in revised form 12 March 2014
Accepted 14 April 2014
Available online 25 April 2014

Keywords:
Tillandsia usneoides L., phytoremediation, airborne heavy metal pollution, atomic absorption spectroscopy (AAS)

ABSTRACT

This research was objected to study of *Tillandsia usneoides* L. as biomornitor accumulating the airborne heavy metal pollutions: lead, cadmium and mercury. The research area was evaluated in Thaksin University (TSU), Phatthalung Campus in 5 sites: gate highway of university, student dormitories and Faculty of Science for 6 months (January-June 2013). Significantly, the accumulated concentration of lead, cadmium and mercury from the tested plants measured by the Atomic Absorption Spectroscopy (AAS) were compared with the control ($p<0.05$, $n = 3$). This results were suggested that *T.usneoides* L. might be a crucial adaptation in the ability to successfully inhabit the extreme environmental conditions of the epiphyte niche and is very appropriate for monitoring air pollution in the metropolis and industrial areas.

To Cite This Article: K. Techato and N.C. van Beem, The use of *Tillandsia usneoides* L. as biomonitor for assessment of atmospheric heavy metal accumulation: a case study in Thaksin University. ***Aust. J. Basic & Appl. Sci.,*** *8(5): 324-328, 2014*

INTRODUCTION

Ascending of an agricultural base to more industrialization, Thailand faces up many environmental problems, particularly, air pollution.In 2012, the Pollution Control Department (PCD) of Thailand reported thatthe major sources of air pollution in Thailand were divided in 3 groups: vehicles in cities, transboundary haze in rural areas and industrial zones.Besides, the particulate matter <10 µm in aerodymic diameter (PM_{10}) is strongly air pollutant in urban and rural areas.The problem of air quality in big apple cities like Bangkok is from vehicular emissions, whereas in the North is from agricultural burning and forest fires (PCD, 2012). Absolutely, the obtaining sustainable development balancing environmental conservation and the well-being of population remains a challenge for Thailand.

Biomornitors have advantages concerning the detection of polluting emission sources providing low costs, possibility to register the effects of air pollution for longer periods and to monitoring many sites simultaneously (Fang *et al*., 2011). *T. usneoides* (Spanish moss) is the most widely distributed member of the Bromeliaceae family, occurring throughout tropical and subtropical America. Spanish moss is a slender perennial, which hangs in festoons up to 1 m long. The plant grows in a zigzagging pattern, and linear, often twisted. This epiphytism is strong independence from soil and utilize Crassulacean acid metabolism (CAM), a type photosynthesis that converses a considerable amount of water for the plant and exhibit reduced rate of transpiration as a result of extremely low stomatal densities and high resistances to gas exchange.*T. usneoides* has proved to be an efficient atmospheric accumulator of the aerosols by the mechanism of phytoremediation (Sutton *et al*., 2014).

In Brazil, Argentina and Mexico, this plant genus was widely primarily used to evaluate the atmorpheric concentrations of heavy metals from industrial and urban areas comparing with control area for 30-45 days (Li *et al*., 2012; Malm*et al*., 1998). However, the understanding of metal accumulation process presented in Spanish moss is important due to its increased utilization as a biomonitor in further.

It is with regards to assess this ability we have investigated *T. usneoides* effectiveness for monitoring inorganic atmospherical pollutants (Pb, Cd and Hg) in 5 sites of Thaksin University from January-June 2013. The metal catchings were detected by AAS.

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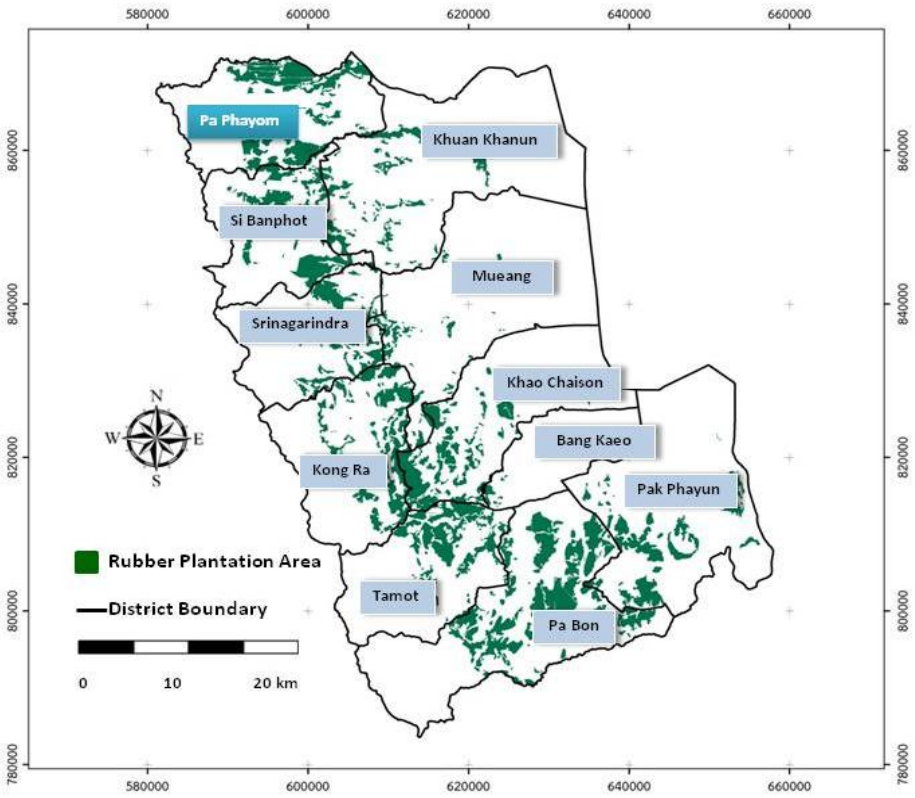

Fig. 1: Field site in Thaksin University, Phatthalung province (Pa Phayom district)

Experimentation:

Sampling Area:

Phatthalung is a province located in South East Thailand located between 07°6´ and 07°53´ North latitude and 09°44´ East longtitude about 858 km from Bangkok, capital city.Phatthalung province is subdivided into 11 districts. The region is inhibited by 509,072 people (average density of 148.80 persons/km^2). Most of population are Thai Buddhists, even if Islamic faith is less than 12%. Many Muslims have some ethnic Malay ancestry and gradually intermarried with the Thais. The majority of people in this province practice living agriculture.The economically most important plants are rice, rubber, palm oil and coconut, generally produced in monoculture plantation sometime gathered with cattle farming (PGO, 2011). TSU, Pa Phayom District,is located in range of 1 km away from the urban areawhich is often causes of agricultural combustions,the state highway to Bangkok and vehicles of community.

Biological Material and Sample Analysis:

Evaluation of *T. usneoides* L. biomonitoing in TSU was tropically located in 5 sites: gate highway (T1), female dormitory (T2), male dormitory I (T3), male dormitory II (T4) and Faculty of Science (T5) for 6 months (January-June 2013). Spanish moss transplants (10 g) were hung on 85% of the steel frames sized 150 cm x 100 cm at each site (Fig. 2). The controlled epiphyte was placed in the botanical nursery building, Department of Biology, Faculty of Science lacking in pollution sources. Plants were cut at 10-13 cm from end part, collected every month and optimized the temperature (℃) and relative humidity (%) by temperature and humidity data logger (SK-L200THIIα, SK Sato). Mineralisation of the plants for Pb, Cd and Hg analysis was adapted from Fang et al. (2011). Briefly, samples were dried at 40℃, digested with NHO_3:$HClO_4$, diluted by distilled water and filtrated with Whatman no. 1. Standard solutions of Pb, Cd and Hg were prepared (Malm*et al*., 1998). Determinations of atmospheric heavy metals (mg/kg) were done by Atomic Absorption Spectrophotometry (AAS), Perkins Elmer Analyst 100 (Table 1).

Table 1: Standard condition and characteristics concentration checks for AAS

Element	Wavelength (nm)	Flame Gases	Characteristics Concentration Checks
Pb	283.3	Air-acetylene	20.0
Cd	228.8	Air-acetylene	1.5
Hg	253.7	Air-acetylene	200.0

Statistical Analysis:

Samples were compared with control group by t-test (n = 3) and considered significant at $P<0.05$ using Software MiniTab 16.1.0, 2010 (Minitab Inc, USA).

RESULT AND DISCUSSION

The results of the analysis of Pb,Cd and Hg (in mg/kg) carried out by *T. usneoides* L. all tested sites and control were shown in Figure 3.Data presented clearly showed that the atmospheric heavy metals were constantly present in all sample sites. The concentration curves of all heavy metals in Figure 3 (b-f) were not exactly follow the temperature (℃) and relative humidity (%) in Jan.-Jun. except control (Fig. 3a). Supposingly,the pollution sources at sample sites were related to the activities of daily living, for examples, times of driving vehicles, burning garbages from communities and agricultural combustions.

Our investigation showed that Spanish moss can be successfully used as an air-biomonotoring tester. The aerosol capture abilities of Spanish moss were reported and monitored in various researches (Sutton *et al*., 2014; Martin*et al*., 2013; Isaac *et al*., 2012). Obviously, the highest concentrations of Pb, Cd and Hg carried out from sample plants and control were showed in Figure 4 and Table 2.

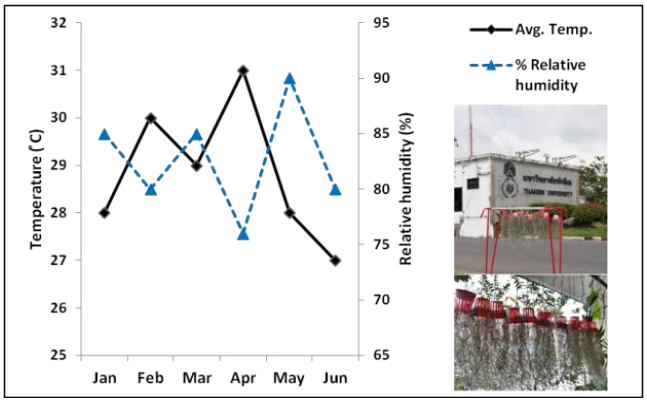

Fig. 2: Average temperature (℃) and relative humidity (%) in January-June 2013 and setting of *T. usneoides* L.

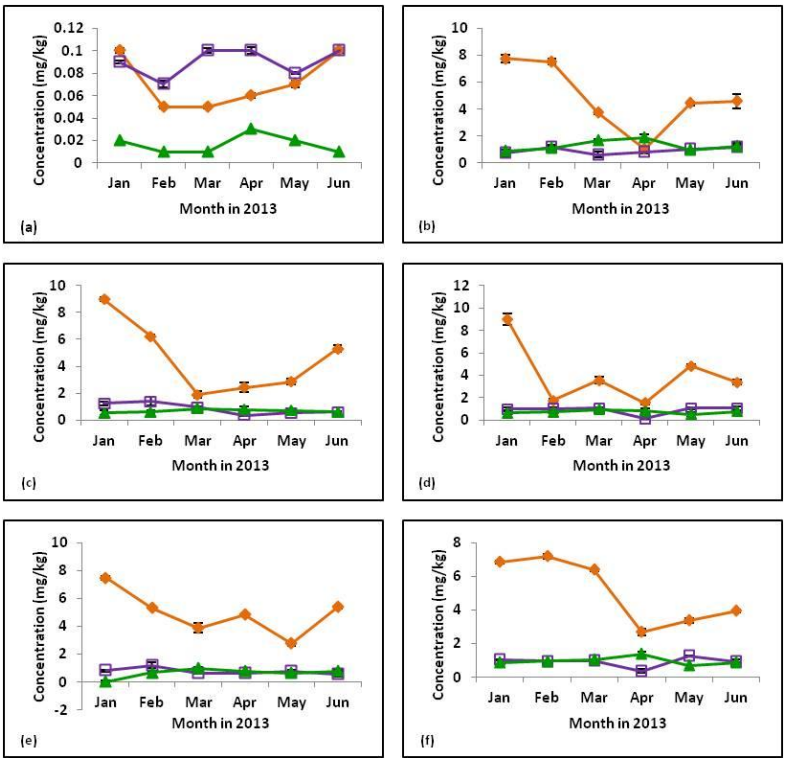

Fig. 3: Concentration of Pb, Cd and Hg (mg/kg) in *T. usneoides* L.at5 sites of TSU and control for 6 months: (a) control, (b) T1,(c) T2(d) T3, (e) T4and(f) T5.Data significant at $P<0.05$. Pb Cd Hg

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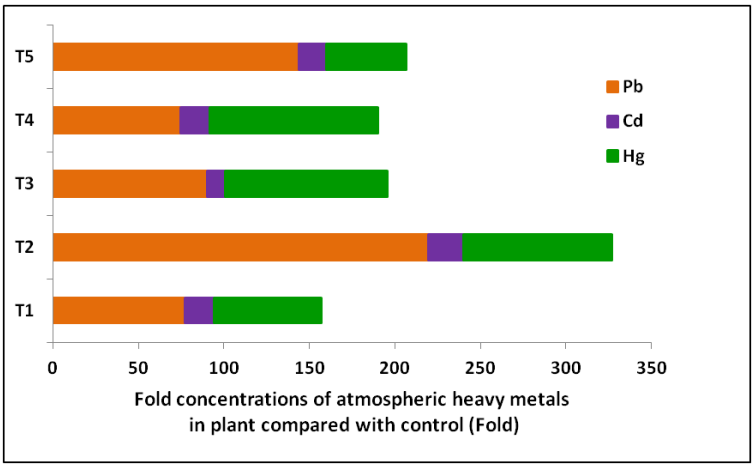

Fig. 4: Fold concentration of Pb, Cd and Hg (-fold) in *T.usneoides* L. from samples(T1-T5) comparing with control

Table 2: Increasing fold concentrations of Pb, Cd and Hg carried out of samples (T1-T5)*comparing with control (C_T, mg/kg)

Sites	Increasing fold concentrations of atmospheric heavy metals in samples (-fold)		
	Pb	Cd	Hg
T1	77.5	16.57	63
C_{T1}	0.1	0.09	0.03
T2	219.8	20.14	87
C_{T2}	0.1	0.09	0.01
T3	90.1	10.7	95
C_{T3}	0.1	0.1	0.01
T4	74.8	14.17	98
C_{T4}	0.1	0.07	0.01
T5	143.8	16.13	46.67
C_{T5}	0.05	0.08	0.03

*T1: gate highway, T2: female dormitory, T3: male dormitory I, T4: male dormitory II and T5: Faculty of Science

Conclusion:

Determination of the atmospheric heavy metal accumulation, Pb, Cd and Hg,of *Tillandsia usneoides* L. was assessed as biomonitor ina case study at Thaksin University using AAS. It could be concluded from this results as below:

a. The highest concentration of Pb in sample was found at the female dormitory (21.8 mg/kg or 219.8-fold concentration of control) in January 2013

b. The highest concentration of Cd in sample was found at the female dormitory (1.41 mg/kg or 20.14-fold concentration of control) in February 2013

c. The highest concentration of Hg in sample was found at the male dormitory II (0.98 mg/kg or 98-fold concentration of control) in March 2013

d. The concentrations of Pb, Cd and Hg of sample sites were significant at $P<0.05$ (n = 3) comparing with control.

ACKNOWLEDGEMENT

This research is supported by the Center of Excellence on Harzardous Substance Management (HSM), Chulalongkorn University, Thailand.

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