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Use of Atmospheric Epiphyte *Tillandsia usneoides* (Bromeliaceae) as Biomonitor

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Abstract

The great benefit sustainability of ecotechnology requires an effective policy supported by social perception, an incorporate with the environment impact assessments, cost-benefit analysis and intellectual property. Ecotechnology of phytoremediation is cost effective and ecologically friendly in which plant utilizes its natural abilities to restore environment. It is the use of green plant based systems to remediate contaminated soils, sediments, water or air. Some epiphyte plants, especially those from Spanish moss, *Tillandsia useneoides* (Bromeliaceae), known as air plants, has been widely used in biomonitoring studies of air pollution in South America countries. The aim of this paper was to review the biological living of *T. useneoides* and applications for applying our current research in summer monsoon rain and rainy season in Southern Thailand .

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Keywords: *Tillandsia usneoides*, crassulacean acid metabolism (CAM), epiphyte, biomonitor, ecotechnology

1. Living of *Tillandsia usneoides* epiphytism

T. usneoides (Spanish moss) is the most widely distributed member of the Bromeliaceae family, occurring throughout tropical and subtropical America. It is found in the southeastern United State, and throughout Mexico, the West Indies, Central and South America, as far south as Argentina and Chile. Spanish moss is a

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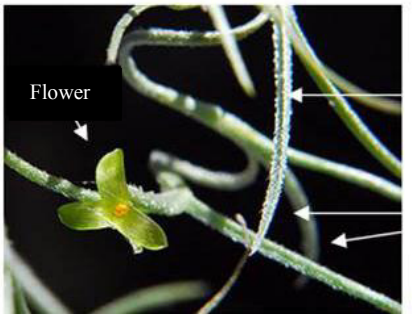
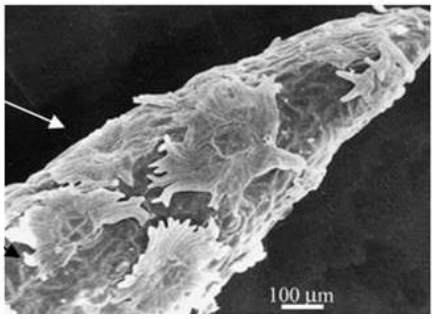
slender perennial, which hangs in festoons up to 1 m long (Fig. 1a.). The plant grows in a zigzagging pattern, and linear, often twisted and densely convered with a thick layer of heavily scaled leaves 2-6 cm long (disc-shaped peltate lodicules), 1 mm broad (Fig. 1b.), which gives it a silvery-gray appearance and can be seen clearly with SEM (scanning electron microscope, Fig. 1c.). 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. Trichome of *Tillandsia* includes a stalk and wing which absorb water and nutrients directly from the air; its adventitious roots do only function to adhere to a substratum. For this reasons, Spanish moss is reportedly 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 [1][2].

(a)





(b) (c)

Fig. 1. (a) morphology of *T. usneoides*; (b) absorbing trichome and flower; (c) disc-shaped peltate lodicules photographed by SEM [18]

2. Atmorpheric biomonitoring studies of *T. usneoides*

Contamination of air by metals is a major environmental problem in recent years. 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. However, the accumulation of metal amounts in plants brings about considerable metabolic changes. Metal ions may directly interfere with the metabolic activities by altering the conformation of proteins. Moreover, high concentrations of metal can be very toxic for plants resulting in varied effects on physiology. *T. usneoides* has

proved to be an efficient atmospheric accumulator of Hg, Cd, Cn, Pb, Ni, Cu, Cr, C and Zn by the mechanism of phytoremediation [1]-[4].

In Brazil, this plant genus was widely primarily used to evaluate the atmorpheric concentrations of heavy metals from industrial and residential areas comparing with control area for 30-45 days (each summer, winter and rainy seasons). Then, the heavy metals were quantified by flame atomic absorption spectrophotometry (AAS), and the particulate matter analyzed by conventional and analytical scanning electron microscope (SEM) [3], [4]. The biomonitoring approach using Spanish moss was successfully applied in the metropolitan region, for example, the evaluation of Hg in urban air of Alta Floresta city-MT in South Amazon and recovered after an exposure of 15 and 45 days during the dry season (August-September, 1995) and repeated during the rainy season (February-March, 1996). Concentration of Hg in exposed plants was up to 26 ppm or 300 times higher than in control [4]. In Rio de Janeiro and Salvador, this plant was exposed to the air of 12 sites for 45 days in two seasons, then heavy metals concentrations were showed as Cd < Cr < Pb < Cu < Zn exhibited a morphology varying from amorphous- to polygonal-shaped particles. Size of particle matter indicatd that more than 80% and less than 10 μm [3]. Briefly, various investigations of *T. usneoides* were made as shown in Table 1.

3. Assessment of atmospheric heavy metals using *T. usneoides* in Thailand

Rising of an agricultural base to more industrialization, Thailand faces up many environmental problems, particularly, air pollution. The major sources of air pollution in Thailand are divided in 3 groups: vehicles in cities, transboundary haze in rural areas and industrial zones. Particulate matter <10 μm in aerodymic diameter (PM_{10}) is strongly air pollutant in urban and rural areas [5]. In Bangkok, the air quality monitoring has performed by the Pollution Control Department (PCD) for past 10 years revealed that the level of PM_{10} have exceeded both annual (50 $\mu g.m^{-3}$) and 24-h (120 $\mu g.m^{-3}$) national standards [5]. The problem of air quality in Bangkok is from vehicular emissions, whereas in the North is from agricultural burning and forest fires [5]. Exactly, the obtaining sustainable development balancing environmental conservation and the well-being of population remains a challenge for Thailand.

We are known as phytoremediation is a way to migrate environment pollutions in vitual of plants, more often than not, combined with their associated microorganisms. The roles from roots to shoots of plant are played in phytostabilization, rhyzodegradation, phytoextraction, phytodegradation, phytovolatilization and phytofiltration (Fig. 2.). Certainly, researches on *T. usneoides* have unpresented and proved to be a suitable biomonitor in Thailand. Our researches in Thailand supported by the Thailand Research Fund and the Center of Excellence on Harzardous Substance Management (HSM) have been going to explore on the background that the best long-term strategy for improving phytoremediation. Interesting, the biological processes involved in metal acquisition, transport and accumulation are understood and exploited. A technique associated with electron microscopy, like energy-dispersive X-ray analysis (EDXA) has been used to detect the ultrastructure level, contaminate elements, heavy metals, helping the understanding of metalic accumulation by organisms [6], [7]. Accordingly, the hypothesis testing of plant proving has been to determine if the available atmospheric heavy metals were only absorbed and trapped by the plant external surface structures or they were absorbed and retained by the the plant. Meanwhile, the investigations of photosynthetic response to light of Spanish moss in various photosynthetic photon flux density (PPFD) levels are important for living conditions in various tested areas [8]-[12]. Presumely, *T. usneoides* can provide a rapid method of estimating the kind and relative degree of local atmospheric metal pollution or urban areas in Thailand. Further researches are based and required to optimize the ecological and economical efficiencies of this epiphyte.

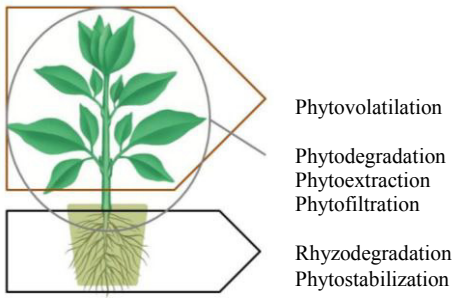


Fig. 2. Different parts of the plants are responsible for differet processes of phytoremediation

Table 1. Summary of biomonitor researches of *T. usneoides*

Studied areas	Methods	Description	References
USA	Measurement of mercury in *T. usneoides* by cold vapor atomic fluorescence spectrophotometry and plant tissue by mass spectrometer	Spanish moss use as a biomonitor of atmospheric mercury potentially	[13]
Germany	Cell turgor measurement of *T. usneoides* using the probe and chlorophyll fluorescence image	The absorption of water vapor increasing by atmospheric humidity and no significant with plant tissue	[14]
Southeastern USA-Argentina	(1) Evaluate the potential of *T. usneoides* for monitoring stable ^{133}Cs from solutions as an analog of radioactive Cs using atomic absorption spectrometry (AAS) (2) Investigate if different foliar trichome cell types contain different Cs ions using x-ray spectra, scanning electron microscopy (SEM) and energy dispersive spectrometer (EDS) analysis	Plant was able to survive relatively high Cs stress and accumulate Cs quickly	[15]
Mexico	Comparison the accumulation of particulate matter (PM_{10}) in *T. usneoides* in various areas using PIXE analysis	The results of atmospheric pollution were reached to maximal level at 6-10 weeks	[16]
Mexico	Evaluation of La, Ce and Sm concentrations in particulate matter from *T. usneoides* by neutron activation analysis (NAA)	La, Ce and Sm concentrations of biomonitor was highly correlated with industrial areas	[17]
Italy	Ultrastructure during ontogeny of trichomes of *T. usneoides* using SEM and TEM	Investigations of absorbing trichomes in shield cells involved atmospheric water, mineral and organic nutrients	[18]

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