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LICHEN (DIRINARIA SP.) AS BIO-INDICATORS FOR DETERMINING ATMOSPHERIC HEAVY METAL CONCENTRATION AT SELECTED INDUSTRIAL AREAS IN MALAYSIA

(LIKEN (DIRINARI SP.) SEBAGAI PENUNJUK BIOLOGI DALAM MENENTUKAN KEPEKATAN LOGAM BERAT ATMOSFERA DI KAWASAN PERINDUSTRIAN TERPILIH DI MALAYSIA)

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Abstract

Heavy metals have been found in the vicinity for a long time. In Malaysia, air pollution still measured using instrumental approach. Hence, this study used lichen as biological indicator to measure air pollution. Study been conducted in four different locations which are Rumah Tumbuhan, UKM (Control station), Section 51 Industrial Area, Petaling Jaya, Spring Crest Industrial Area, Batu Caves and Nilai Industrial Area, Negeri Sembilan. This study used lichen Dirinaria sp. an endemic species of tropical country as the biological indicator. Heavy metals been analyzed using ICP-OES and motor vehicles frequency for every sampling location recorded. One way ANOVA and Pearson's correlation used to test the relationship between heavy metals and sampling locations also relationship between heavy metals and motor vehicle frequency. Result shows that heavy metals such as Cr, Fe, Cu, Ni, Zn and Pb have been recorded. One way ANOVA test shows there is significant relationship between heavy metals and sampling locations where F is 2.7728 and P-value is 0.0001 (where P is significant when < 0.05). Pearson's correlation also shows the relationships between all heavy metals recorded with motor vehicles frequency are significant where all the P value are< 0.05. Heavy metals are so much related with motor vehicles frequency in the particular location. Higher frequency of motor vehicles will produce higher heavy metals concentration in the vicinity. Lichen can be used as the alternative approach in determining the heavy metals content in the environment.

Keywords: Heavy metals, Lichens, Air pollution, Environmental management, Urban ecosystem

Abstrak

Logam berat telah lama ditemui wujud di persekitaran. Di Malaysia, pencemaran udara diukur menggunakan pendekatan instrumental. Oleh itu, kajian ini menggunakan liken sebagai penunjuk biologi bagi mengukur pencemaran udara. Kajian ini telah dijalankan di empat kawasan kajian iaitu Rumah Tumbuhan UKM (Stesyen kawalan), Kawasan Perindustrian Seksyen 51, Petaling Jaya, Kawasan Perindustrian Spring Crest, Batu Caves dan Kawasan Perindustrian Nilai, Negeri Sembilan. Kajian ini juga menggunakan liken Dirinaria sp. yang merupakan spesies yang endemik di kawasan tropika sebagai *penunjuk biologi. Logam berat dianalisis menggunakan ICP-OES dan kepadatan kenderaan bermotor diambil bagi setiap stesen persampelan. ANOVA sehala dan Korelasi Pearson digunakan bagi menguji hubungan di antara logam berat dan juga kawasan persampelan serta hubungan di antara logam berat dan kepadatan kenderaan bermotor. Dapatan kajian menunjukkan logam berat seperti Cr, Fe, Cu, Ni, Zn dan Pb berjaya direkodkan. Analisis ANOVA sehala menunjukkan ada hubungan signifikan di antara logam berat dengan kawasan persampelan di mana F adalah 2.7728 dan Nilai P adalah 0.0001 (P adalah signifikan pada < 0.05). Korelasi Pearson juga menunjukkan hubungan yang signifikan di antara kesemua logam berat dengan kepadatan kenderaan bermotor yang direkodkan di mana semua Nilai P adalah < 0.05. Logam berat adalah sangat berkait rapat dengan kepadatan kenderaan bermotor di sesuatu kawasan.Semakin tinggi kepadatan kenderaan bermotor semakin tinggi kepekatan logam berat di sesuatu kawasan itu. Liken juga boleh digunakan sebagai pendekatan alternatif di dlaam penentuan logam berat di persekitaran.*

***Kata kunci**: Logam berat, Liken, Pencemaran udara, Pengurusan persekitaran, Ekosistem bandar*

INTRODUCTION

Human well-being has been degrading tremendously due to the air pollution that caused by industrialization and urbanization in the city. In Malaysia, with the newly launched vision "National Transformation 2050 (TN50)" has been implementing several policies to sustain the human well-being in the city and also actions has been taken to create a livable vicinity. To tackle the issue of the degradation of human well-being in Malaysia due to air pollution, The Department of Environment has outlined few protocols to be followed. But, in term of the measurement it still not sufficient. The three major causes of air pollution are transportation, stationary sources and open burning. The problem they face now is that the quality of air in areas far away from their air monitoring stations is difficult to determine, hence lichen has been selected as a potential bio-indicator for this purpose.

Heavy metals can be measured and analyzed using two approaches which are sampling directly from the atmosphere and sampling using biological indicator. According to Gharaibeh et al. (2010), High volume air samplers and glass fiber filters were used to collect the samples containing heavy metals. Collected samples were digested using a mixture of analytical grade nitric acid and analytical grade hydrochloric acid, and analyzed to evaluate the levels of heavy metals by atomic absorption spectrophotometry. Heavy metals also can be sampled from lichen where selected lichen from specific sampling location brought to the lab and analyzed using atomic absorption spectrophotometry (Wahid et al. 2013). Heavy metals also can be found from the dust inside building as studied by Ali et al. (2017) where they stated heavy metals such as Fe, Pb, Zn, Cu and as are existed inside the university building which can bring harm to the occupant health.

Lichen has been used as bio-indicator for air pollution since decades ago. In Italy, a standard called Lichen Biodiversity Index been developed and used to monitor air pollution in the district of Faenza, Italy (Cioffi 2009). Also, Loppi&Frati (2006) conducted a research in Central Italy measuring the nitrogen compounds in foliose lichen. Foliose-type lichen *Hypogymniaphysodes* also been used and collected to analyse the heavy metals contents due to traffic pollutants (Koroleva&Revunkov 2017). Transplanting foliose type lichen from remoted and clean air area to much more polluted area is widely used to monitor the air pollution in certain vicinity. As examples, in Thailand they used *Parmotrematinctorum*tp monitor airborne trace elements near a petrochemical industry complex (Boonpeng et al. 2017). Apart of assessing outdoor pollution, transplanted lichen also used to indicate the level of indoor air quality where heave metals such as As, Cd, Cr, Cu, Hg, Ni, and Pb also 12 Polycyclic Aromatic Hydrocarbon (PAH) been recorded (Protano et al. 2017). In Malaysia, research on lichens more focused on lichens dwelling in the highland such as GunungMachincang, Cameron Highland, Genting Highland, Fraser Hills and Bukit Larut. In addition, these researches only touched about the ecological and chemical part of the lichen (Din et al. 2010; Zulkifly et al. 2011). None of them studied about the relationship between lichen and its vicinity, not until 2015 where a study on lichen diversity distribution in Kuala Lumpur (Abas &Awang 2017). The research found that lichen diversity distributions are much related with the population density in Kuala Lumpur.

The aim of this study is to analyze the heavy metals contents using lichen as the alternative approach in air quality measurement and to determine the relationship between motor vehicles frequency and heavy metals concentration.

MATERIALS AND METHODS

Sampling

Lichens were collected from one control station and three selected urban stations. RumahTumbuhan, UKM was selected as the control station because of its location that remoted from the urban area, still sustaining the natural vicinity and less anthropogenic activity (Wahid et al. 2013). For sampling in the urban area, three industrial areas has been selected as the urban station which are a) Section 51 Industrial Area, Petaling Jaya, b) Spring Crest Industrial Area, Batu Caves and c) Nilai Industrial Area, Negeri Sembilan. These three selected urban areas are known as congested traffic and industrial area. Each location comprises of 4 sampling sites to have variety set of data.Figure 1, 2, 3 and 4 shows the location of each station and sampling sites. Lichens that collected were from genus of *Dirinaria*. Dirinaria sp. had been recorded in many urban areas such as Kuala Lumpur (Abas 2015), Bandar BaruBangi (Abas &Awang 2015) also at Penang and Selangor (Norela et al. 2018). The procedures in collecting lichens for further analysis are as follows:

i) Lichens collected on tree bark near to the road < 10 meter.
ii) Selected tree bark must be facing to the road.
iii) Lichens must be in the range of 1-2 meter from the land.
iv) Motor vehicles also counted for comparative test.

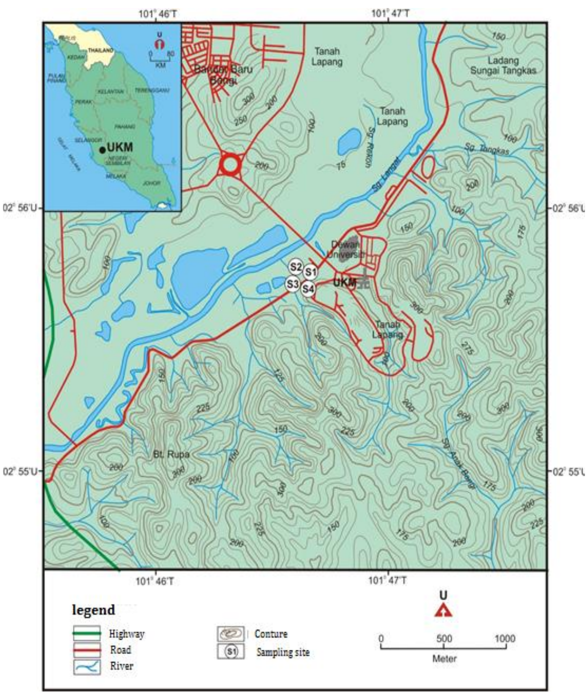

Figure 1. RumahTumbuhan, UKM (Control Station)

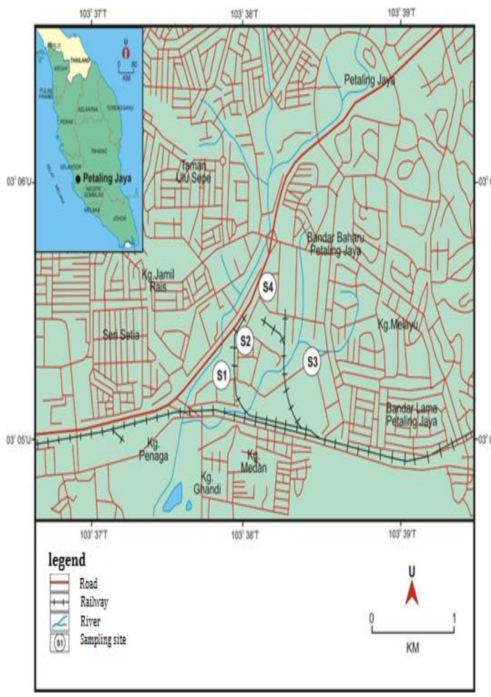

Figure 2. Section 51 Industrial Area, Petaling Jaya

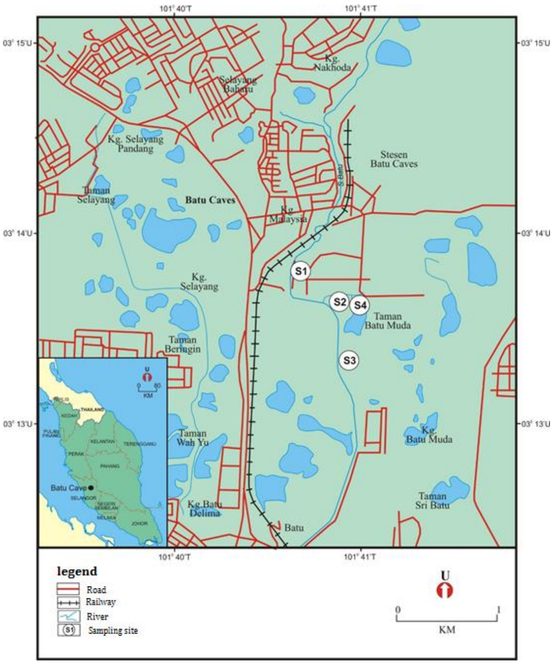

Figure 3. Spring Crest Industrial Area, Batu Caves

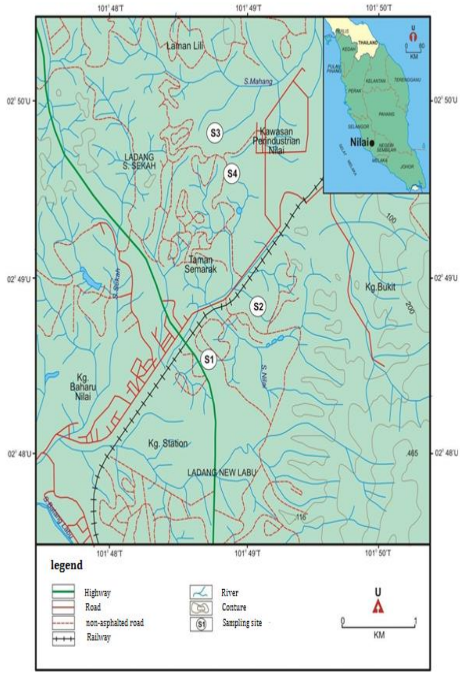

Figure 4. Nilai Industrial Area, Negeri Sembilan

Heavy Metals Analysis

The collected lichens were cleaned, oven dried at 60°C for 48 hours and ground for further analysis. The ground samples then were homogenized. About 1 g of samples was weighted accurately for 3 replicates and digested using wet acid digestion procedure. The acid mixture used for digestion is 5.0 mL nitric acid 65% and 2.0 mL hydrogen peroxide 30%. After that, the mixtures were heated on the hot plate at 90°C for 4 hours. The residue of digestion then was rinsed with 1 mL hydrochloric acid 2% and diluted to 100 by deionized water before carrying out the ICP-OES (Optima 4300 DV, Perkin Elmer) analysis.

Statistical Analysis

One-way Analysis of Variance (ANOVA) was used in order to analyzethe relationship of heavy metals content between control stations and sampling stations. Pearson's correlation also used to analyze the relationship between heavy metals content and motor vehicles frequency.

RESULTS AND DISCUSSION

In this study, the heavy metals founds are Fe, Cr, Ni, Zn, Pb and Cu. Table 1 shows the average concentration of heavy metals content that found in Dirinaria sp. from all sampling sites for each location. The highest concentration collectively is Fe followed by Zn, Pb, Cr, Ni and the lowest is Cu. All of the sampling stations have higher average concentration of heavy metals compare with the control station. All of the heavy metals been recorded the highest in Section 51 Industrial Area then followed by Spring Crest Industrial Area, Batu Caves, Nilai Industrial Area, Negeri Sembilan and the lowest is the control station. Table 2 shows the frequency of motor vehicle recorded in each to sampling station. One way ANOVA analysis for heavy metals shows there are significant differences between heavy metals concentration to the sampling locations where F is 2.7728 and P-value is 0.0001 (where P is significant when < 0.05). Pearson's correlation test also shows there are significant relationships between the frequency of motor vehicles with the heavy metals concentration in all sampling stations where r value for Cr is 0.9568 (P-value = 0.0433), Fe is 0.9528 (P-value = 0.0472), Cu is 0.9976 (P-value = 0.0024), Ni is 0.9624 (P-value = 0.0376), Zn is 0.9707 (P-value = 0.0293) and Pb is 0.9562 (P-value = 0.0438) where p-value is significant when $p < 0.05$.

Table 1. Average of heavy metals concentration

Sampling location	Heavy metals μg/g(ppm)					
	Cr	Fe	Cu	Ni	Zn	Pb
RumahTumbuhan, UKM (Control Station)	1.17± 27.01	908.00± 235.99	0.16± 0.28	3.29± 14.69	88.58± 15.72	30.34± 4.90
Section 51 Industrial Area, Petaling Jaya	24.67± 11.76	5836.59± 1127.39	1.08± 0.22	9.91± 1.15	183.89± 36.39	67.66± 15.88
Spring Crest Industrial Area, Batu Caves	13.55± 2.65	3493.49± 887.35	0.83± 0.11	7.59± 3.54	152.67± 29.66	48.93± 17.89
Nilai Industrial Area, Negeri Sembilan	11.75± 8.95	2673.38± 773.92	0.61± 0.17	4.62± 4.71	117.27± 18.77	39.31± 6.85

Table 2. Frequency of motor vehicles at sampling location

Sampling location	**Motor vehicles frequency (per hour)**
RumahTumbuhan, UKM	33
Section 51 Industrial Area, Petaling Jaya	1942
Spring Crest Industrial Area, Batu Caves	1547
Nilai Industrial Area, Negeri Sembilan	1022

Three of the listed heavy metals (Fe, Zn and Cu) are known as the essential metal content where defined as very important in the growth of biological component. Even called as common metals, Fe also produced in large concentration by motor vehicles. Study of Monaci et al. (2000) stated that Fe is very rich in the leaded petrol and diesel oil, even unleaded petrol emission contain Fe in some lesser extent. That's why the sampling location with the highest number of motor vehicles passing by has the highest number of Fe. Fe has the greater number compare to all of the other heavy metals due to it excessive contents in the soils and the ability of its which can be easily oxidized to the air (Olivia & Espinosa 2007). Zn in the other way cannot be found as greater as Fe in the vicinity. Though it also one of the essential metals, but its concentration is less higher compare to Zn. According to Councell et al. (2004), Zn can be emitted to the atmosphere from the corrosion process of the tire of the vehicles and also can be hazardous if found at largest number in the atmosphere. Cu is a trace element in most soils. It is an essential element for plants, animals, and people, but it also has a toxic element, which has been a major concern, to all organisms. There is strong evidence that shows Cu is one of the pollutants emitted to the atmosphere (Monaci et al. 2000).

The other three heavy metals (Cr, Ni and Pb) are called as non-essential metal in our vicinity which means just a little of these heavy metals in the growth of biological component. Cr is well known as the main component in car coating and painting. The deterioration of the painting or coating might be the main source of Cr in the atmosphere (Hjortenkrans 2008). Ni emitted to the atmosphere from two main components of motor vehicles which are tire and lining brake (Monaci et al. 2000). The corrosion between tire and asphalt from the road makes the Ni emitted to the atmosphere and later enter the food cycle of the biology (Hjortenkrans 2008). Pb is the major compound and very excessive in the leaded petrol and diesel. The emission of fuel cell contains high concentration of Pb and it will be hazardous to the biology when occur at high concentration (Olivia & Espinosa 2007).

CONCLUSION

Based on the literature provided, heavy metals occurrences are very much related with the density of traffic in the particular location. More congested the location with motor vehicles, the higher it will be accumulated with heavy metals. Motor vehicles have been the main contributor in emitting heavy metals to the atmosphere which is later ending up in the ecosystem such soils and water. In Malaysia, we only have the regulations for freshwater and marine towards heavy metals content but no regulations for heavy metals in the atmosphere which is something that can be ponder and should be discussed in the future.

The utility of lichen as the biological indicator should be enhance in Malaysia. Practically, lichens are much more relevant where we can find it on almost tree bark in Malaysia. So there is no need for observation station for air quality or portable machine in conducting air quality assessment generally, heavy metals analysis, specifically.

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