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Relationship of Polycyclic Aromatic Hydrocarbons (PAHs) from Vehicle Emission in Air Particulate and Plant Leaves From Highway Roadsides in Johor, Malaysia

Kaitan Antara Hidrokarbon Polisiklik Beraroma daripada Asap Kenderaan dalam Partikel Udara dan Daun Pokok di Pinggir Lebuhraya Johor, Malaysia

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ABSTRACT

Polycyclic aromatic hydrocarbons (PAHs) produced from the incomplete combustion of the organic and fossil fuel, and are usually attached to the particulate matter from the emission. Abundance of PAHs occurrence in the atmosphere has the ability to accumulate into vegetation. This study, by using selected species of plants is carried out to determine the relationship between the composition of PAHs in plants and the degree of PAHs pollution in the atmosphere to discover the ability of plants to absorb PAHs from the atmosphere. The study is concentrated on 3 toll station along PLUS' North-South Expressway in Johor. From this study, it was observed that some plants are suitable for absorption of PAHs pollutant from the environment and suitable to be introduced as a medium for biomonitoring.

Key words: Polycyclic Aromatic Hydrocarbons; pollutant; environment; Johor

ABSTRAK

Polisiklik hidrokarbon aromatik (PAH) dihasilkan daripada pembakaran tidak lengkap bahan api organik dan fosil, dan biasanya melekat pada zarah dari pelepasan. Banyak kejadian PAH di atmosfera mempunyai keupayaan untuk mengumpul ke dalam tumbuh-tumbuhan. Kajian ini, dengan menggunakan spesies tumbuhan terpilih dijalankan untuk menentukan hubungan antara komposisi PAH dalam tumbuhan dan tahap pencemaran PAHs dalam suasana untuk mencari keupayaan tanaman menyerap PAH daripada atmosfera. Kajian ini tertumpu kepada 3 stesen tol di sepanjang PLUS Lebuhraya Utara-Selatan di Johor. Dari kajian ini, pemerhatian menunjukkan bahawa sesetengah tumbuhan yang sesuai untuk menyerap pencemar PAH dari persekitaran dan sesuai diperkenalkan sebagai medium untuk pemonitoran biologi.

Kata kunci: Polycyclic Aromatik Hidrokarbon; pencemar; alam sekitar; Johor

INTRODUCTION

Malaysia has risen to the industrial age at the cost of the environment. The increasing need of mobility by urban dwellers increase the need of fossil fueled vehicle. PAHs from combustion sources are widespread and are typically concentrated in the urban centers. The distribution pattern of PAHs in Kuala Lumpur shows that vehicular emission is the dominant source of PAHs in atmospheric particles (Omar 2001). PAHs in gaseous or particulate state can be easily accumulated in plants due to its lipophilicity.

Organic pollutants may enter plants by partitioning from contaminated soil to enter the roots and translocated in the plants through xylem or from the atmosphere by gas-phase and particle phase deposition onto the waxy cuticles or by uptake through stomata and be translocated by phloem (Simonich and Hites 1995). However, for most species examined under controlled exposure experiments, uptake of lipophilic organic pollutants through roots are generally not a significant way of accumulation (Paterson et al. 1994). Various analyses has been done to spotlight the deposition and accumulation of PAHs in plant leaves (Nicola et al. 2008; Prajapathi and Tripathi 2007). Due to the various factors, some plants might have the ability to absorb PAHs among other pollutants to assist in removal of pollutants from the environment via bioremediation. Various bacteria, genetically modified microorganisms and some plants had been adopted for bioremediation involving removing of PAHs in soil (Harayama 1997; Haritash and Kuashik 2009).

The objective of this study is to determine the relationship of PAHs concentration from vehicle emission in air particulate and plant leaves from highway roadside in Johor, Malaysia and determine the suitable species for biomonitoring and to be further studied as potential medium of bioremediation for a sustainable environment.

SAMPLING SITE AND METHODOLOGY

SAMPLING SITE SELECTION

The North-South Expressway connects Peninsula Malaysia from Skudai, Johor in the south to Bukit Kayu Hitam, Kedah in the north for about 807 km. The North-South Expressway comprises of nine toll stations in the closed system and 2 toll stations in the open system. Three sampling sites along the closed system of North-South Expressway in Johor were chosen namely Ayer Hitam toll station, Skudai toll station and Tangkak toll station as shown in figure 1.

FIGURE 1. Map of PLUS' North-South Expressway Exits in Johor Region

TABLE 1. Total number of vehicle using the Ayer Hitam, Skudai and Tangkak toll station (data acquired from PLUS UEM Bhd.)

Month	*Ayer Hitam*		*Skudai*		*Tangkak*	
	Entry	Exit	Entry	Exit	Entry	Exit
Jun	262,900	267,300	669,200	668,700	195,800	198,000
July	249,300	257,200	658,300	637,200	180,700	187,100
August	237,800	239,400	624,500	623,800	176,400	173,300
September	293,000	296,600	694,100	688,000	214,600	217,900
October	248,400	253,300	655,800	647,700	178,300	179,900
November	265,700	270,100	676,600	675,000	195,400	196,300
December	289,200	296,400	744,500	742,500	211,900	217,100

SAMPLING PROCEDURE

Atmospheric particulate matter were acquired using an environmental sampler (Met One Instruments E – Sampler) with PM10 cut point at 2L/minute through a particle size separator with baked (300°C for 8 hours) 47mm pure quartz fibre filter (Whatmann QM-A) for eight hours.

Eight species of plants found in the three sampling sites were chosen as plant leaves sample in this study namely *Baphia* sp., *Bougainvillea* sp., *Codiaeum* sp., *Ficus* sp., *Heliconia* sp., *Hibiscus* sp., *Ixora coccinea* and *Ixora taiwanensis*. The presence of species are as shown in Table 2.

TABLE 2. Presences of species in each sampling site

Species	Ayer Hitam	Skudai	Tangkak
Baphia nitida	√		
Bougainvillea sp.	√	√	√
Codiaeum sp.	√		√

Ficus microcarpa	√	√	√
Heliconia sp.		√	
Hibiscus sp.			√
Ixora coccinea	√	√	√
Ixora taiwanensis		√	√

Leaves samples of the same species were collected from 3 different sites in one sampling area to ensure homogeneity of the samples. Leaves samples collected were as far as possible to be of the same maturity, size and healthy appearance and collected at approximately 1.0 – 1.5 m from the ground. The leaves were collected in aluminum containers separately according to the species and brought back for laboratory analysis. The samples were immediately kept in a freezer at -20°C if analysis was not done immediately. Plant leaves samples were collected once in 2 weeks for 6 months from June 2010 to December 2010 by random selection.

LABORATORY ANALYSIS

The method use for sample extraction in this study is a typical ultrasonic extraction method (Ratola et al. 2006) with some modifications. The air filter/5 g wet weight of plant leaves sample were extracted three times using ultrasonic agitation for a 15-min period each with 150 ml of dichloromethane.

1 mL dried extract dissolved in dichloromethane and applied to the top of a 20 cm column with 1 cm I.D prepared by adding 5 g activated silica gel (slurry packed with n-hexane) followed by 10 g activated aluminum oxide (dry packed). The extract was fractionate using eluent with increasing polarity and collected in different round bottom flask. The alkanes were collected in the first fraction (20 mL of n-hexane), the alkenes and polycyclic aromatic hydrocarbons (PAHs) were eluted in the second fraction (30 mL of 10% dichloromethane in n-hexane; 20 mL of 50% n-hexane in dichloromethane) and the polar compounds were obtained in the third fraction (40mL 10% methanol in dichloromethane)

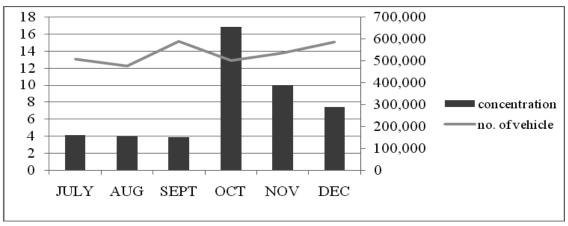
Fraction I, II and III of sample were analyzed by gas chromatography – mass spectrometry (GCMS) method. Compound identification was based on GCMS data. Quantification was made by comparing the retention time of each sample to the retention time of the external standard.

Spearman's rank correlation test were carried out using SPSS 17.0 software to determine the correlation of concentration of PAHs in air particulate and plant leaves sample.

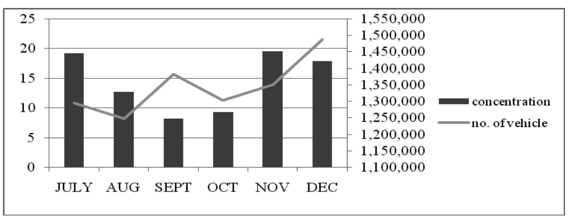
RESULTS & DISCUSSION

Seven PAHs were identified and quantified in this study. Those PAHs were acenaphtylene (ACN), phenanthrene (PHE), fluorene (FL), pyrene (PY), chrysene (CHR). Benzo[a]anthracene (BaA), and benzo[a]pyrene (BaP). Among the seven PAHs, three are of the 3-rings PAHs, namely CAN, PHE and FL, two are 4-rings, CHR and BaA while BaP is the only 5-rings PAHs detected from all three sampling station.

The distribution of PAHs collected throughout all three sampling stations shows similarity of compounds detected only in different concentration. There are presence of PAHs of car exhaust characteristics such as PHE, FL, PY and BaP while PHE, FL and PY are characteristic of diesel vehicle exhausts (Andreou and Rapsomanikis 2009; Dejean et al. 2008) showing that most of the PAHs found originated from exhaust emission. Figure 2 shows the comparison of total concentration of PAHs with utilisation from Ayer Hitam toll station, Skudai toll station and Tangkak toll station. From the 3 stations, Skudai station recorded the highest concentration reading of PAHs. This is expected because Skudai toll station is the station with the highest utilization.



a)



b)

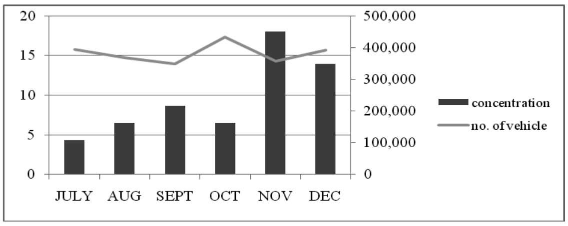
c) 

FIGURE 2. Comparison of total concentration of PAHs with utilisation from: a) Ayer Hitam toll station, b) Skudai toll station and c)Tangkak toll station.

Based on the Spearman's rho for correlation between air sample and plant leaves sample from the same sampling site as shown in table 3, there exist medium significance of correlation at the 0.05 level (2-tailed) in sample of *Baphia nitida*, *Bougainvillea* sp., *Codiaeum* sp., *Ficus microcarpa*, *Hibiscus* sp., *Ixora coccinea* and *Ixora taiwanensis*. *Ficus microcarpa*, *Codiaeum* sp., *Hibiscus* sp., and *Ixora coccinea* have the highest correlation coefficient and significant at the 0.05 level (2-tailed).

TABLE 3. Spearman's rho for correlation between air sample and plant leaves sample from the same sampling site

	Ayer Hitam	Skudai	Tangkak
Baphia nitida	0.538*		
Bougainvillea sp.	0.522*	0.462	0.538*
Codiaeum sp.	0.524*		0.643*
Ficus microcarpa	0.497	0.531*	0.622*
Heliconia sp.		0.224	
Hibiscus sp.			0.680*
Ixora coccinea	0.608*	0.490	0.427
Ixora taiwanensis		0.238	0.517*

*. Correlation is significant at the 0.05 level (2-tailed).

The use of plant leaves samples provides an easier and cheaper option to indicate the level of air pollution compared to performing direct ambient air measurements. Accumulation of PAHs in vegetation depends on the properties of the particular PAH as well as on the properties of the accumulating surface. Leaf characteristics such as leaf size, leaf surface, waxes, hairs and number of stomata play an important role in PAH uptake and accumulation (Prajapati and Tripathi 2007).These plants are perfect to reflect the local conditions of the environment because they are immobile, more sensitive in terms of physiological reactions to air pollutants and the abundant of presence in the locality

Plants acting as bioremediator or phytoremediation is an advantage where plants can be planted to provide in situ cleaning of polluted environment if the right condition can be created or the most suitable species can be chosen to be planted at polluted area to reduce if not totally remove the pollutant in the environment. Apart from providing relatively easy method to clean the atmosphere, phytoremediation is also a low-tech and low-cost method and feasible for low to medium amounts of pollution.

CONCLUSION

From the findings of this research, removal of organic pollutants from the environment by using plants is a feasible way of biomonitoring. *Ficus microcarpa*, *Codiaeum* sp., *Hibiscus* sp., and *Ixora coccinea* are the species with most potential for biomonitoring and to be introduced as a medium for bioremediation. This provides a safer and better option for environmental management in pursuing a healthier and better environment to live in. However, the medium significance of correlation shows that this method might only be feasible for low and medium level pollution.

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REFERENCES

Andreou G. and Rapsomanikis S. 2009. Polycyclic aromatic hydrocarbons and their oxygenated derivatives in the urban atmosphere of Athens. *Journal of Hazardous Materials* 172(1): 363-373.

Dejean S. et al. 2008. Polycyclic aromatic hydrocarbons (PAHs) in atmospheric urban area: monitoring on various types of sites. *Environmental Monitoring and Assessment* 148(1-4): 27-37.

Harayama, S. 1997. Polycyclic aromatic hydrocarbon bioremediation design. *Current Opinion in Biotechnology* 8: 268-273.

Haritash A. K. and Kaushik C. P. 2009. Biodegradation aspects of polycyclic aromatic hydrocarbons (PAHs): A Review. *Journal of Hazardous Materials* 16: 1-5.

Nicola, F. D. et al. 2008. Leaf accumulation of trace elements and polycyclic aromatic hydrocarbons (PAH) in Quercus ilex L. *Environmental Pollution* 153(2): 376-383.

Omar, N. Y. 2001. Characteristization of solvent – extractable hydrocarbons from airborne particulate and street dust of Kuala Lumpur. Universiti Malaya: Masters Dissertation. Unpublished.

Paterson, S. et al. 1994. A model of organic chemical uptake by plants from soil and atmosphere. *Environmental Science and Technology* 28(13): 2259-2266.

Prajapati, S. K. and Tripathi, B. D. 2007. Biomonitoring seasonal variation of urban air polycyclic aromatic hydrocarbons (PAHs) using Ficus bengalensis leaves. *Environmental Pollution* 151(3): 543-548.

Ratola N. et al. 2006. Analysis of polycyclic aromatic hydrocarbons in pine needles by gas chromatography – mass spectrometry Comparison of different extraction and clean-up procedures. *Journal of Chromatography A* 1114: 198-204.

Simonich, S. L. and R. A. 1995. Hites. Organic pollutant accumulation in vegetation. *Environmental Science & Technology* 29(12): 2905-2914.

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