
**UNIVERSITI PUTRA MALAYSIA**

***SPATIAL DISTRIBUTION AND SOURCE APPORTIONMENT OF AIR POLLUTION IN MALAYSIA THROUGH ENVIRONMETRIC TECHNIQUES***

**DOREENA ANAK DOMINICK**

**FPAS 2013 8**

# SPATIAL DISTRIBUTION AND SOURCE APPORTIONMENT OF AIR POLLUTION IN MALAYSIA THROUGH ENVIRONMETRIC TECHNIQUES

**By**

**DOREENA ANAK DOMINICK**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science**

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Master of Science

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**June 2013**

**Chairman: Hafizan Juahir, PhD**

**Faculty: Environmental Studies**

This research involves the analyses of secondary air quality data collected at twelve monitoring stations in Malaysia between 2001 and 2009. Several environmetric techniques were applied on this nine-year daily average database. The environmetric techniques incorporated discriminant analysis (DA) to investigate the significant discriminating air quality variables, hierarchical agglomerative cluster analysis (HACA) to access the spatial air quality patterns and principal component analysis (PCA) to determine the probable sources of air pollutants. The artificial neural network (ANN) analysis used to determine the air quality model structure as well as the most significant variable that influenced the Air Pollutant Index (API). A combined receptor model (PCA/MLR) was then used is to assess the source apportionment of the significant variables. The DA computed nine significant variables to discriminate the five levels of air quality. HACA grouped the twelve air monitoring stations into three different clusters. The PCA results showed that the

probable sources of air pollution within the study areas were combustion of fuels in all modes of transportation, offshore oil installation, agriculture operations, combustion of wood and industrial activities. For the overall air quality spatial assessment, ANN produced the best fit model with high $R^2$ values ($0.803 \leq R^2 \leq 0.807$, $p<0.05$). It also revealed that more than 80% of the air quality variability is explained by the nine significant variables (CO, $O_3$, $PM_{10}$, $NO_2$, $SO_2$, temperature, humidity and wind speed). Further, the ANN analysis showed that among the nine significant variables, $PM_{10}$ was the most important variable that influenced the API value variation. In addition, the combined receptor model (PCA/MLR) showed that in all three clusters, more than 70% of the API values were influenced by ozone, $O_3$ (secondary gas pollutant) and particulate matter with diameter of less than 10 micrometers, $PM_{10}$ (non-gas air pollutants). The research verifies that environmetric techniques are highly viable and effective for analyzing large amounts of complex data to glean vital knowledge about air quality, especially the behavior characteristics of specific air pollutants and air pollution patterns. This knowledge can be employed as decision tools for policy makers in planning for more effective air quality monitoring programs.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai keperluan untuk ijazah Master Sains

# TABURAN SPATIAL DAN PEMBAHAGIAN SUMBER PENCEMARAN UDARA DI MALAYSIA MELALUI TEKNIK ENVIRONMETRIK

Oleh

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**Jun 2013**

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Kajian ini telah menganalisis data sekunder kualiti udara yang diperolehi dari dua belas stesen pemantauan kualiti udara di Malaysia di antara tahun 2001 hingga 2009. Beberapa teknik environmetrik telah diaplikasikan ke atas data purata harian untuk sembilan tahun tersebut. Teknik environmetrik termasuklah analisis diskriminan (AD) yang bertujuan untuk menentukan pembolehubah yang signifikan, hirarki algorithma analisis klaster (HAAK) untuk mengkaji corak spatial kualiti udara dan analisis komponen utama (AKU) untuk menentukan sumber serta punca yang berpotensi tinggi dalam menyumbang kepada pencemaran udara. Rangkaian neural buatan (RNB) telah dijalankan untuk menentukan struktur model yang terbaik serta penbolehubah yang paling mempengaruhi Indeks Pencemaran Udara (IPU). Gabungan model reseptor (AKU/RLB) kemudiannya digunakan untuk menentukan peratusan pembahagian sumber bahan pencemaran udara di 12 stesen pemantauan kualiti udara di Malaysia. Analsisi AD dalam kajian ini menunjukkan bahawa

semua sembilan pembolehubah yang digunakan di dalam kajian ini adalah pembolehubah yang signifikan dalam usaha untuk mendiskriminasikan lima tahap status kualiti udara di Malaysia. Berdasarkan sembilan pembolehubah yang signifikan, HAAK telah membentuk tiga kelompok yang berbeza di antara satu sama lain. Keputusan AKU telah menunjukkan bahawa sumber yang menyumbang kepada kebarangkalian yang tinggi dalam pencemaran udara di kawasan kajian ialah pembakaran bahan api daripada semua jenis kenderaan bermotor, pelantar minyak di pesisiran, sektor pertanian, pembakaran kayu dan aktiviti perindustrian. Bagi penilaian spatial untuk keseluruhan kualiti udara, analisis RNB telah menghasilkan struktur model yang terbaik dengan nilai $R^2$ yang tinggi ($0.803 \leq R^2 \leq 0.807$, $p < 0.05$). Ianya juga menjelaskan bahawa lebih daripada 80% daripada nilai kebolehubahan IPU telah dipengaruhi oleh sembilan pembolehubah yang penting (CO, $O_3$, $PM_{10}$, $NO_2$, $SO_2$, suhu, kelembapan dan kelajuan angin). Di samping itu, analisis RNB juga menunjukkan bahawa di antara sembilan pembolehubah yang signifikan, zarah-zarah halus dengan diameter kurang daripada 10 mikrometer ($PM_{10}$) merupakan pembolehubah yang paling penting yang mempengaruhi perubahan nilai IPU. Seterusnya, gabungan model reseptor AKU/RLB menunjukkan bahawa dalam ketiga-tiga klaster, lebih daripada 70% nilai IPU dipengaruhi oleh ozon, $O_3$ (bahan pencemaran udara sekunder dalam bentuk gas) dan zarah-zarah halus, $PM_{10}$ (bahan pencemaran udara dalam bentuk bukan gas).

Hasil analisis daripada penyelidikan ini telah mengesahkan bahawa teknik environmetrik merupakan teknik yang berteknologi tinggi dan sangat berkesan untuk menganalisis data yang kompleks dan besar. Ianya juga dapat memberi pengetahuan yang terperinci dan berguna tentang kualiti udara terutamanya ciri-ciri tingka laku

bahan pencemaran udara serta corak spatial pencemaran udara. Pengetahuan ini boleh diguna sebagai penanda aras dalam program pemantauan kualiti udara.

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I certify that a Thesis Examination Committee has met on 21 June 2013 to conduct the final examination of Doreena Dominick on her thesis entitled "Spatial Distribution and Source Apportionment of Air Pollution in Malaysia through Environmetric Techniques" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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## DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institutions.

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**DOREENA ANAK DOMINICK**

**Date:** 21 June 2013

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