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DAILY CYCLES OF SUSPENDED PARTICULATE AIR POLLUTION IN THE KELANG VALLEY REGION, PENINSULAR MALAYSIA

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Sinopsis

Kertas ini mengemukakan hasil kajian mengenai variasi pola pencemaran partikel ampaian di empat buah stesen di kawasan bandar, Wilayah Lembah Kelang. Hasil kajian menunjukkan bahawa meskipun kemuncak paras pencemaran pada waktu pagi dan petang itu agak jelas kelihatan bagi stesen-stesen yang jauh dari jalan raya yang sesak dengan kenderaan, dan didapati serupa dengan yang diperhatikan di negara-negara garisan lintang pertengahan, tetapi bagi stesen-stesen yang terletak di pusat bandar dan berhampiran dengan jalan raya yang sesak, bilangan kemuncaknya adalah lebih daripada dua. Pola ini tidak dapat dijelaskan semata-mata berasaskan kepada mekanisma fumigasi sahaja. Penulis menyarankan bahawa di kawasan pusat bandar pengaruh lalu lintas adalah penting selain daripada pengaruh fumigasi itu.

Synopsis

The paper describes variation patterns in the daily cycle of airborne paticulate pollution at four locations in the urban areas of the Kelang Valley Region. The results indicate that while the morning and evening peaks were clearly evident for stations away from major thoroughfares and compares favourably with findings from the mid-latitudes, stations located by busy streets in the downtown area appeared to be characterized by more than two peaks. Such pattern cannot satisfactorily be attributed to fumigation mechanism alone. Variation in emission due to traffic flow is thought to have played a more dominant role in contributing to such patterns.

Introduction

In an urban area, ground level concentrations of pollution show well-marked mean daily and seasonal patterns. Several authors (e.g. Munn & Katz, 1959; Summers, 1966; Munn, 1973) have attributed such variations to cycles of weather or emissions, or to a combinations of both. Neglecting photochemical type of pollution, there are usually evident a strong early morning and a secondary evening surpluses in concentrations. For mid-latitude locations such patterns appear to vary according to seasons of the year (Munn & Katz, 1959, p. 66). Very few such studies, however, are available for the lowlatitude tropics. In view of the differences in meteorological conditions operating in both these areas, a similar study which is relevant to air quality management strategy will be useful.

The present paper which forms part of an ongoing study reports examples of a series of observations of daily cycles of suspended particulate air pollution taken during September 1980 – August 1981 for four locations in the Kelang Valley Region, Peninsular Malaysia (Figure 1). It attempts to describe the variation patterns and speculate on the probable causes of such patterns. However, as the number of days of hourly observation is at present still limited (13 days altogether), no meaningful statistical analysis is as yet possible. For the purpose of this note, only selected examples are given. A more comprehensive report on the subjet must await for more data covering not only days with different emission conditions but also those with different meso-scale weather situations. The main purpose of this brief note is to draw attention to some of the preliminary findings and their likely relationship with traffic flow and the much-discussed urban heat island dynamics (Oke, 1979; Chandler, 1961, 1962, 1965; Sham, 1973 & 1979). It is hoped that this brief paper will promote the publication of data on the subject from other urban areas in the tropics.

Instrumentation and Method of Data Collection

Suspended particulate concentrations in the present study were measured using digital dust indicator Model P – 5 manufactured by Sibata Manufacturing Company, Tokyo. This is a portable instrument operated by dry batteries. It provides immediate indication of airborne particulate concentrations in the range from 1 to 10,000 ug/m^3. Light scattered by the particulate as it aspirates past a fixed intensity light beam is measured by a photomultiplier tube yielding a count rate directly proportional to dust concentration. Factory calibration of the P – 5 Model is performed using a stearic acid aerosol with a mean particulate size of 0.3 um and geometric standard deviation of 1.25. A calibration card is provided with the instrument to enable estimation of airborne particulate concentration in ug/m^3 of air from the number of count per minute (cpm) measured. Accuracy of reading is estimated to be in the region of $\pm$ 10%.

Records of particulate levels were taken hourly at four locations with varied site characteristics (Figure 1). Stations 1 and 2 were in the commercial area of Kuala Lumpur; one was by the Jalan Pekeliling Flat and the other was at the intersection of Jalan Tuanku Abdul Rahman and Jalan Tun Perak. The monitoring site in station 1 was close to a busy round-about which received traffics from two major thoroughfares: Jalan Pahang and Jalan Pekeliling. The Jalan Tuanku

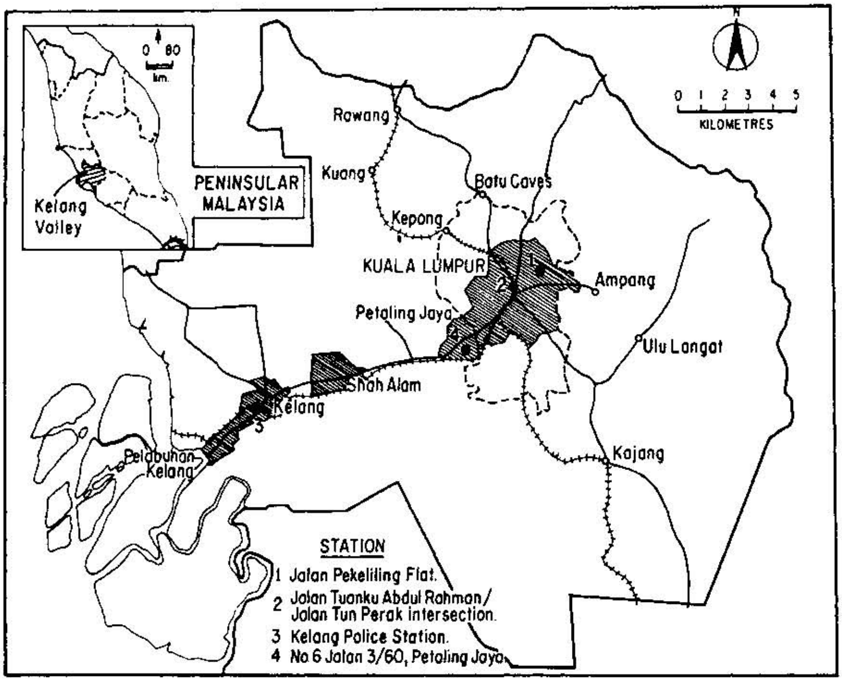

Figure 1
The Kelang Valley Region Showing Sampling Stations Used in the Study

Abdul Rahman — Jalan Tun Perak intersection (station 2) was in the midst of one of the most popular shopping areas of Kuala Lumpur and both roads were among the busiest in the city especially during working hours. The roads were relatively less congested late in the evening as shops along Jalan Tuanku Abdul Rahman were normally closed by 7 p.m. Station 3 was in the compound of the Kelang Police Station. It was somewhat away from the busy streets and thus unaffected by direct vehicular emissions. It was nevertheless still very much in the commercial centre of Kelang Town. Station 4 was sited in a residential area of Petaling Jaya surrounded by plenty of mature trees and away from major thoroughfares. It was outside th commercial area proper.

Examples of Results and Discussion

Figure 2a – 2d shows respectively the examples of hourly variation of particulate levels for stations 1, 2, 3 and 4 taken during 18.9.80/19.9.80 (for stations 1, 2 and 4) and 6.8.81/7.8.81 (for station 3). Detailed meteorological condition for each specific station was not available. However, an indication of the meso-scale weather situation in the Kelang Valley Region during the observation period as recorded at Subang Airport is given in Table 1. Except for some light

Table 1
Meteorological condition as recorded at Subang Aiport
During the Observation Period

Weather Elements	Observation Period			
	18.9.80	19.9.80	6.8.81	8.8.81
Mean temperature	26.3°C	26.5°C	27.6°C	26.8°C
Relative humidity	87.8%	84.9%	72.0%	78.0%
Mean amount of cloud	89.0%	90.0%	84.0%	84.0%
Sushine duration	4.5 hrs	1.1 hrs	8.3 hrs	3.5 hrs
Rainfall	7.3 mm	Trace	Nil	Nil
Wind speed	1.3 ms^{-1}	0.8 ms^{-1}	1.9 ms^{-1}	1.7 ms^{-1}
Wind directions	W	SW	S	SE

Source: Malaysian Meteorological Service.

rain between 11 – 12 midnight on 18.9.80, the observation period was dry with mean temperatures ranging from 26.3°C – 27.6°C. Wind was generally light with mean speed ranging between 1 – 2 ms^{-1}. Figure 2 indicates that in all the four cases, the early morning peak in concentrations was well-marked. Contrary to observations made in the mid-latitude areas, however, the morning peak was not necessarily the stronger of the two surpluses. Although stations 2 and 4 were observed to have higher peaks in the mornings, such ocurrences were not evident in stations 1 and 3. In the latter cases, the morning peaks were lower by 19 and 45 ug/m^3 respectively.

The patterns for the evening peaks were less clear. It was observed that in certain stations, there was more than one peak. Station 1 which was right at the intersection of some very busy thoroughfares in the City shows three very distinct pekas; one in the morning (about 8 a.m.),[1] one in the evening (about 5 p.m.) and another in the afternoon between about 1 – 2 p.m. A somewhat similar pattern was

[1]All times quoted in the paper refer to local times. Official time is half an hour ahead of local time.

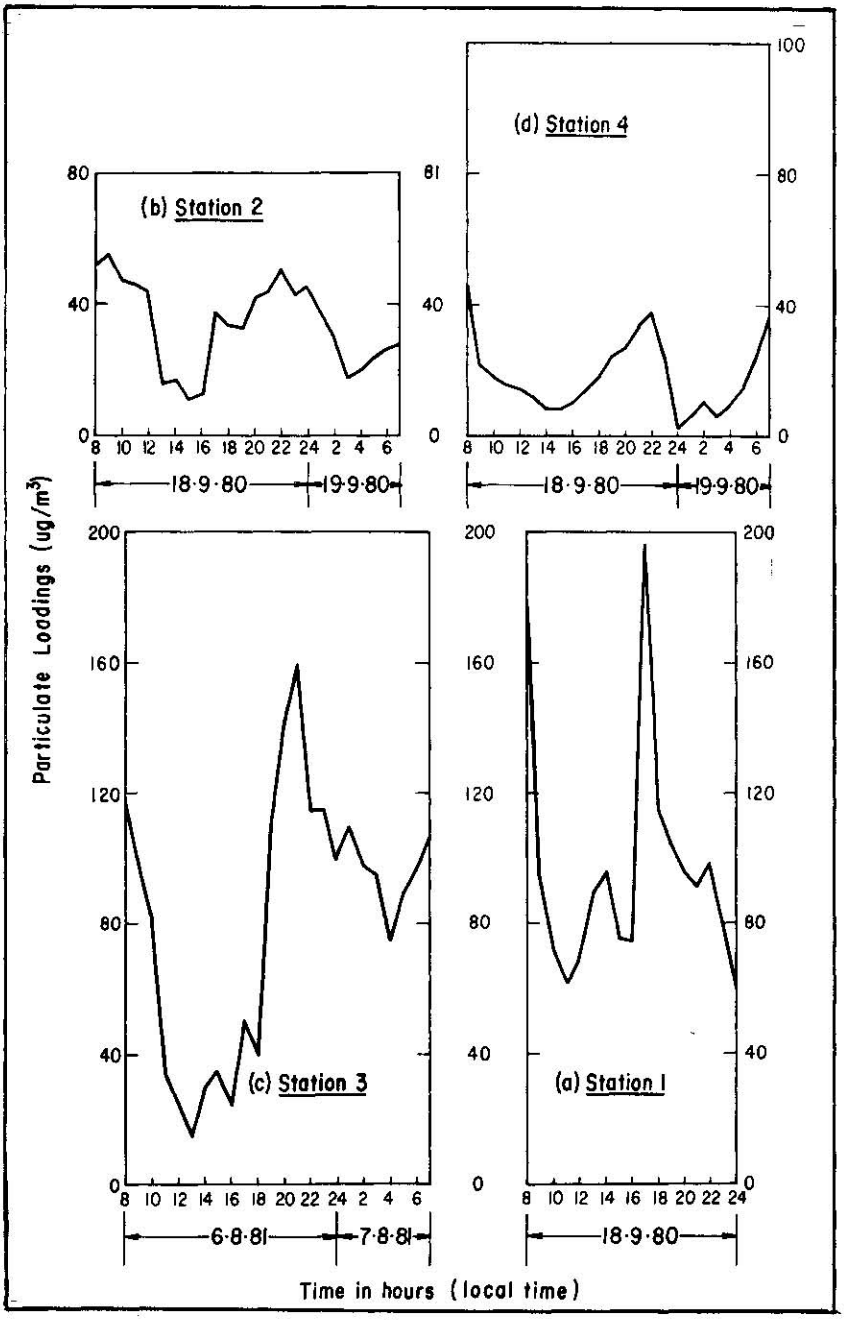

Figure 2
Hourly Levels of Particulate Loadings at Four Locations in the Kelang Valley

observed at station 2. Three distinct peaks were evident; one in the moring (8 – 9 a.m.), one in the evening (about 10 p.m.) and another in the early evening about 5 p.m. to coincide with the traffic rush hour. Indeed, Jalan Pekeliling next to the Municipal Flat has always been known for its massive traffic jam especially during rush hours. Unlike stations 1 and 2, stations 3 and 4 were away from busy thoroughfares and the direct influence from vehicular congestion. For these latter stations, the two-peak pattern as observed in the mid-latitude studies was more evident although the evening surplus was not necessarily the secondary peak. For station 3 for example, the evening peak was higher by 45 ug/m^3 compared with the morning surplus.

To date there has been no satisfactory theory which is able to explain the variation patterns observed in the daily cycle of pollution in urban areas. Several authors (e.g. Munn & Katz, 1959, p. 74) have attributed such peaks to fumigation mechanism which operates both in the morning and late evening. In the latter case, its occurrence has in some way, been associated with the heat island whose thermal influence can extend up to 200 – 300 meters or even more. Summers (1964) suggested that this increased mixing would result in an adiabatic layer over the city with the boundary layer height increasing with height downwind of the urban/rural leading edge as a response to the urban heat island (Figure 3). Such a situation creates a fumigation mechanism in which there is eddy activity near the ground with stable air aloft.

In the morning after sunrise, the cool air near the ground is warmed and an adiabatic or super-adiabatic lapse rate develops. The night time stable air is thus eroded from below by convective mixing. As this process continues, pollutants which may have collected aloft during the night are brought rapidly downward to the surface resulting in momentarily high concentration round about 7 – 9 a.m. Eventually, the stable air is completely replaced by a well-mixed surface layer, which prevails near sunset when the night-time stability begins to develop again.

In the present study, such explanation at best accounts for only part of the pattern of daily cycle of pollution. Although the effect from Hewson fumigation appears to be more definite in the case of morning peak, the evening surpluses cannot be fully explained by the fumigation mechanism of Summer alone. Such mechanism, for example, cannot satisfactorily explain the occurrence of the third peak observed in stations 1 and 2. In this connection, the author is of the opinion that both weather and emission are important factors in accounting

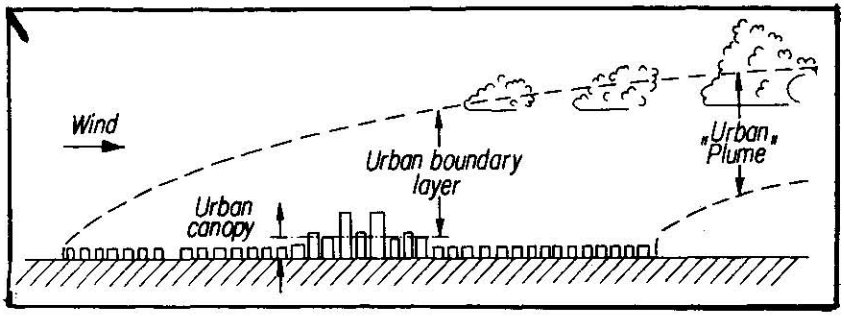

Figure 3
Schematic Representation of the Form of Air Layer Modified by a City with Steady Regional Airflow

for the daily cycle of pollution especially those in downtown Kuala Lumpur. It is felt that while the late evening peak (about 8 – 11 p.m.) may possibly be attributed to fumigation mechanism as suggested by Summers, the transitional peak which occurred at 1 p.m. for station 1 and 5 p.m. for station 2 will have to be attributed to increased emission due to increased traffic flow. It is interesting to note also that as the measurements in stations 1 and 2 were carried out at a street side and the major contributing sources were vehicular traffic, the short distance and time lapse between the source and receptor could not have allowed the meteorological condition to be a dominant factor in the dispersion of pollutants especially during rush hours. However, on the same token, it is equally incorrect to suggest that meteorological condition is unimportant or influences pollution dispersion only when the relative distance between the source and the receptor is considerable. The secondary peak in Station 2, for example, occurred about 10 p.m. (Figure 2b) when traffic volume was a great deal less.

Conclusion

Studies from mid-latitude areas show well-marked patterns in the daily cycle of airbone particulate pollution in urban areas. There are usually evident a strong early morning peak and a secondary peak in concentrations. Several authors have attributed such patterns to fumigation mechanism and the heat island effect. In the present study, more than two peaks were observed for two of the four stations. It was noted that while the two-peak pattern was more characteristic of stations which were away from busy thoroughfares, those located close to busy streets had more than two surpluses. Such pattern cannot satisfactorily be attributed to fumigation mechanism alone. Variation in pollutant emission due to traffic flow appears to have played a more dominant role in contributing to such patterns.

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