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Urbanisation and Air Quality in Malaysia

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ABSTRACT

The growth of urbanisation has had a significant impact on air quality in Malaysia particularly in the Federal Capital, Kuala Lumpur, and the Klang Valley conurbation. While the levels of air pollution are still relatively low when compared to those of some large world cities, these have already exceeded the WHO standards and the Malaysian Guideline recommended levels. There are legislation and other mitigating measures available but these have not been sufficiently effective to contain the problem. A comprehensive approach to include more stringent enforcement of existing legislation, higher penalties for non-compliance, public awareness and environmental education is needed in order to ensure an acceptable level of air quality in urban areas. In view of the multi-functional nature of trees, a National Urban Forestry Policy has been proposed. This will provide a useful framework to enhance tree planting efforts throughout all urban areas in the country which will help moderate both air pollution and excessive heat island formation.

ABSTRAK

Pertumbuhan bandar mempunyai impak penting terhadap kualiti udara di Malaysia terutama di ibu negara Kuala Lumpur dan Lembah Klang. Walaupun paras pencemaran udara masih relatif rendah berbanding dengan bandar-bandar raya lain di dunia, namun ini telah pun jauh melebihi piawai Pertubuhan Kesihatan Sedunia (WHO) dan paras panduan yang dicadangkan bagi Malaysia. Undang-undang dan langkah-langkah kawalan tidak cukup berkesan untuk membendung masalah ini. Suatu pendekatan yang lebih menyeluruh melibatkan penguatkuasaan undang-undang yang lebih ketat, denda yang lebih tinggi, kesedaran awam dan pendidikan alam sekitar diperlukan bagi mempastikan paras kualiti udara yang boleh diterima di kawasan bandar. Berdasarkan kepada fungsi pokok yang berbagai-bagai, suatu Polisi Perhutanan Bandar Kebangsaan dicadangkan. Ini akan bertindak sebagai suatu rangka bagi menggalakkan penanaman pokok di kesemua kawasan bandar dan membantu menyederhanakan pencemaran udara dan pembentukan pulau haba.

INTRODUCTION

While urbanisation and all that it stands for has contributed greatly to economic growth and better standard of living, the manner and speed with which urban growth is taking place is causing a great deal of concern among planners, architects, social and environmental scientists and decisionmakers. The situation becomes more urgent in developing countries where the problem is compounded by rapid population growth, a lack of resources to cope with an increasing demand for facilities and the need for development. The central issue of concern is the sustainability of the urban systems both as suitable habitats for mankind and in terms of their ecological and environmental support systems. Evidence so far indicates that while some aspects of the environment have been enhanced and improved, the general state of the environment and quality of life for many parts of the city are deteriorating. This paper focuses on just one aspect of this deteriorating environment – air quality. It examines the growth and impact of urbanisation on air quality in Malaysia and discusses issues relating to its management and planning. Illustrations are drawn from Kuala Lumpur and the Klang Valley conurbation – the largest and most rapidly growing urban complex in the country.

URBAN GROWTH IN MALAYSIA

In Malaysia, urbanisation in the western sense evolved only relatively recently – around the second half of the 18th century – following the establishment of British interests first in the Straits of Melaka and later in the entire Malay Peninsular. Penang, Singapore and Melaka became the Straits Settlements in 1829 and continued to grow. Later, with the discovery of tin, more settlements were established including those in the Larut Valley and Kinta Valley of Perak and the Klang Valley of Selangor (Figure 1). With the development of rubber in the late 19th century, a number of new urban places were added to the existing settlements. Much of the development, however, was concentrated in the western belt of the Peninsular. Thus, by 1891 the four largest urban centres were Penang (pop.85,000), Kuala Lumpur (pop.19,000), Melaka (pop.16,500) and Taiping (pop.13,300). In the meantime, new growth centres continued to emerge including Alor Setar, Kota Bharu, Kuala Terengganu, Ipoh, Klang and Johor Bahru.

The Japanese Occupation during Second World War, dampened the growth of towns temporarily for a few years but soon recovered following the return of the British. This became more aggressive after Independence in 1957. Indeed, the number of settlements with 10,000 or more people during the 1911-70 period increased by more than six times – from 8 to 49 (Pryor

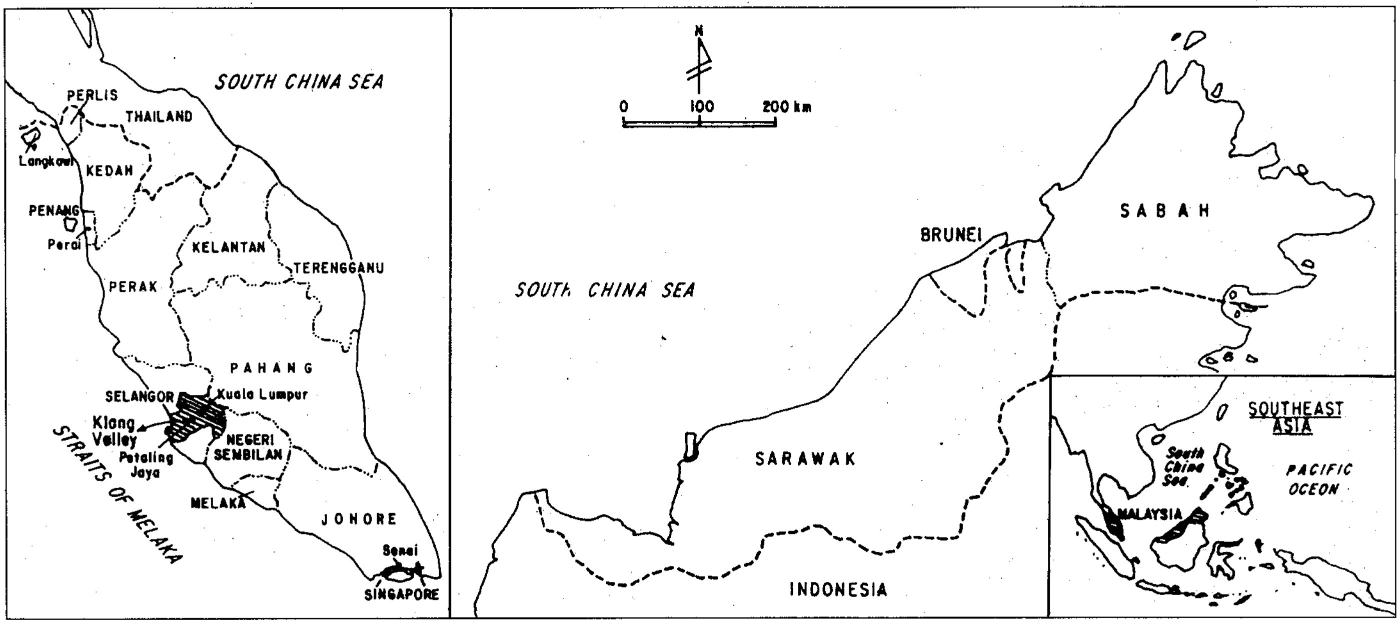

FIGURE 1. Malaysia showing place names mentioned in text

1973). By 1970, Kuala Lumpur, Georgetown and Ipoh occupied the three top positions in that order followed by Johor Bahru, Klang, Petaling Jaya, Melaka, Kota Bharu, Taiping, Kuala Terengganu, Teluk Anson (now Telok Intan) and Kuantan. However, as urban areas tended to expand beyond the official limits, comparison of populations between gazetted areas might not be very meaningful. A more useful exercise would be to compare the 1957 population in the gazetted areas to that of the urban conurbation in 1970, the urban conurbation being the gazetted area plus the continuous built-up area beyond the official boundary limit. On this basis, Pryor (1973) showed that Kuala Lumpur and Ipoh grew at a rate three times that of the total population of Peninsular Malaysia between 1957 and 1970.

Comparing the 1970 and 1980 census, we note that the number of urban places (> 10,000 people) for the whole country increased from 50 to 67 – an increase of about 34%. Changes in the number of urban areas with populations of 20,000 and 100,000 are shown in Table 1. It is noted that for Malaysia as a whole there was a 22% increase in the number of urban areas with a population of 20,000 and more over the 1970-80 period. The corresponding figure for urban places with population 100,000 and more was 120%. The number increased from 5 to 11. During the 1980-90 period, the growth of urbanisation continued; the percentage of people living in urban

TABLE 1. Changes in the number of urban areas with population 20,000 and more and those with 100,000 and more, 1970-80

State	Population 20,000 & more			Population 100,000 & more		
	1970	1980	change	1970	1980	change
Johor	4	7	3	1	1	0
Kedah	2	3	1	0	0	0
Kelantan	1	2	1	0	1	1
Melaka	1	1	0	0	0	0
N. Sembilan	1	2	1	0	1	1
Pahang	2	3	1	0	1	1
Penang	4	4	0	1	1	0
Perak	5	5	0	1	2	1
Perlis	0	0	0	0	0	0
Selangor	3	3	0	1	2	1
Terengganu	1	2	1	0	1	1
K. Lumpur	1	1	0	1	1	0
Sabah	3	3	0	0	0	0
Sarawak	3	3	0	0	0	0

Source: 1970 and 1980 Census

TABLE 2. Urban population as a percentage of total population in Malaysia, 1980-1990

	1980	1985	1990
Peninsular	37.5	41.1	44.7
Sabah	20.0	22.6	25.6
Sarawak	17.6	19.2	20.9
MALAYSIA	34.2	37.4	40.7

Source: Second Outline Perspective Plan, 1991: Sixth Malaysia Plan, 1991

areas increased from 34.2% in 1980 to 37.4% in 1985 and to 40.7% in 1990 (Table 2).

By the end of the Sixth Malaysia Plan (1991-95), some 45% of the population will live in urban areas. Rural-urban migration is expected to continue especially following increases in employment and income opportunities within the expanding industrial and service sectors. The greatest pressure is expected to be felt in the already existing urban areas including the state capitals.

Perhaps one of the most outstanding features of urbanisation and urban growth in Malaysia today is the dramatic growth and dominance of Kuala Lumpur, the Federal Capital, and the merging Klang Valley conurbation (Figure 2). In the mid-nineteenth century, Kuala Lumpur was merely a small trading post. Today, Kuala Lumpur with a population of about 1.2 million (Elyas 1988), is the largest urban centre in the country and is currently expanding as part of a merging conurbation in the Klang Valley. The latter stretches from Port Klang on the Straits of Melaka, in the west to the foothills of the Main Range in the east, a distance of approximately 48 km. The six major centres which combine to form the conurbation are Kuala Lumpur, Petaling Jaya, Subang Jaya, Shah Alam, Klang and Port Klang (Figure 2). As these centres expand to merge with one another, a similar linear expansion is developing to the north of Kuala Lumpur towards Rawang and to the south towards Serdang, Kajang, Bandar Baru Bangi and beyond to Seremban. The Kuala Lumpur-Seremban highway which has shortened travel-time from Seremban to Kuala Lumpur considerably is expected to facilitate the growth in this direction (Abdul Samad Hadi 1982).

During the period 1970-80, the population of the Valley grew slightly over 2.0 million at an average annual growth rate of 4.3%. On the basis of moderate growth, the population of the Valley is expected to reach 3-7 million by the end of 1990 and more than 80% of this will be in the new conurbation.

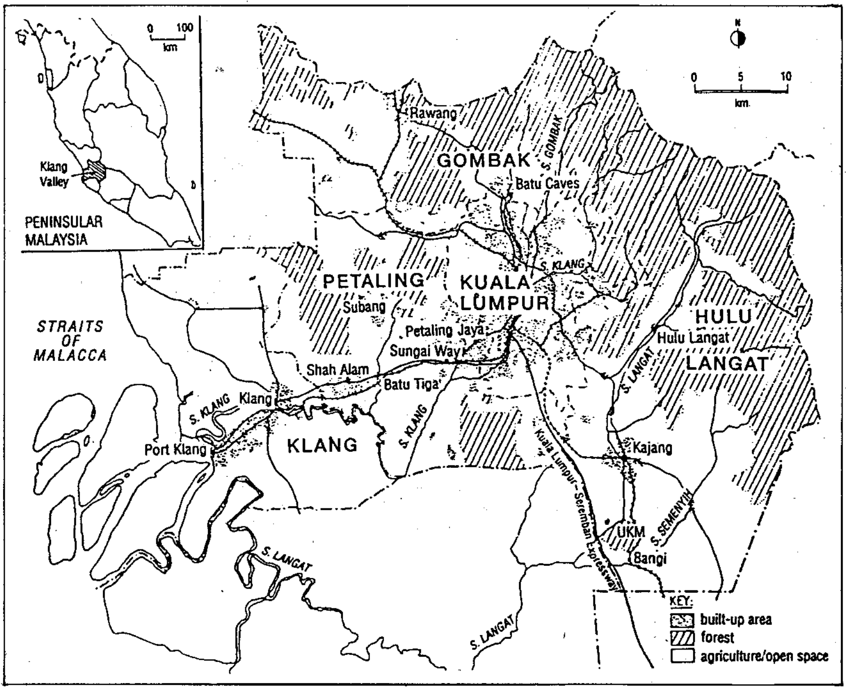

FIGURE 2. The Klang Valley

URBANISATION AND AIR QUALITY

As in other parts of the world, urban growth in Malaysia has led to a profound transformation of the environment including climate and air quality. In the city, the effects of the complex geometry of the urban surface, the shape and orientation of individual buildings and structures, the peculiar thermal and hydrological properties of the urban morphology, the heat from metabolism and various combustion processes, and the pollutants released into the city's atmosphere all combine to create a climate which is quite distinct from that of the rural surrounding. An indication of the extent of urban effects on climate in Malaysia is summarised in Table 3. For certain areas, such effects are further complicated by site and detailed topography. In Kuala Lumpur and the Klang Valley, for example, the proximity to the sea and the valley topography exert a considerable influence. Here, there is a reversal of windflow during the day and night (Sham 1981). At night, the windflow is from the easterly quarter, blowing from Kuala Lumpur-Petaling Jaya towards Shah Alam, Klang and Port Klang. During the day, the flow pattern is reversed; the wind blows from the sea inland. Such flow patterns

TABLE 3. Average changes in climatic elements caused by urbanisation on studies from Malaysia

Elements	Comparison with rural environment
Global radiation	Evidence of low values for urban location was unclear. Perhaps due to microclimatic factors of instrument sites.
Sunshine duration	9–10% less.
Temperatures	
Annual mean	1–2°C more.
Night-time	3–4°C more.
Wind speed	
With light wind (less than $1.5ms^{-1}$)	40–50% more.
With wind more than $1.5ms^{-1}$	9–10% less.
Precipitation	Slight increase in the downward areas but statistically not significant.
Relative humidity	
Annual	2–4% less.
Night-time	10–15% less.

Source: Sham, 1979a, 1980

are likely to cause much of the pollutants produced within the Valley to remain very much where they are especially when there is an inversion aloft (Sham et al. 1991). The valley topography encourages ground level inversion in the first half of the morning and, together with low speed, causes poor dispersion.

Probably the single most important aspect which has been extensively examined in the study of urban climate in Malaysia is the changing form and intensity of the heat island. Observations carried out over the last 15 years indicate that the buildup areas are usually several degrees warmer than the surrounding countryside (Sham 1973,1979a & b, 1989). This appears to be true even with relatively small urban centres (Table 4). Studies in the Klang Valley area show the following additional major points:

1. The heat island intensity for Kuala Lumpur appears to have slightly declined over the last 15 years and could well be attributed to the relatively aggressive tree planting programme of the City Hall.
2. The number of cooler days at Subang Airport for the period 1970-83 was greater than that of Petaling Jaya by about 64%.

TABLE 4. Maximum intensity of heat island for selected urban centres in Malaysia

Urban centres	Max. heat island (°C)	Source
Kuala Lumpur – Petaling Jaya	4	Sham (1973,1979a,1984)
Urban centres in the Klang Valley	2-5	Sham (1986a)
Georgetown	4	Lim (1980)
Johor Bahru	3	Zainab Siraj (1980)
Kota Kinabalu	3	Sham (1983)

3. The number of warmer days in Petaling Jaya was greater than that of the Airport by 113% for the same period.
4. The annual mean minimum temperatures for both Petaling Jaya and Subang Airport increased by 0.7°C and 0.9°C respectively for the same period.

The effects of urbanisation are not confined to horizontal temperatures alone, but are also felt in the vertical direction with far-reaching consequences. Overseas studies (Oke 1974,1979) have shown that the thermal influence of a large city commonly extends up to 200-300m and even to 500m and more. When the warm air is advected by the wind, an urban "plume" in the downward region is formed; in calm conditions, an urban "dome" may be created (Figure 3). Under the latter conditions at night, the city can even create its own circulation with wind blowing from the cooler surrounding area into the warm city centre bringing with it plume from the outskirts into the city area. In both cases, these modified air layers are invariably being capped by an elevated inversion inhibiting upward dispersion of pollutants. To a limited extent, this mid-latitude finding has been verified in the Klang Valley study using both observed and standard meteorological data (Sham 1980, 1986a & b).

The development of an "urban dome" and "urban plume" in a valley situation such as the Klang Valley or the Kinta Valley, can have a far-reaching effect not only on the urban centre(s) concerned but also on the immediate rural surroundings. Further, if the spacing between cities within the valley is insufficient, their alignment with the wind may cause a cumulative pollution build-up. In addition, as a result of the urban heat island effect, pollution sources located outside the urban limits may also contribute to poor air quality inside the city. This is best illustrated by Oke (1976) in Figure 4. Here, on entering the stable atmosphere, emissions from stack A are inhibited from spreading up or down so that the plume fans as a

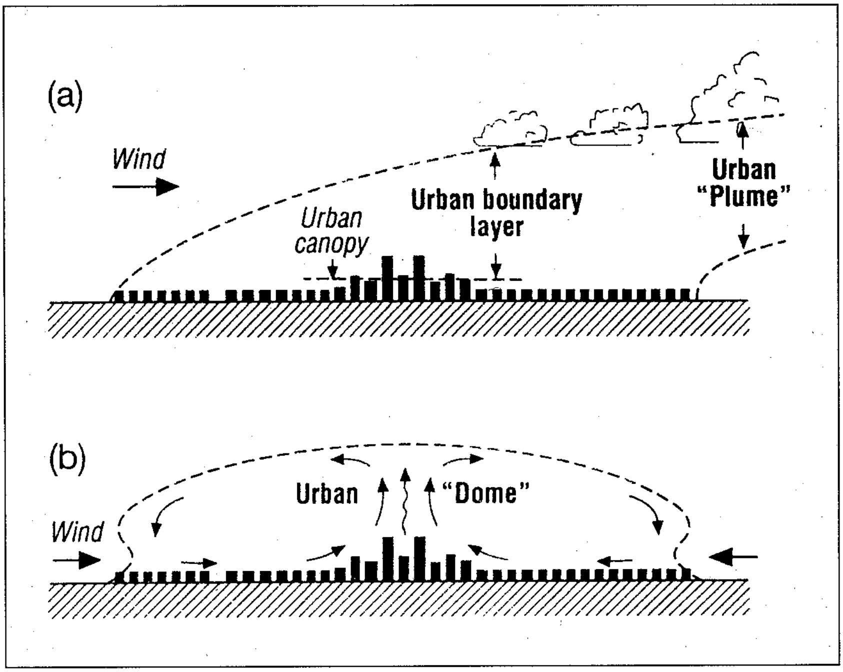

FIGURE 3. Schematic representation of the form of the air layer modified by a city (a) With steady regional air flow (b) In calm conditions (Oke, 1976)

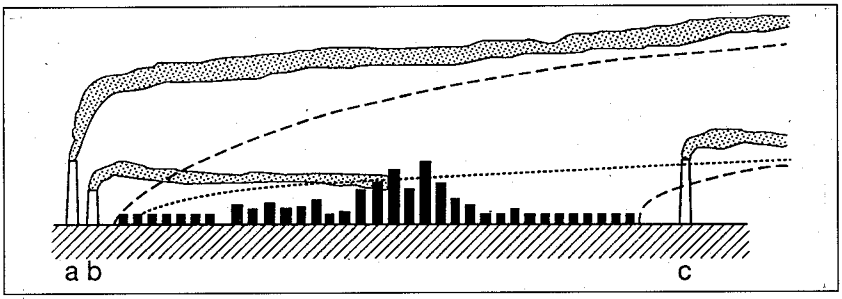

FIGURE 4. Interaction between plumes from rural pollution sources and the nocturnal urban boundary layer of a large city (*Oke*, 1976)

concentrated ribbon travelling with the mean wind. From the point of view of ground-based receptors, therefore, this type of plume is relatively non-hazardous. Pollutants emitted at a lower level, on the other hand, produce a plume which will initially fan but changes its character as soon as it enters the modified urban air (stack B). Here, the greater roughness and reduced stability in the urban atmosphere lead to greater turbulence. This provides a means of diffusing the plume contents, and in the lowest layer, where the heat island causes instability even at night, there is sufficient convective activity to transport it to the ground. Conversely, stack C in Figure 3 is downwind of the city and ideally placed to loft its effluents into the unstable plume. However, should regional winds become calm and a city wind system form, as is very often the case in low-latitude areas at night, both stacks B and C would contribute to pollution build-up inside the urban plume.

Apart from that, observations using radiosonde data from Subang Airport indicate that on average, mixing depths of 900m and less account for approximately 83% of the afternoon values while 87% of the morning mixing depths are less than 500m (Sham 1979a & b). About 90% of the morning ventilation volumes fall within or below 2,000m^3s^{-1} and 97% of the afternoon values belong to the category 6,000m^3s^{-1} and less. Indeed, 85% of the morning values fall within the category of 1,000m^3s^{-1} or less and 84% of those in the afternoon fall in the category 2,500m^3s^{-1} and less. The critical values used by the U S National Air Pollution Potential Forecasting Program (NAPPFP) to classify hazardous conditions are 2,000m^3s^{-1} for the morning and 6,000m^3s^{-1} for the afternoon. Using these as a basis of assessment, it becomes obvious that the situation of air pollution potential in the Klang Valley can be more serious than even those observed in some mid-latitude locations like Los Angeles which is known for its pollution. A recent study by a group from Universiti Pertanian Malaysia (UPM) using YAGI antennae and a SAR-4 receiver to receive signals from radiosonde confirms most of these observations (Azman 1988). The study by the UPM group indicates that the mixing depth is shallow at night and early morning ranging between near-zero to less than 100m and increases gradually reaching 1,000m during the afternoon with strong insolation.

Air quality monitoring results released by the DOE (1992) indicate that the annual concentration of total suspended particulate matter remained high in many of the trafficked and industrial areas for which monitoring stations were available (Tables 5 & 6). Indeed, all stations in trafficked areas showed an average reading far in excess of the Malaysian Recommended Guidelines. For industrial areas, 60% of the states monitored showed averages in excess of the Malaysian Recommended Guidelines. The industries in the state of Perak were the worst with 312 ug/m^3 followed by Kedah (177 ug/m^3), Pulau Pinang (157 ug/m^3), Selangor (145 ug/m^3), Negeri Sembilan (133 ug/m^3) and Johor (105 ug/m^3). For the commercial areas, 2/3 of the states monitored had averages equal to or in excess of the Malaysian Recommended Guidelines (Table 7). The Sate of Perak, the Kuala Lumpur Federal Territory, Johor and Pulau Pinang all had an average equal to or in excess of the Malaysian Recommended Guideline. For residential areas, the situation was comparatively better. With the exception of Selangor where the average

TABLE 5. Annual mean concentration of total suspended particulate (TSP) in trafficked areas, 1991#

State	Concentration (ug/m^3)
Kuala Lumpur, F.T. (Bangsar, Pudu and Science Centre)	202
Pulau Pinang (Butterworth)	167
Johor (Tampol, Johor Bahru)	146
Pahang (Kuantan)	125

The Malaysian Recommended Guideline is 90ug/m^3
Source: DOE, 1992

TABLE 6. Annual mean concentration of total suspended particulate (TSP) in industrial areas, 1991#

State	Concentration (ug/m^3)
Perak (Ipoh)	312
Kedah (Sg. Petani)	177
Pulau Pinang (Prai Ind. Est.)	157
Selangor (Petaling Jaya)	145
N. Sembilan (Senawang)	133
Johor (Johor Bahru, Pasir Gudang)	105
Melaka (Tangga Batu Ind. Est., Air Keroh)	77
Sarawak (Kuching)	77
Kelantan (Kota Bharu)	42

The Malaysian Recommended Guideline is 90ug/m^3
Source: DOE, 1992

TABLE 7. Annual mean concentration of total suspended particulate (TSP) in commercial areas, 1991#

State	Concentration (ug/m^3)
Perak (Ipoh)	160
Kuala Lumpur, F.T. (City Hall)	130
Johor (Johor Bahru)	107
Pulau Pinang (Georgetown)	90
Sarawak (Kuching)	79
Terengganu (Kuala Terengganu)	47

The Malaysian Recommended Guideline is 90ug/m^3
Source: DOE, 1992

TABLE 8. Annual mean concentration of total suspended particulate (TSP) in residential areas, 1991#

State	Concentration (ug/m^3)
Selangor (Shah Alam)	116
Pulau Pinang (Bt. Mertajam)	72
Sabah (Kota Kinabalu)	68
Kuala Lumpur, F.T. (U.o.Malaya)	61
Terengganu (Kuala Terengganu, Kemaman)	49

The Malaysian Recommended Guideline is 90ug/m^3
Source: DOE, 1992

reading was 116 ug/m^3. The measurements for the rest were below the Malaysian Recommended Guideline (Table 8).

Over the last ten years, Malaysia, particularly the Klang Valley region, has begun to experience yet another form of atmospheric pollution – the haze. Although haze occurrences were already realised as early as the 1960s, the haze became a problem only relatively recently. The September 1982 haze and that of August 1990 attracted a great deal of public attention, disrupted traffic and posed a health hazard. At its peak the August 1990 haze recorded suspended particulate levels exceeding 785 ug/m^3 (Sham et al. 1991). A similar episode but less dramatic, was also recorded between October 8-11, 1991 where the TSP level in Petaling Jaya was between 300-490 ug/m^3 compared to 90-150 ug/m^3 during the dry spells in August and early September although it may appear as late as early October. Generally, such an episode is closely associated with the intensification of the Southwest Monsoon (Sham et al. 1991).

The DOE Report (1992) indicates that the annual mean of lead levels in the atmosphere appeared to have improved over the last 4 years especially in trafficked and industrial areas (Table 9). This could largely be due to the enforcement of the *Control of Lead Concentration in Motor Gasoline Regulations 1985* which came into force on August 1, 1986. Through this regulation, the lead concentration in petrol was reduced from 0.45gml^{-1} to 0.15gml^{-1}. Indeed, today almost all gasoline companies have already embarked on the sale of unleaded petrol for some selected areas of the country.

Another environmental issue which has become increasingly more important in recent years is acid rain. Although the problem of acid rain is not as serious as in some countries in Europe and North America, it is nevertheless worsening steadily (Leong et al. 1988). Industrial areas of Prai, Petaling Jaya and Senai experienced low pH in Peninsular Malaysia during 1985-87 with annual average values as low as 4.40.

TABLE 9. Annual mean values of lead level by land use type, 1988-91

Land use	Annual mean values (ug/m^3)			
	1988	1989	1990	1991
Traffic	0.80	1.45	0.48	0.43
Industrial	0.14	0.23	0.89	0.09
Commercial	0.08	0.10	0.18	0.37
Residential	0.20	0.36	0.14	0.24

Source: DOE, 1992

Countrywide, some 911,000 tonnes of air pollution were discharged in 1991 (DOE 1992). Of this, about 70% came from mobile sources. Power generation contributed about 8%, industries 10% and open burning 10.5%. Domestic sources accounted for less than 1.0%. No emission estimate was available specifically for urban areas. But the Klang Valley Environmental Improvement Project (KVEIP) Report (1987) indicates that transport accounts for close to 79% of emissions with CO and SO_2 constituting the largest two pollutants – 65% and 15% respectively. Hydrocarbons, NOx and SPM each constitutes 13%, 5% and 2% respectively.

AIR QUALITY MANAGEMENT

Two specific sets of regulations made under the Environmental Quality Act (EQA) 1974 have been gazetted to control air pollution. These are (1) Motor Vehicle (Control of Smoke and Gas Emission) Rules 1977; and (2) Clean Air Regulations 1978. In addition, the recent Environmental Quality (Control of Lead Concentration in Motor Gasoline) Regulations 1985 is also of relevance to air pollution control management. The latter regulations restrict the import or manufacture of any motor gasoline which contains lead or lead compounds expressed as lead in excess of 0.40 gm/litre including the sale of motor gasoline at petrol stations. The regulations also prohibit, as of 1st January 1990, the import, manufacture and sale of motor gasoline containing lead or lead compounds in excess of 0.15 gm/litre.

Under the Motor Vehicle (Control of Smoke and Gas Emission) Rules 1977, it is an offence for motor vehicles to emit dark smoke in excess of 50 Hartridge units. This is especially relevant in the case of diesel-powered vehicles such as buses, trucks and taxis which operate in concentrated numbers in urban centers. The DOE is still working on standards for exhaust gas emissions appropriate for Malaysia.

The Clean Air Regulations 1978 provides for detailed specifications on waste burning, dark smoke emissions by factory chimneys, and the emissions of air impurities. With effect from October 1978, it was mandatory for new industrial and trade premises to ensure that smoke emissions were not darker than shade no.1 on the Ringelmann Chart for burning equipments using liquid fuel, and shade no.2 for those using solid fuel. For trade premises which were in operation before October 1978, the smoke emissions should not be darker than shade no.2 of the Ringelmann Chart with effect from March 1979. In cases where technological and economic considerations do not permit the installation of pollution control measures, the operators are allowed to apply to the Director General of Environment for licence to contravene specified acceptable conditions.

In line with the provisions of the Montreal Protocol and the series of meetings of the parties to the Protocol, two draft regulations to reduce and ultimately eliminate the use of CFCs and halons were also prepared — Draft Customs (Prohibition of Imports and Exports) (Montreal Protocol) (CFCs and Halon) Order and Draft Environmental Quality (Use of CFCs and other gases as Propellant and blowing agent). In addition, the regulations to control gaseous pollutants from motor vehicles are also being finalised.

Besides these specific regulations gazetted under the EQA 1974, there are several other legislation which are relevant to air quality but are being enforced separately by local governments and other government agencies. These legislation include the Local Government Act 1976, Town and Country Planning Act 1976, Municipal and Town Boards (Amendments) Act 1975, City of Kuala Lumpur (Planning) Act 1975 and the Streets, Drainage and Building Act 1974.

As a complementary strategy to minimise pollution, *Guidelines for the Siting and Zoning of Industries* were introduced (DOE 1982). The main feature of this strategy was the incorporation of the environmental component as an integral element in the medium term development planning process with a view to bring about an ecologically balanced relationship between development and environment. Another relevant guideline to control air pollution is the *Guidelines for the Disposal of Solid Wastes on Land.* This guideline specifies in detail the disposal site requirements and the procedure of solid wastes disposal on land. The Environmental Quality (Prescribed Activities) (EIA) Order 1987 was gazetted and enforced on April 1, 1988. In this integrated project planning approach, environmental considerations are incorporated into project planning and implementation via a mandatory requirement under Section 34A of the Environmental Quality (Amendment) Act 1985. This section requires anyone who intends to undertake a prescribed activity to first conduct a study to assess the likely environmental impact that will occur from the activity and the mitigating measures that need to be taken in order to overcome it. The Environmental Quality (Prescribed Activities)

(EIA) Order 1987 specified some 19 categories of activities requiring EIA reports prior to project approval for implementation. In 1991, at the request of the Housing Developers Association (HDA), an *Interim Guideline for the Controlled Burning of Felled Plant Material and Combustible Solid Wastes* from the housing industry in the Klang Valley was also prepared.

It will be observed that, with the exception of Environmental Quality (Prescribed Activities) (EIA) Order 1987, the Environmental Quality (Control of Lead Concentration in Motor Gasoline) Regulations 1985 and perhaps the two draft regulations on the control of CFCs and halons, the legislations are largely concerned with curative measures. In other words, it is accepted that air pollution is occurring and that the legislation is essentially to control such pollution. The Environmental Quality (Control of Lead Concentration in Motor Gasoline) Regulations 1985, although not completely effective initially are now showing positive results if the most recent DOE report is of any indication. The Environmental Quality (Prescribed Activities) (EIA) Order 1987, as the name suggests, refers largely to "prescribed activities". A number of potentially polluting activities in urban areas, however, are not included as "prescribed" in the terms of reference of the Environmental Quality (Prescribed Activities) (EIA) Order 1987. But generally even the EIAs have had many problems. An examination of the timing of report submission for the period 1988-91 suggests that only 2% of a total of 334 reports were submitted early, that is during the planning stage. The quality of many of the EIA reports was also questionable. The DOE (1992) identified five factors contributing to this weakness – lack of baseline data, failure to describe project concept, failure to predict impacts particularly in quantitative terms, lack of alternatives for siting, technology for production and pollution control, and lack of proposal for monitoring the predicted impacts. These weaknesses usually cause a delay in report processing especially when project proponents are given time to submit supplementary information. Obviously, there is an urgent need for an upgrading of the quality of EIA reports in the future. Based on the submissions for the period 1988-91, the average cost of preparing EIA reports as a percentage of total project costs range from 0.001% (for a recreation project) to 1.8% for a waste treatment and disposal project (DOE 1992: 130). Public participation in the EIA procedure has also been poor except for the much publicised proposal for developing Penang Hill. Even here, nearly 70% of the written comments was received after the closing date.

Apart from these specific problems, and as with all forms of legislation, the effectiveness of implementation is crucial. With all the constraints of funding and manpower availability, such efforts are limited. As of January 1991, the DOE staff comprised 490. Of this, only 183 or 37% are professionals or sub-professionals. Of the Department's total expenditure for 1991 of MR11.1 million, about 83% was for operating expenditure; only 17% was for development. Approximately 58% of the operating expenditure was for salary and related expenditure and 38.5% for services and supplies. In addition, and to make matters worse, the EQA 1974 allows for contravention licenses to be issued for cases of non-compliance. Table 10 shows the number of contravention licences (related to air quality) issued under section 22(1) of the EQA 1974 for the period 1988-91. These approvals were given in order to conduct open burning of wastes and to operate incinerators not of approved design.

TABLE 10. Contravention licences (related to air quality) issued under Section 22(1) of the EQA 1974, 1988-1991

Type of concentration	Year			
	1988	1989	1990	1991
Open burning of wastes	51	123	21	43
Operation of incinerator not of approved design	16	1	-	6
Emission of dark smoke	2	3	-	1
Emission of particulates	3	7	-	1
Others	2	2	-	1

Source: DOE, 1992

The quantum of fines for non-compliance was relatively small and non effective. This has led to an increase in the number of non-compliance. In 1991, fines collected from prosecution cases averaged about MR1900. Fines paid for compound cases averaged MR385. It is interesting to note that offences compounded under the Clean Air Regulations 1978 accounted for 92% of the total cases and 46% of these were for open burning of wastes (DOE 1992). Due to manpower shortage, the enforcement of Motor Vehicle (Control of Smoke and Gas Emission) Rules 1977 was also limited. The total number of vehicles stopped for inspection was less than one percent (0.9% in 1989, 0.8% in 1990 and 0.8% in 1991).

It will be obvious from the discussion that while legislation is helpful and necessary, on its own, it is not likely to solve air pollution problems in the future even if there is sufficient manpower. More preventive measures are needed to complement the existing legislation. One important policy consideration which is directly relevant to this issue is the need to increase the level of public awareness and commitment to environmental cause. At both the federal and state levels, efforts to educate the public and disseminate environmental information must be intensified. Since environmental education is basically aimed towards community action, efforts to reach the different target groups need to be varied involving not only governmental institutions, but also a wide variety of professional groups, the private sectors and the non-governmental organisations (NGOs).

In addition, and recognising that there is a significant impact of urbanisation upon air quality and realising the need to contain the negative side-effects of urbanisation on the atmospheric environment, it is imperative that climatic considerations be incorporated early in the planning stage. Such considerations need to take into account not only the existing atmospheric condition but also those which will enable planners to anticipate the kind of modifications that are likely to occur after urban development. In this regard, perhaps a number of observations made by local studies in the Klang Valley over the last 15 years may be useful.

PLANNING IMPLICATIONS OF RESEARCH RESULTS FROM LOCAL STUDIES

One aspect of air pollution climatology which has been researched locally is that of air pollution potential, that is the capability of the atmosphere to disperse pollutants (Sham 1979a). It was noted earlier that the situation of air pollution potential in the Klang Valley was more difficult than even that of Los Angeles, a city well-known for its air pollution. Given this situation, it is obviously unwise for Malaysia, and indeed for other low-latitude countries, to adopt emission standards which have been largely based on those designed specifically for mid-latitude regions. Some forms of modifications are needed to suit local conditions which should be based on local research. While there are still gaps in our present knowledge of local conditions, all available evidence suggests that emission standards to be adopted need to be more stringent than the existing ones in order to compensate for the high pollution potential.

It is also observed that despite the relatively heavy annual rainfall received in Malaysia, studies both at home and abroad are still inconclusive about the effectiveness of precipitation scavenging in cleansing the atmosphere. Studies carried out in the Kuala Lumpur-Petaling Jaya area so far, indicate that such effect is not likely to be completely helpful especially with small size particulates. Only a low negative correlation was obtained between pollution levels and rainfall (Sham 1979a). But even if the atmosphere is capable of being cleansed by rainfall, there is still the question of redelivery of particulates and other pollutants into the atmosphere both during and after the rain, thus negating any meaningful cleansing effect. Such occurrence was observed experimentally in Sandakan, a town in Sabah, Malaysia (Sham 1985). Indeed, the atmosphere tends to be relatively more stable and calm soon after rain thus inhibiting dispersion, while the reinjection process of pollutants continues.

While the effectiveness of precipitation scavenging as a cleansing agent is still uncertain, cities in the tropics receive abundant sunshine and this together with emissions of nitrogen oxides and hydrocarbons from traffic, sets an ideal condition for the formation of photochemical smog. Studies by overseas groups (Jacobson & Salottolo 1975) indicate that the meteorological conditions which generally must co-exist for the photochemical smog forming reactions to occur are daily solar radiation greater than 400 langleys, temperatures of 24°C or more and an early morning mixing depth of less than 1,000m. In the case of the Klang Valley region, particularly the large urban centres, the area meets all the requirements (Sham 1984). Preliminary measurements of ozone by the DOE in the commercial centre of Kuala Lumpur showed that there was evidence of diurnal increase in ozone levels, rising from near-zero at daylight to a maximum of 0.06 p.p.m. between mid-day and early afternoon, and returning to near-zero again after dark. A more recent measurement by the group at Universiti Pertanian Malaysia also confirms the significance of ozone in the Klang Valley (Inouye & Azman 1985; Muhammad Awang & Izham Ismail 1987). While little can be done to change the climate of the area, we definitely could reduce the photochemical process by controlling emissions of hydrocarbons and nitrogen oxides from the exhausts through catalytic converters. In Malaysia, although there are set regulations at present which prohibit excessive smoke from motor vehicles, no similar regulation exists to control other exhaust emissions.

The changing forms and intensity of the heat islands along with their likely impacts on air pollution dispersion, human thermal comfort and power ultilisation for cooling were noted earlier. These indicate that in the design or tropical cities, the buildings and their spatial arrangements should be planned such that they help weaken the heat island. This may be done by the use of sufficient and properly spaced parks and the careful choice of building materials. A radial street plan, allowing country air to penetrate as deeply as possible into the city centre, has also been suggested in order to ameliorate adverse temperature conditions. A study on the ameliorative effect of urban forest in the Kuala Lumpur area shows that a mini park can moderate the high afternoon temperatures by as much as 4-5°C (Sham 1986b, 1987). Experience in the United States suggests that urban forests can be functional not only in moderating high temperatures but also in reducing air pollutants. Research shows that with each degree of increase in temperature within a heat island, Americans on the average spend US$1.0 million per hour in cooling expenses (quoted from Anon 1989:22). In another study, tree canopies have been shown to substantially reduce the cost of air conditioning; saving could amount to US$147 per year for a mobile home in the United States (quoted form Giedraitis & Kielbaso 1982). A discussion of the urban forestry concept as applied to Kuala Lumpur was provided by Justice (1986). Trees also cleanse the atmosphere by filtering out impurities and by adding oxygen to the air. It has been shown that the value of CO2 removed from the air by an 80-foot-tall beach tree each day is equivalent to that produced daily by two single-family dwellings. Reduction of particulate pollutants of 7,000 or more dust particles per liter of air is possible along tree-lined streets (Giedraitis & Kielbaso 1982).

Several overseas studies (Akbari et al. 1989, 1990; Bretz & Rosenfeld 1992) have shown that when combined with high-albedo surfaces, shade trees contribute significantly to urban heat island reduction. In fact, Akbari et al. (1990) argue that light-coloured surfaces may even be more effective than trees in moderating heat island, and cost less especially if colour changes are incorporated into routine maintenance schedules. Apart from that, the moderating effect of light-coloured surfaces is immediate; a tree may take a few years before it is large enough to produce significant energy savings. Computer simulation fit to a real house in Sacramento shows that applying a white coating to the roof and adding three shade trees can reduce the cooling electricity use by about 50% (Breta & Rosenfeld 1992:6).

In view of the moderating function of trees, it might well be useful for Malaysia to examine the possibility of adopting the urban forestry concept to all urban areas in the country and perhaps come up with a "National Urban Forestry Policy". The latter will streamline policies, procedures and related issues with regard to urban forestry throughout the country. A good start has already been made in the Kuala Lumpur area but for many other urban areas, tree planting efforts leave much to be desired. As the National Urban Forestry Policy in the United States is now comparatively well developed, it may be helpful to examine this and make an assessment of its operation for possible adaptation.

CONCLUDING REMARKS

This paper has provided an illustration of the manner in which urbanisation has affected air quality and climate in Malaysia with illustrations from Kuala Lumpur and the Klang Valley conurbation. It notes that (1) while air pollution levels in urban areas in Malaysia are still not as high as in some other busy cities, they have nevertheless exceeded the WHO standards and the Malaysian Guideline recommended levels; (2) While there are mitigating measures currently available, due to several constraints, these have not been sufficiently effective to contain the problems especially in the face of expanding urban-industrial activities within the region; (3) A more comprehensive approach to include public awareness and environmental education is needed in order to ensure an acceptable level of air quality in urban areas. Besides stringent enforcement of existing legislation, public support is equally essential in order to ensure the success of air quality management programmes. The latter can only be obtained from a public which is informed, aware and comitted and; (4) environmental education and public awareness can be greatly enhanced through NGOs and the media and these should be fully utilised whenever possible.

Evidence from local studies indicate that along with legislation and its effective enforcement, there is an urgent need for (1) a more stringent air quality emission standard; (2) increased efforts to reduce the heat islands; (3) greater considerations of climate and air quality factors in future planning and urban renewal programmes; and (4) a more systematic baseline study of urban climate and air quality as a basis for assessments which provide environmental policy analysts and decision-makers with reliable scientific data so essential for the planning and implementation of future policies.

In view of the multifunctional nature of trees, a National Urban Forestry Policy has been proposed. This will provide a useful framework to enhance tree planting efforts throughout all urban areas in the country. Besides ensuring improved air quality and health, urban forests are also a means through which energy saving can be effected.

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