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FUEL USAGE AND ESTIMATES OF AIR POLLUTION EMISSIONS IN THE KUALA LUMPUR—PETALING JAYA AREA MALAYSIA

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SINOPSIS

Berdasarkan kepada penggunaan bahan api, pengeluaran bahan-bahan pencemaran di Kuala Lumpur – Petaling Jaya telah dianggarkan. Hasilnya menunjukkan bahawa Kuala Lumpur–Petaling Jaya adalah tertakluk kepada pencemaran jenis 'Los Angeles'. Walaupun tingkat pencemaran masih rendah pada keseluruhannya berbanding dengan keadaan yang terdapat disetengah-setengah bandar di garislintang pertengahan, penggunaan tenaga terutama bahan-bahan minyak petrol telah bertambah diwaktu akhir-akhir ini. Ini akan memburukkan lagi keadaan pencemaran udara di kawasan kajian.

SYNOPSIS

On the basis of fuel usage, estimates of air pollution emissions in the Kuala Lumpur–Petaling Jaya area were attempted. This shows that Kuala Lumpur–Petaling Jaya is subject to the 'Los Angeles' type pollution. Although pollution is still generally low compared to some mid-latitude cities, marked increases in energy use, particularly petroleum products, have occurred recently. This can aggravate further the pollution situation in the study area.

INTRODUCTION

The documentation of air pollution sources and emission strengths within a community provides the basic framework for air conservation activities. The extent of the source surveys used in obtaining this information depends greatly on individual objectives and available resources. Comprehensive emission inventories, including field visits, plant surveys, questionnaires, and stack sampling, have been conducted in a number of major metropolitan areas.[1] Emission inventory data have many applications in air conservation programmes. They can be used effectively in metropolitan planning, pollution abatement, initiation of sampling programmes, interpretation of sampling

1 A.J. Van Tassel (ed.) 1973. *Our Environment: the outlook for 1980*. Lexington Books p.311-389; Kennedy, A.M. *et al*, 1974. *Survey of Fuel, Energy and Air Pollution in the Christchurch Urban Area (1966-73)*, Department of Chemical Engineering, University of Canterbury, Christchurch, N.Z., 71 pages.

results, and estimation of anticipated pollutant concentrations in the atmosphere. The aim of this paper is two-fold: firstly, to describe the pattern of fuel usage in Kuala Lumpur—Petaling Jaya; and secondly, to evaluate the probable rates of emission of pollutants from such uses (Figure 1).

Data Sources and Procedures

Published information relating to the supply and use of fuels within the Kuala Lumpur—Petaling Jaya urban area is almost non-existent. The majority of information used has been supplied entirely by private companies. The final figures that are presented must be taken as the best estimates possible based on the data available for fuels used within the Kuala Lumpur—Petaling Jaya urban area.

Calculation of emissions has been based on emission factors mainly from those given by Ozolins & Smith[2] and Duprey[3]. Pollutants considered are carbon monoxide, hydrocarbons, oxides of nitrogen, oxides of sulphur, and particulates.

Patterns of Fuel Usage, 1972-75

Table 1 shows the total amount of the various fuels supplied to the Kuala Lumpur—Petaling Jaya area between 1972 and 1975. This indicates that between 1972 and 1975 there was an increase of 39.1 percent in the total fuels estimated to have been used within the area together with 23.1 percent increase in the use of electricity for all purposes. In domestic demand the single most important growth has been for gas, the use of which increased by over 72 percent. Electricity increased by 32 percent. Both increases are the result of urban population growth[4] and the changeover from kerosene to gas as cooking fuel. All major forms of fuel and power consumption for industrial and commercial purposes have also shown increases. This is particularly true of petroleum products the use of which increased by 46 percent. The use of electricity for industrial and commercial purposes increased by 21.6 percent and gas by 19.4 percent. With regard to transport, petroleum products are by far the most significant fuels. The use of coal by the railways ceased during 1963 and today all railway engines are diesel operated. Motor spirits shows the greatest increase with 44.3 percent while the increase for gas oils is 28.6 percent.

2 G. Ozolins & R. Smith, 1968. *A Rapid Survey Technique for Estimating community Air Pollution Emissions*, USDHW, Public Health Service, Environmental Health Service, and the National Air Pollution Control Administration, Raleigh, 77 pages.

3 R.L. Duprey, 1968. *Compilation of Air Pollution Factors*, Durham, North Carolina.

4 S.R. Aiken & C.H. Leigh, 1975. "Malaysia's emerging conurbation" *Annals Association of American Geographers*, v.65, n.4., p.546-563.

TABLE 1
ESTIMATES OF TOTAL FUELS SUPPLIED TO KUALA LUMPUR—PETALING JAYA, 1972-75, IN THOUSANDS OF TONS AND ELECTRICITY IN MILLION OF UNITS

	1972	1973	1974	1975
Domestic				
Kerosene	50.1	50.1	52.2	53.6
Gas	14.3	19.3	22.6	24.7
	64.4	69.4	74.8	78.3
Industrial and Commercial				
Gas	3.1	3.5	3.7	3.7
Petroleum products— fuel & gas oils	229.4	260.8	315.1	334.8
	232.5	264.3	318.8	338.5
Transport				
Motor spirits	146.4	172.1	192.3	211.3
Gas oils	111.2	100.1	134.7	143.0
	257.6	272.2	327.0	354.3
TOTAL TONS (THOUSANDS)	554.5	605.9	720.6	771.1
Electricity				
Domestic	165.1	183.7	201.2	217.9
Industrial & Commercial	923.2	976.4	1,073.1	1,122.3
Transport	12.6	13.6	14.3	14.6
TOTAL UNITS (MILLIONS)	1,100.9	1,173.7	1,288.6	1,354.8

Source: Malaysian oil companies and the National Electricity Board, Malaysia.

Table 2 illustrates the data in Table 1 for 1972 and 1975 converted to kilowatt hours thus making the information on fuel supplied to Kuala Lumpur—Petaling Jaya comparable on an energy equivalent basis. These show that over the 1972-75 period there has been a 34.7 percent increase of total energy supply. Gas oils dominate the scence accounting for 31.6 percent of the total in 1975 although this is 3.4 percent less than the corresponding figure in 1972. This is followed by motor spirits and fuel oils both of which indicate positive changes over the 1972 figures in terms of percentage of annual total. Altogether, petroleum products accounted for over 87 percent of the total energy supply during 1975; the remainder comes from electricity.

Estimates of Pollution Emissions

From the estimates of total fuels supplied to Kuala Lumpur—Petaling Jaya over the 1972-75 period and by using emission factors for the main pollutants resulting from the use of fuels an attempt was made to calculate the total estimated annual emissions for 1972 and 1975 (Table 3).

In 1975, approximately 82,600 tons of carbon monoxide, 17,700 tons of

TABLE 2

ENERGY SUPPLIED TO THE KUALA LUMPUR—PETALING JAYA AREA, 1972-75 (IN MILLION OF KWhr.) AND AS A PERCENTAGE OF ANNUAL TOTAL

Energy source	1972	% of annual total	1975	% of annual total	Change in percentage 1972-75
Motor spirits	1,940.53	25.03	2,801.26	26.82	+1.79
Gas oils	2,711.12	34.97	3,300.70	31.60	-3.37
Fuel oils	1,305.46	16.84	2,269.45	21.72	+4.88
Kerosene	694.90	8.96	718.18	6.87	-2.09
Gas	0.15	*	0.24	*	*
Electricity	1,100.96	14.20	1,356.73	12.99	-1.21
Total	7,753.12	100.00	10,446.91	100.00	-

* Negligible

Source: Malaysian oil companies, Malaysian gas companies, and Malaysian Electricity Board

Footnotes:

Figures in this Table were derived by converting those in Table 1 to kilowatt hours using the following conservative calorific values for the different fuels:

Fuel	Calorific Value
Motor spirits	20,200 Btu's per pound
Gas oils	19,500 Btu's per pound
Fuel oils	18,500 Btu's per pound
Kerosene	19,900 Btu's per pound
Gas	450 Btu's per cubic foot
Electricity	1,000,000 Btu's per 293 KWhr.

hydrocarbons, 10,000 tons of oxides of nitrogen, 6,600 tons of oxides of sulphur and 2,650 tons of particulate materials were produced from the combustion of fuels. The bulk of carbon monoxide and hydrocarbons comes from motor spirits accounting respectively for 98.7 and 83.7 percent of the total. The main source of oxides of nitrogen is gas oils followed by motor spirits as a close second. Both gas oils and motor spirits account for over 77.0 percent of the years total of oxides of nitrogen. Oxides of sulphur is produced mainly by gas oils and fuel oils accounting for nearly 96.0 percent of the total. About 73 percent of the particulate matter come from gas oils.

Between 1972 and 1975 there was an increase in air pollution emitted from all sources. Fuel oils recorded the largest increase with nearly 74.0 percent followed by motor spirits with 44.4 percent. Air pollution emitted from gas oils and kerosene increased by 24.7 and 7.0 respectively. It is worth noting that although the absolute amount of air pollution produced by gas was very small, this represents an increase of 65.8 percent over the 1972 figure.

Table 4 shows the major sources of air pollutant emissions in Kuala Lumpur—Petaling Jaya as estimated from the supply of fuels during 1975. Transport accounts for nearly 92.0 percent of total emissions and together

with industries they produce over 99.0 percent of the pollutants emitted in the study area.

The role played by motor vehicles as the major source of air pollution in the Kuala Lumpur—Petaling Jaya area surpasses even that of the United States[5] where substantial amount of air pollution is also contributed by industry, power plants and space heating. In Kuala Lumpur—Petaling Jaya particularly and indeed in most tropical cities generally, domestic space heating is non-existent. Air conditioning units and fans which are widely used cooling systems are normally run on electricity and do not therefore contribute to air pollution directly especially in cases where electricity is produced far outside the urban centres. Industries are also mainly light in nature and do not produce as much air pollution. However, in the study, there is a tendency for an increase of air pollutant emissions during the 1972–75 period from industries.

Attempts to compare Kuala Lumpur—Petaling Jaya emissions with those of other cities are not always easy. The emissions factors used, the types of sources and pollutants considered in each case may sometimes be quite different such that indiscriminate comparison may be misleading.

Some form of comparison with other cities are provided by Table 5 where average concentrations of pollutant emissions have been expressed both in (a) tonnes/km^2/year, and (b) Ug/m^3. To obtain figures for (b), a modified concept of the simple box model as described in Masters[6] was assumed where pollutant emission rate was divided by the product of the city area and the mean maximum mixing depth. Information on wind speed and direction, and the base dimension of each city in the prevailing wind directions were not available and was therefore excluded in the calculation of pollution concentration. Mixing depth was estimated from maps prepared by Holzworth[7] for American cities, while that for Christchurch, New Zealand this was derived from Tapper[7]. Sources for other variables are noted at the bottom of the Table.[9]

Results in Table 5 suggest that although emissions for Kuala Lumpur—Petaling Jaya are still small by western standards, these have nearly equalled those of some city areas in the United States. The emissions would have

5 W. Bach, 1972. *Atmospheric Pollution*, McGraw-Hill, 144 pages.

6 G.M. Masters, 1974. *Introduction to Environmental Science and Technology*, John Wiley & Sons, 404 pages.

7 G.C. Holzwörth, 1964. "Estimates of mean maximum mixing depths in the contiguous United States" *Monthly Weather Review*, v.92, p.235-240; G.C. Holzworth, 1967 "Mixing depths, wind speeds and air pollution potential for selected locations in the United States" *Journal Applied Meteorology*, v.6, p.1039-1044.

8 N. Tapper, 1976. *An Investigation of Incoming Short and Long Wave Radiation over Christchurch*, M.A. thesis, University of Canterbury, Christchurch, New Zealand, 123 pages.

9 A.J. Van Tasselz (ed.) 1973. *Our Environment: the outlook for 1980*, Lexington Books, p.311-389; C.J. Sparrow, 1969. *A Geographical Review of Air Pollution in Auckland*, unpublished Ph.D. thesis, University of Auckland, New Zealand, 228 pages; A.M. Kennedy *et al* 1974. *Survey of Fuel, Energy and Air Pollution in the Christchurch Urban Area (1966–73)*, Department of Chemical Engineering, University of Canterbury, Christchurch, New Zealand, 71 pages; Christchurch Regional Planning Authority, 1966. *Air Pollution Advisory Committee Report*, Department of Scientific and Industrial Research Information Series no.55, p.9-16, 39-55.

TABLE 3

ESTIMATED EMISSIONS FROM FUELS SUPPLIED TO THE KUALA LUMPUR–PETALING JAYA AREA, (a) 1972 and (b) 1975

		Pollutants Discharged (tons)							
		Fuel burned ('000 tons)	Carbon monoxide	Hydrocarbon	Oxides of nitrogen	Oxides of sulphur	Particulates	Total pollutants	% of total
(a)	Motor spirits	146.4	56,474.8	10,169.3	2,193.0	174.7	213.4	69,225.2	82.7
	Gas oils	211.8	776.5	2,284.0	3,607.1	2,309.3	1,518.3	10,495.2	12.5
	Fuel oils	125.7	26.0	26.0	937.5	2,070.3	156.3	3,216.1	3.8
	Kerosene	53.2	N.A.	19.3	594.0	25.7	121.9	760.9	1.0
	Total*	537.1	57,277.3	12,498.6	7,331.6	4.580.0	2,009.9	83,697.4	100.0
	Gas	1.1m.cu.fit.	0.4 gm	-	128.0 gm	0.4 gm.	18.2 gm.	147.0 gm.	-

		Pollutants Discharged (tons)							
		Fuel burned ('000 tons)	Carbon monoxide	Hydrocarbon	Oxides of nitrogen	Oxides of sulphur	Particulates	Total pollutants	% of total
(b)	Motor spirits	211.3	81,534.6	14,681.8	3,166.1	252.2	308.2	99,942.9	83.7
	Gas oils	257.9	995.2	2,933.5	4.520.2	2,709.4	1,931.5	13,089.8	10.9
	Fuel oils	218.6	45.3	45.3	1,629.8	3,599.2	271.6	5.591.2	4.7
	Kerosene	55.0	N.A.	20.6	635.8	27.5	130.5	814.4	0.7
	Total*	742.8	82,575.1	17,681.2	9,951.9	6.588.3	2,641.8	119,438.3	100.0
	Gas	1.8m.cu.ft.	0.7 gm.	-	208.2 gm.	0.7 gm.	34.1 gm.	243.7 gm.	

* Pollutants discharged from gas excluded

N.A. Not available

TABLE 4

MAJOR SOURCES OF AIR POLLUTANT EMISSIONS IN THE KUALA LUMPUR—PETALING JAYA AREA (TONS), 1975, AS ESTIMATED FROM SUPPLY OF FUELS*

Source	Carbon Monoxide	Hydrocarbon	Oxides of nitrogen	Oxides of sulphur	Particulates	Total	% of total
Transport	82,504.8	17,599.3	6,752.0	898.3	2,085.0	109,839.4	91.9
Industry	71.3	71.3	2,564.1	5,698.5	427.3	8,832.5	7.4
Domestic	–	20.6	635.8	27.5	130.5	814.4	0.7
Total	82,576.1	17,691.2	9,951.9	6,624.3	2,642.8	119,486.3	100.0

* Pollutants discharged from gas excluded

probably been greater if the central business district of Kuala Lumpur alone had been considered and that wind speed through the mixing depth was included as a variable in the calculation of pollution concentration. The inclusion of wind speed in the calculation would result in the relative increase of concentration values for Kuala Lumpur—Petaling Jaya by a factor of several times when compared, for example, with those of New York and Los Angeles[10] as wind speeds in the study area[11] are a great deal lower than those experienced in most mid-latitude cities.

The average concentration of pollutant emissions by weight and expressed as percentage of total for selected cities (Table 6) suggests that Kuala Lumpur—Petaling Jaya is subject to the 'Los Angeles' type pollution[12] with a high percentage of carbon monoxide.

Summary and Conclusions

Transport, particularly motor vehicles, and industries represent the two most important sources of air pollution in Kuala Lumpur — Petaling Jaya. Together they produce 99.3 percent of the major pollutant emissions. This, and examination of pollutants emitted, suggests that Kuala Lumpur — Petaling Jaya is subject to the 'Los Angeles' type pollution.

Computation of total emissions and comparison of these figures with those obtained from other cities suggests that pollution in the Kuala Lumpur — Petaling Jaya area is of the same order as low to moderately polluted mid-latitude cities. However, marked increases in energy use have occurred recently which can aggravate further the pollution situation in the study area.

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10 G.C. Holzworth, 1967. "Mixing depths, wind speeds and air pollution potential for selected locations in the United States" *Journal Applied Meteorology*, v.6, p.1039-1044.

11 S. Sham, 1977. *Aspects of Air Pollution Climatology in the Kuala Lumpur—Petaling Jaya Area, Peninsular Malaysia*, unpublished Ph.D thesis, University of Canterbury, Christchurch, N.Z. 376 pages.

12 R.A. Bryson & J.E. Kutzbach, 1968. *Air Pollution*, Association of American Geographers, Commission on College Geography, Washington, D.C. 20036, Resource Paper No.2, 42 pages.

TABLE 5

AVERAGE CONCENTRATION OF POLLUTANT EMISSIONS FOR SELECTED CITIES EXPRESSED IN (a) TONNES/KM²/YEAR, AND (b) $\mu g/m^3$ IN THE LATTER, FIGURES WERE DERIVED BY DIVIDING TOTAL DAILY EMISSIONS FOR EACH CITY BY THE PRODUCT OF ITS AREA AND MEAN MIXING DEPTH

		Carbon monoxide	Hydrocarbons	Oxides of nitrogen	Oxides of sulphur	Particulates	Total
New York SMSA (1969)	a	588.92	154.23	131.17	577.98	23.45	1475.75
	b	1337.54	350.27	297.92	1312.70	53.25	3351.68
Pittsburgh SMSA (1969)	a	82.81	21.75	15.96	34.09	6.51	161.12
	b	161.85	42.50	31.20	66.63	12.73	314.91
Atlanta SMSA (1969)	a	37.01	12.24	10.58	30.22	7.56	97.61
	b	94.44	31.23	26.98	77.10	19.30	249.05
Chicago City (1969)	a	2324.93	1531.90	555.39	1412.13	273.32	5163.21
	b	1913.01	7444.47	1778.37	4521.66	875.16	16532.67
St. Louis City (1969)	a	2823.04	751.96	650.00	1701.47	337.74	6264.21
	b	2501.60	9391.60	2162.40	5660.40	1123.60	20839.60
Cleveland City (1969)	a	2707.91	693.68	590.91	1243.48	277.47	5513.45
	b	2311.20	9022.24	1968.80	4143.04	924.48	18369.76
New Orleans City (1969)	a	381.89	96.96	81.13	1.98	3.96	565.92
	b	290.57	1144.49	243.13	5.93	11.86	1695.98
Los Angeles City (1969)	a	2397.03	630.80	253.16	22.71	1.68	3305.38
	b	9350.50	2197.50	881.93	79.11	5.86	11514.90
San Francisco City (1969)	a	1778.19	558.37	283.48	Negligible	8.59	2628.63
	b	7025.58	2206.10	1120.02	Negligible	33.94	10385.64
Salt Lake City (1969)	a	1019.40	256.50	144.69	72.35	6.58	1499.52
	b	1280.30	322.14	181.72	90.86	8.26	1883.28
London (1957)	a	682.50*	284.70	284.70	697.52†	313.17	2262.59†
	b	-	-	-	-	-	-
Auckland (1966)	a	122.85*	19.63	21.50	23.25†	8.28	195.51*
	b	-	-	-	-	-	-
Christchurch (1973)	a	185.25*	73.87	36.16	37.49†	22.23	355.10*
	b	576.51*	229.90	112.54	116.70†	69.51	1105.16*
Kuala Lumpur–Petaling Jaya (1975)	a	315.73	67.64	38.05	25.33	10.11	456.86
	b	1271.67	272.44	153.26	102.01	40.70	1840.08

* estimated

† Figures refer to SO_2 only

(Source: Van Tassel[2], 1973, Sparrow, 1969; Kennedy *et al*, 1974; Christchurch Regional Planning Authority, 1972; Holzworth, 1964 & 1967; Tapper, 1976)

TABLE 6

AVERAGE CONCENTRATION OF POLLUTANT EMISSIONS BY WEIGHT FOR SELECTED CITIES EXPRESSED AS PERCENTAGE OF TOTAL†

	Carbon monoxide	Hydrocarbon	Oxides of nitrogen	Oxides of sulphur	Particulates
Los Angeles (1969)	72.5	19.0	7.7	0.7	0.1
London (1957)	30.2	12.6	12.6	30.8*	13.8
New York (1969)	39.9	10.4	8.9	39.2	1.6
Christchurch (1973)	52.2	20.8	10.2	10.5*	6.3
Auckland (1966)	62.8	10.0	11.0	11.9*	4.3
Kuala Lumpur–Petaling Jaya (1975)	69.1	14.8	8.3	5.6	2.2

† For Los Angeles and New York, total weight refers only to emission from automobiles, power plants and heating.

* Figures refer to SO_2 only.

(source: Calculated from Table 5)

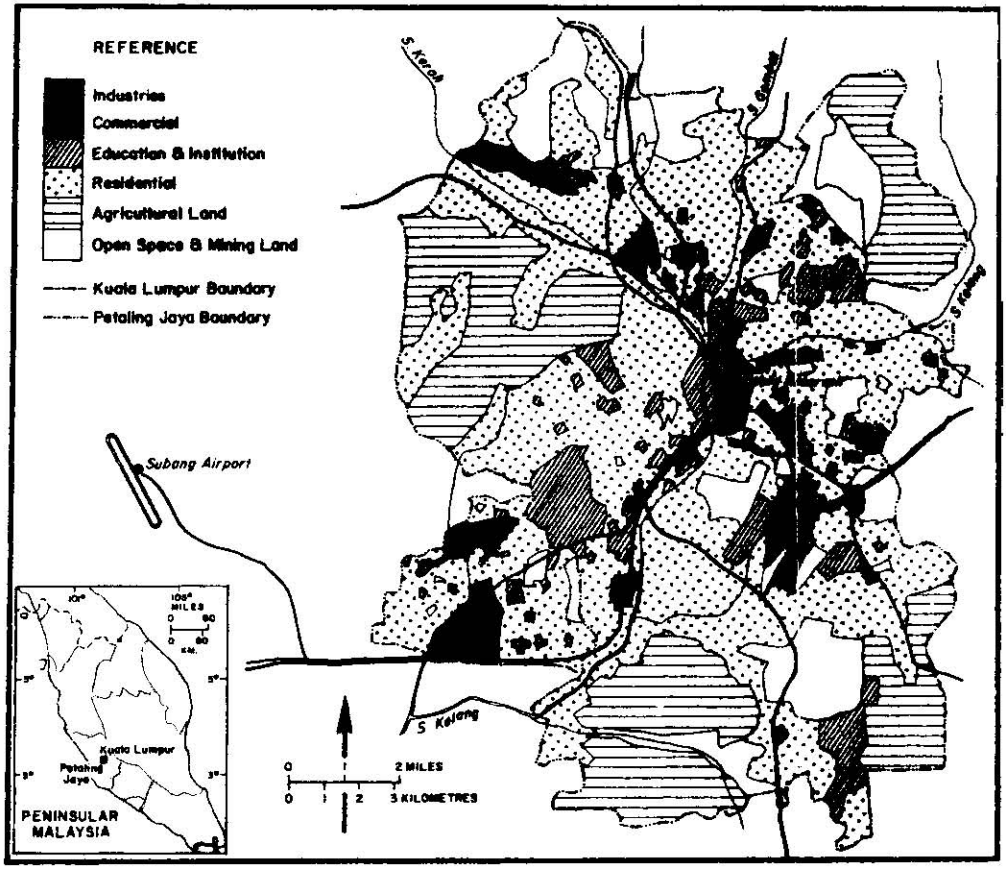

Figure 1: Kuala Lumpur--Petaling Jaya: Landuse