NILU OR: 19/96 App.

URBAIR

Emissions · Air Quality · Exposure · Damage · Cost · Abatement

Urban Air Quality Management Strategy in Asia

DKI JAKARTA City Specific Report

APPENDICES

Prepared under contract from
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DKI JAKARTA

Appendices

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Notice

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This present version of the report is distributed upon request, from NILU, until the official World Bank version is available. The two versions can be used interchangably, as they are basically identical.

Preface

In view of the potential environmental consequences of continuing growth of Asian metropolitan areas, the World Bank and UNDP launched the Metropolitan Environmental Improvement Program (MEIP) in five Asian metropolitan areas - Beijing, Bombay, Colombo, Jakarta, and Metro Manila. In 1993, Kathmandu joined the intercountry program as the sixth MEIP city. The mission of MEIP is to assist Asian urban areas in tackling their rapidly growing environmental problems. Presently, MEIP is supported by the governments of Australia, the Netherlands and Belgium.

Recognizing the growing severity caused by industrial expansion and increasing vehicle population, the World Bank started the Urban Air Quality Improvement (URBAIR) initiative in 1992 as a part of the MEIP. The first phase of URBAIR covered four cities - Bombay, Jakarta, Kathmandu, and Metro Manila. URBAIR is an international collaborative effort involving governments, academia, international organizations, NGOs, and the private sector. The main objective of URBAIR is to help local institutions in these cities to develop action plans which would be an integral part of their air quality management system (AQMS) for the metropolitan regions. The approach used to achieve this objective involves the assessment of air quality and environmental damage (e.g. on health, materials), the assessment of control options, and comparison of costs of damage and costs of control options (cost-benefit or cost-effectiveness analysis). On this basis, an action plan can be set up containing the selected abatement measures for implementation within the short/medium/long term.

The preparation of this city-specific report for DKI Jakarta is based upon the collection of data and specific studies carried out by the local consultants, and upon workshops and fact-finding missions carried out in April and August 1993, and May 1994. A first draft of the report was prepared by Norwegian Institute for Air Research (NILU) and Instituut voor Milieuvraagstukken (IVM, Institute for Environmental Studies) before the first workshop, based upon general and city-specific information available from earlier studies. A second draft report was prepared before the second workshop, with substantial inputs from the local consultants, and with assessment of air quality, damage and control options, and cost analysis carried out by NILU and IES.

This report contains the appendices to the main report.

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Air Quality Status, Jakarta

1. Description of past and present measurement programs

Stations and parameters

In 1991 air quality was measured at 17 stations in Jakarta. 7 stations run by BMG (Meteorological and Geophysical Agency) and two stations run by the Jakarta Municipal Government (JMG) (before 1980 by the Ministry of Health) are permanent. 8 rotational stations are run by DKI-KPPL (District of Jakarta - Research Centre for Urban Development). The temporary nature of the KPPL sites is dictated by the availability of equipment and resources to operate the network.

The location of the stations are shown in Figure 1 and a listing and description of the stations as of 1991 are presented in Table 1.

The first BMG station has been in operation since 1976 and is located at the BMG Headquarters in Central Jakarta. The six other BMG stations were started in 1980/81, but were not operated in the late 1980's. These six stations were restarted in 1991. At the BMG Headquarters TSP, NO_x and SO_2 are measured, while only TSP are measured at the other six BMG stations. At the BMG stations there is one 24 hour measurement every 6th day.

The two stations run by the JMG are part of the United Nations Global Environment Monitoring System (GEMS) since 1979. At the GEMS sites TSP, SO_2 and NO_x are monitored every 6th day.

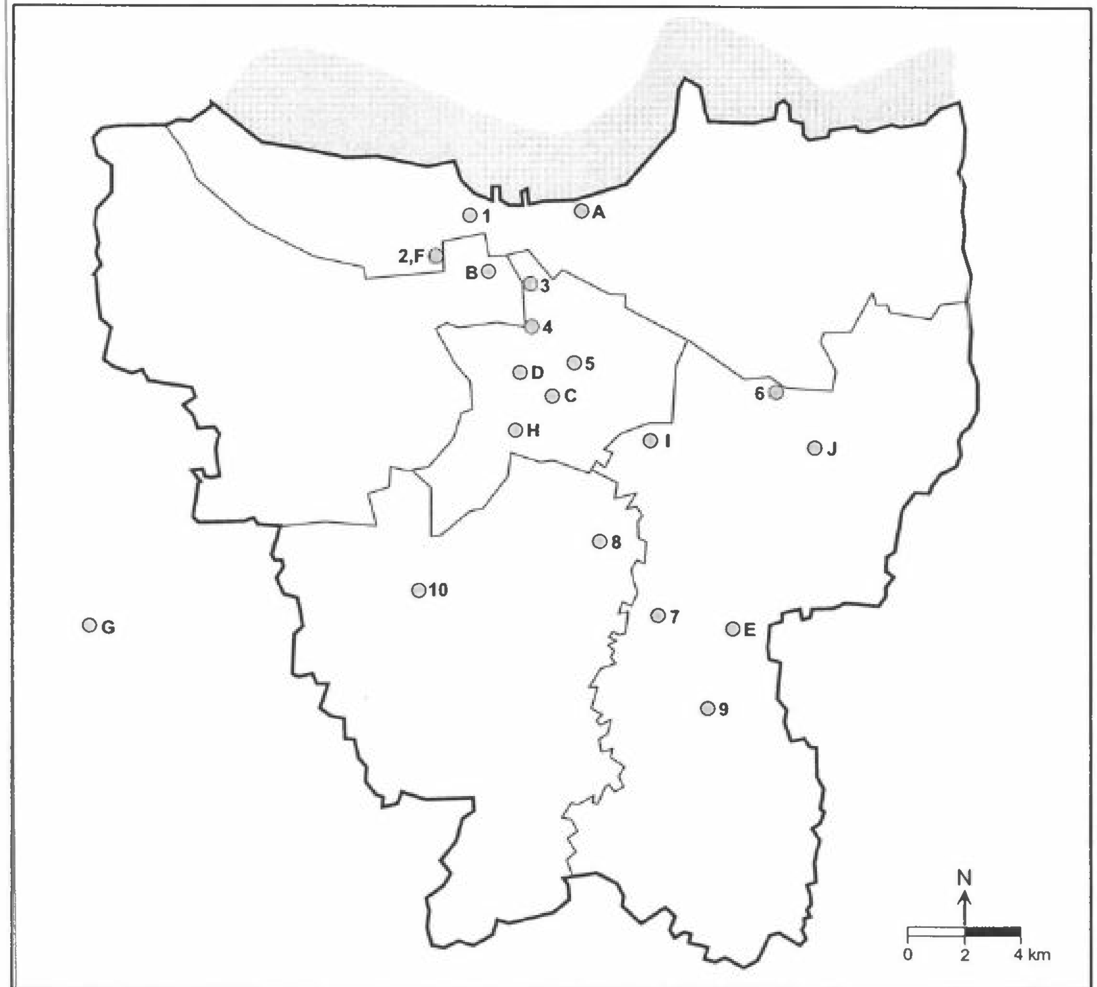
DKI-KPPL operates 8 air monitoring stations on a rotational basis (i.e. every 8 days, 4 stations are operated and then the equipment is moved to 4 other stations). These stations are only operated 8 months a year. TSP, NO_2, SO_2 and CO (and oxidants on occasions) are measured at all sites.

The location of the 8 DKI-KPPL sampling points were originally selected to record air pollution impacts on land use and are therefore not representative for most of the DKI Jakarta, notably the areas with heaviest population concentration and traffic. In the WHO/UNEP 1992 report are three of the DKI-KPPL stations characterized as road side stations (Pasar Baru, Pasar Senen and Mangga Besar) as well as the BMG Headquarters, Monas and Pulo Gadung stations.

Table 1: Air Quality Monitoring Network in Jakarta

Station	Operation started	Period Dis-continued	Date Restarted	Purpose/Land Use Classification	Remarks
B.M.G. JAKARTA					
B.M.G. Head Quarter	1976			Reference/Standard - C*	Operated 1976-1992, Parameter TSP, NO_x, SO_2, Acid Rain, Turbidity 2 Particulate Analysis.
Ancol	1980	1988-1990	1991 (July)	Urban/recreation - I, C	
Bandengan	1980	1988-1990	1991 (April)	Urban/mixed area, industry - I	
Glodok	1980	1988-1990	1991 (April)	Urban/shopping center, transportation - C	
Monas	1980	1986-1990	1991 (April)	Urban/regreening, recreation - C*	National Monument Area
Halim Perdana Kusumah	1980	1988-1990	1991 (June)	Urban/airport area - C, R	
Ciledug	1981	1988-1990	1991 (June)	Rural area - RA	Meteorological Station Class II
JMG/Ministry of Health					
Kayu Manis	1979			Urban Air Quality/ Residential area - C	TSP, SO_2, NO_X
Pulo Gadung	1979			Urban air quality/ Industrial area - I*	TSP, SO_2, NO_x
Jl M.H. Thamrin	1992			Urban/traffic	SO_2, NO, NO_2. CO, PM_{10}, continuously 1 hr.
DKI - KPPL					
Pulo Gadung	1983-1990			Urban Air Quality/ Industrial & Residential - I	TSP, SO_2, NO_x, NH_3
Tebet	"			Residential - R	TSP, SO_2, NO_x, NH_3
Bandengan Utara	"			Residential & Warehouse/ Urban Air Quality - I, C	TSP, SO_2, NO_x, NH_3
Cililitan	"			Urban Air Quality/ Bus Terminal - C	TSP, SO_2, NO_x, NH_3
Pasar Baru	"			Urban Air Quality/ Shopping Centre - C, R*	TSP, SO_2, NO_x, NH_3
Pasar Ikan	"			Urban Air Quality/ Residential & Warehouse I, C	TSP, SO_2, NO_x, NH_3
Pasar Senen	"			Urban Air Quality/ Trade Centre & Residential - C*	TSP, SO_2, NO_x, NH_3
Mangga Besar	"			Urban Air Quality/ Trade Centre & Residential - C*	TSP, SO_2, NO_x, NH_3

*Land Use Classification: R: Residential area RA: Rural area I: Industrial area C: Commercial area *: Road side station*



Stations operated by BMG
A Ancol
B Glodok
C BMG Head Quarter
D Monas
E Halim Perdana
F Bandengan
G Ciledug

Stations operated by JMG
H Jl M.H. Thamrin
I Kayu Manis
J Pulo Gadung

Stations operated by DKI KPPL
1 Pasar Ikan
2 Bandengan Delta
3 Mangga Besar
4 Pasar Baru
5 Pasar Senen
6 Pulo Gadung (bus terminal)
7 Cililitan
8 Tebet
9 Pondok Gede
10 Radio Dalam
11 PT. JIEP

Figure 1: Air Quality Monitoring Networks in Jakarta.
The PT. JIEP and BMG Bandengan stations are not marked on the map, because the positions are uncertain.

DKI-KPPL has had continuous instruments for several years, but have only used these for short term special studies. The limited operation is because of the operating/maintenance cost and the availability of calibration gases. DKI - KPPL has received continuous monitoring equipment from Japan for measuring O_3, SO_2, NO_2 and CO, and this equipment has been put into operation at the Jl M.H. Thamrin by JMG (see below).

In addition to the permanent and rotational stations in Jakarta, several short-term air quality monitoring studies have been done in selected cities. Two earlier short-term studies of interest are the transportation study in Jakarta in August-September 1982 by BMG and the Ministry of Communications, and a study in 1984 in 15 centres in Indonesia by BMG, KLH (State Ministry for Population and Environment), Ministry of Health and DKI. In December 1991-February 1992, a transportation related air quality study was done in Jakarta and Bandung by the BAPEDAL (Environmental Impact Management Agency) with the assistance of ITB (Bandung Institute of Technology) and DKI-KPPL.

Measurement and analyses methods

The measurement methods used by the various agencies are based on the WHO methods and are listed in Table 2.

Continuous monitoring methods have been used on a limited basis in the past in Jakarta, but their use has been restricted due to the availability of calibration gases and resource constraints. The recent BAPEDAL study noted above utilized a combination of continuous and wet chemical sampling methods.

Table 2: Measurement methods used in Indonesia.

Parameter	Analyses method
Sulphur dioxide (SO_2)	Pararosaniline method collected in midget impinger.
Carbon monoxide (CO)	Detector tube method (i.e. Draeger tube).
Nitrogen oxides as NO_2	Saltzman method collected in midget impinger.
Oxidant as O_3	NBKI method collected in midget impinger.
Suspended particulates (TSP)	Gravimetric. High-volume sample.

Special road side station at Jl M.H. Thamrin

Since April 1992 the JMG has been measuring air pollution from road traffic by a new display monitoring station at Jl M.H. Thamrin. This station is the only one in Indonesia using modern technology and located to record road side air pollution. The pollutants measured are SO_2, NO, NO_2, CO and PM_{10}. For suspended particles, only particles below 10 μm (PM_{10}) in diameter are recorded as opposed to other TSP (total suspended particulates) air concentration data available in Indonesia, which include all particle sizes up to 50-100 μg/m^3. The PM_{10} is of special interest when relating health effects to air particle pollution.

Also heavy metals are sampled and analyzed monthly in Japan where the monitoring equipment originates.

2. Analysis of measurement results

Long term monitoring networks in Jakarta

At the BMG and JMG stations 24 hour samples are taken every 6 days. TSP, SO_2 and NO_2 are measured at three stations and only TSP at the other six stations. The 8 DKI-KPPL stations are operated every 8 days on a rotational basis and TSP, SO_2, NO_2, CO and O_3 are measured. In general these three agencies use the standard reference methods recommended by the WHO and/or the USEPA. Generally, flow calibration is made on the instruments every 6 months. Calibration procedures for the gaseous sampling (SO_2 and NO_2) would follow the WMO/WHO requirements. A new station at Jl M.H. Thamrin with continuous monitoring equipment was put in operation in April 1992.

Total suspended particulates (TSP)

Annual averages of total suspended particulates in Jakarta are shown in Tables 3 and 4. Some results from the new display monitoring station Jl M.H. Thamrin are shown in Table 5.

The results show that TSP is generally very high in all areas. The 1991 value from Glodok (648 $\mu g/m^3$) exceeds the proposed national ambient air quality annual standard of 90 $\mu g/m^3$ by as much as a factor of 7. All stations, with the exception of the Halim Perada location, exceed the standard at least by a factor of 2.

The TSP levels from the DKI-KPPL stations are not directly comparable to the BMG/Health results, because the DKI-KPPL represents different sampling locations and time periods, i.e. dry/wet seasons for each year. But there are similar trends in TSP levels between the three networks. The 1990/91 annual TSP averages in the Pasar Ikan and Bandengan areas exceeded the national ambient air quality standards by about a factor of 6. Also Table 4 shows the increasing average TSP concentrations from 1986/87 to 1990/91 for all stations, except for Pasar Senen which stayed at essentially the same level.

Figure 2 shows annual average TSP concentrations for the period 1980-1991 for some selected stations in the BMG/Health network. The Glodok location (commercial, W. Jakarta) is in the most polluted area and the Halim Perada location (commercial/residential, E. Jakarta) has the lowest concentrations.

Figure 3 shows TSP isopleths based on the measurements in the years 1980-1985 (Office of State Min. of Population and Environment, 1990). The areas of highest TSP levels are the city centre and the eastern part of western Jakarta. The TSP levels are much lower in the eastern parts of the city where the GEMS sites are located.

Table 3: 1980-1991 Annual Average Total Suspended Particulates (µg/m³) in Jakarta for permanent BMG and Health Stations.

Location Year	BMG (C)	Ancol (I/C)	Bandengan (Delta) (I)	Glodok (C)	Monas (C)	Halim P. (C/R)	Ciledug (RA)	Kayu Manis* (C)	Pulo Gadung* (I)
1980	197.9	139.2	474.9	508.2	123.9	108.4	-	256.2	177.9
1981	337.0	117.1	409.6	455.9	142.1	98.4	73.0	223.0	164.3
1982	272.2	336.3	512.3	516.9	199.0	129.4	133.5	278.0	223.0
1983	169.5	382.6	606.4	492.1	332.2	144.1	156.0	338.2	310.3
1984	169.7	161.7	447.1	487.8	167.2	160.3	135.5	272.7	151.8
1985	150.5	158.5	468.7	450.3	284.8	120.2	155.1	213.0	184.0
1986	117.7	146.3	540.5	395.9	-	140.0	213.3	191.0	185.0
1987	175.2	169.0	272.8	390.4	-	212.3	266.4	148.0	181.0
1988	228.1	-	-	-	194.0	-	-	188.0	187.0
1989	186.1	-	-	-	-	-	-	238.0	252.0
1990	168.5	-	-	-	-	-	-	188.9	227.0
1991	182.2	261.2	458.8	648.3	205.8	156.4	276.2	159.0	270.0
Average	189.9	231.3	463.7	555.3	206.0	147.8	219.1	224.4	208.9

Land Use Classification:
*R: Residential Area   I: Industrial area   C: Commercial area   RA: Rural area   *: Ministry of Health (JMG) (GEMS)*

Table 4: Comparison of Annual averages for TSP, SO_2 and NO_x for the periods 1986/1987, 1990/1991 and 1992/1993 for DKI-KPPL Monitoring Network in Jakarta

Pollutants	TSP (µg/m³)			SO_2 (ppb)			NO_x (ppb)		
Stations	1986/1987	1990/1991	1992/1993	1986/1987	1990/1991	1992/1993	1986/1987	1990/1991	1992/1993
Pasar Ikan (I/C)	220	570	536	8	3	2	9	19	58
Bandengan (I/C)	420	520	453	7.2	5	3	11	15	62
Pasar Senen (C)	300	295	270	5.5	3	1	9	19	51
Pasar Baru (C/R)	220	400	353	6	3	2	2	15	66
Mangga Besar (C)	180	200		7	2.5		9	11	
Cililitan (C)	170	360		5	3		10	17	
Pulo Gadung (I)	160	270	367	6	4	2	9	12	78
Tebet (R)	160	250	207	3.5	5	2	6.5	9.5	42

Land Use Classification:
R: Residential areaI: Industrial area *C: Commercial area*

Table 5: Display Monitoring Station, JL. Mh. Thamrin

Daily averages, Thursdays, the first two months of monitoring, 1992.

Day	SO_2 (ppb)	NO (ppb)	NO_2 (ppb)	NO_x (ppb)	PM_{10} (µg/m³)	CO (ppm)
16 April	14.0	138.0	75.3	213.0	92.8	5.40
23 April	7.3	138.0	46.1	185.0	33.7	5.05
30 April	7.7	105.0	46.0	151.0	67.0	3.43
7 May	7.4	103.0	44.7	147.0	96.5	3.60
14 May	18.4	113.0	83.2	197.0	111.0	4.80
21 May	13.0	85.0	61.0	147.0	79.0	3.00
28 May	12.0	74.0	71.0	145.0	109.0	3.00
04 June	13.1	101.0	61.7	163.0	98.3	3.93
11 June	13.0	71.0	49.7	120.0	106.0	2.42
18 June	13.2	92.5	72.1	164.0	114.0	3.35
25 June	22.1	136.0	92.7	228.0	77.2	4.9
Average	12.8	105.1	64.0	169.1	89.5	3.9

PM_{10} data for 11 June is computed as an interpolation.

Hourly monitor results 25 June, 1992.

Hour	SO_2 (ppb)	NO (ppb)	NO_2 (ppb)	NO_x (ppb)	PM_{10} (µg/m³)	CO (ppm)
1	10	32	32	64	30	1.2
2	9	36	32	68	30	1.3
3	8	16	22	38	30	0.5
4	9	65	23	88	10	1.5
5	11	150	49	199	30	3.6
6	18	230	112	342	65	7.8
7	24	218	145	363	95	8.1
8	21	140	118	258	110	5.0
9	20	164	138	302	65	5.4
10	29	162	162	324	60	6.2
11	40	190	106	296	100	6.3
12	26	192	130	322	70	6.5
13	26	178	157	335	90	6.3
14	42	178	152	330	100	6.4
15	64	204	178	382	100	8.2
16	70	190	106	296	110	7.7
17	27	160	122	282	100	7.7
18	15	190	114	304	100	7.5
19	13	124	86	210	95	4.4
20	15	218	95	313	90	8.2
21	14	128	56	184	150	4.0
22	11	56	31	87	140	1.7
23	1	18	25	43	60	0.8
24	11	28	34	62	25	0.8
Average	22.25	136.13	92.71	228.83	77.29	4.88

Daily (24 hour) average, high and low values, week 22-28 June, 1992

Day	NO_x (= NO_2 + NO), ppb			PM_{10}, µg/m³		
	Average	High	Low	Average	High	Low
Monday 22 /6	196	302	58	116.0	200.0	45.0
Tuesday 23/6	196	302	58	116.0	200.0	45.0
Wednesday 24/6	212	348	84	123.0	200.0	60.0
Thursday 25/6	229	382	38	77.2	150.0	10.0
Friday 26/6	210	363	0	81.0	130.0	40.0
Saturday 27/6	163	275	62	80.0	110.0	40.0
Sunday 28/6	106	168	76	73.7	120.0	30.0

Source: KPPL

There is limited information on the 24 hour average TSP levels. According to Kozak and Sudarmo (1992) the daily TSP concentrations in Jakarta exceeded the 24 hour TSP air quality guideline on the average 173 days per year over a 7-year period.

The 24-hour mean TSP values from 4 selected stations, Pasar Ikan, Bandengan, Pasar Baru and Pasar Senen for the period 1992/1993 are shown in Figure 4. Most of the 24-hour mean TSP values are well above the proposed national ambient air quality standard of 230 $\mu g/m^3$. The highest value of 865 $\mu g/m^3$ was measured at Bandengan on 4 March 1993.

At the new display monitoring station Jl M.H. Thamrin near a roundabout in central Jakarta, PM_{10} is continuously monitored on an hourly basis. PM_{10} is the sum of particles with diameter less than 10 µm and is more related to possible health effects of particles in the air.

PM_{10} daily levels at Jl M.H. Thamrin station in April-June 1992 varied between 34-114 $\mu g/m^3$ with an average of 90 $\mu g/m^3$. The WHO 24-hour guideline of 70 $\mu g/m^3$ was therefore exceeded most of the days. PM_{10} levels are somewhat lower during weekends than during working days.

The PM_{10} levels were considerably higher during working hours than during the night, indicating human activities (probably mainly road traffic) to be the main emission source.

The PM_{10} data from Jl M.H. Thamrin station indicate that PM_{10} levels in Jakarta are very much lower than TSP levels measured at all the other stations. There is no reason to believe that TSP in traffic-exposed central Jakarta areas should be lower than at the TSP stations. If the TSP measurements are correct, the obvious conclusion is that most of the TSP particles have a diameter above 10 µm.

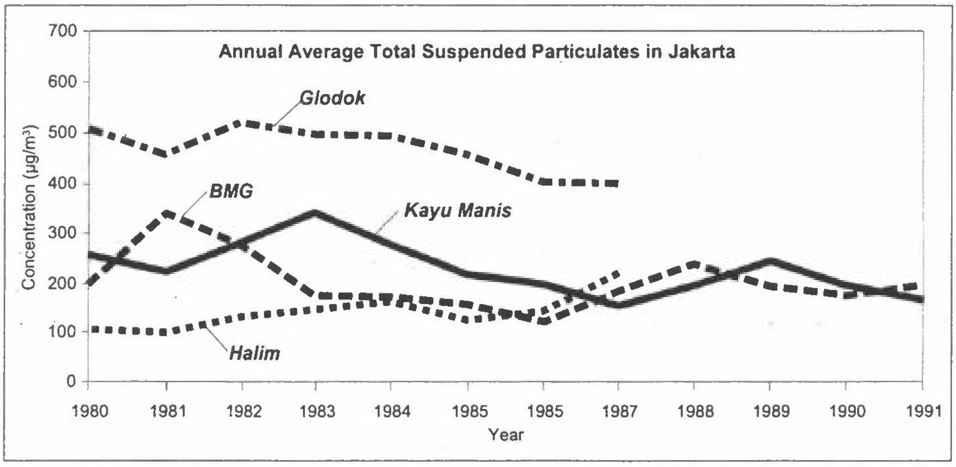


Figure 2: Annual average TSP concentrations for the period 1980-1991 for some selected stations (µg/m³).

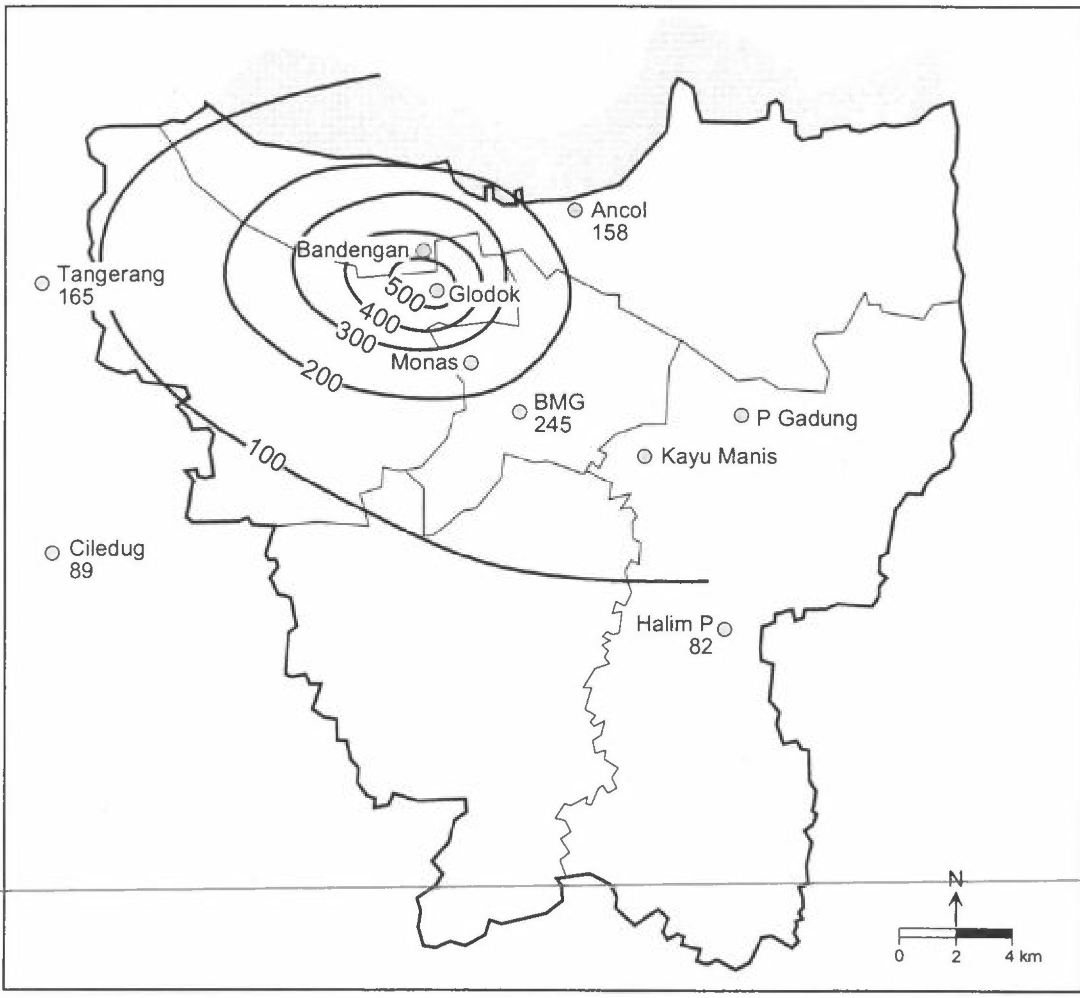


Figure 3: Suspended particulate matter isopleths 1980-1985.

After Office of State Ministry of Population and Environment, 1990

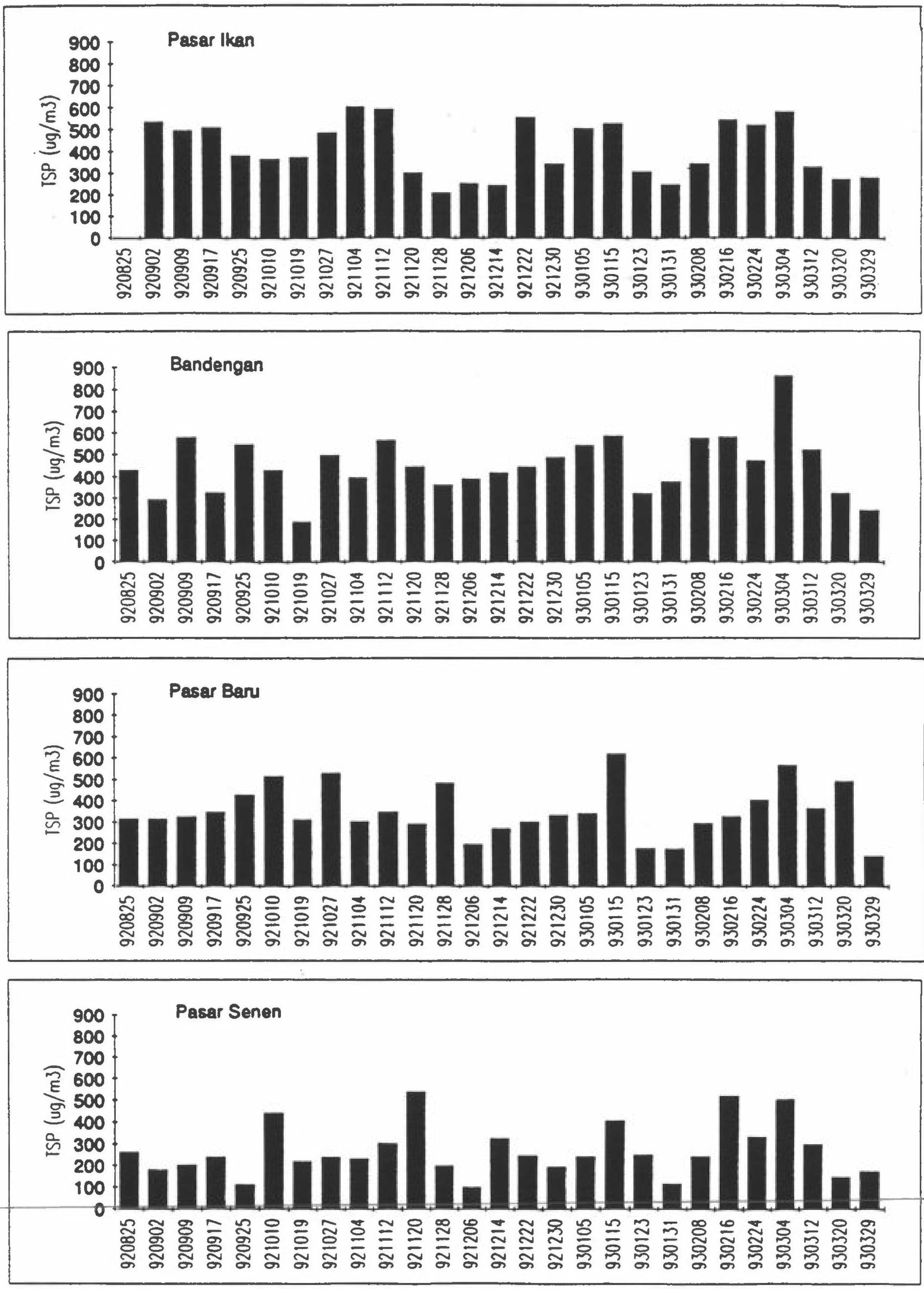


Figure 4: 24-hour mean values of TSP at selected sites during the measurement period 1992/1993 (µg/m³).

Sulphur dioxide (SO_2)

Long-term SO_2 data is available from BMG (one station), JMG (2 stations) and KPPL (8 stations).

Annual SO_2 averages are shown in the Tables 4 and 6. Generally the annual levels are very low, from 5 ppb (14 µg/m³) to less than 0.1 ppb (0.3 µg/m³). The JMG stations Pulo Gadung and Kayu Manis show significantly lower values than all other stations, even in the same areas. According to Kozak and Sudarmo (1992) this could be due to specific sampling location characteristics, but it might be also due to varying sampling and analysis performance by the various agencies. They point out that consistent siting criteria and inter-laboratory comparisons should be considered to resolve these differences.

Table 6: Comparison of annual SO_2 concentrations from 1986-1991, from BMG and Min. of Health air monitoring stations in Jakarta.

YEAR	SO_2 (ppb)		
	BMG.HQ	Min. of Health	
		Kayu Manis	Pulo Gadung
1986	2.0	0.1	0.2
1987	1.4	0.1	0.2
1988	1.7	0.5	0.4
1989	1.8	0.1	0.1
1990	4.0	<0.1	<0.1
1991	2.0	<0.1	0.1

There is little available information on 24-hour average SO_2 values from the BMG/JMG/KPPL networks. In 1983 maximum 24-hour average concentrations of SO_2 were reported to be around 240 µg/m³, but daily averages decreased to 8 µg/m³ in 1986-1989. This remarkable sudden change cannot be explained at this time.

The 24-hour mean SO_2 values from 4 selected stations, Pasar Ikan, Bandengan, Pasar Baru and Pasar Senen for the period 1992/93 are shown in Figure 5. Most of the values are below 5 ppb (14 µg/m³). The highest value was 15 ppb (40 µg/m³).

The available 24-hour data suggest that SO_2 concentrations in Jakarta is ***probably*** not a serious problem. Large differences in SO_2 concentrations, both in time and between agencies, however, make the question of the reliability of the measurements important.

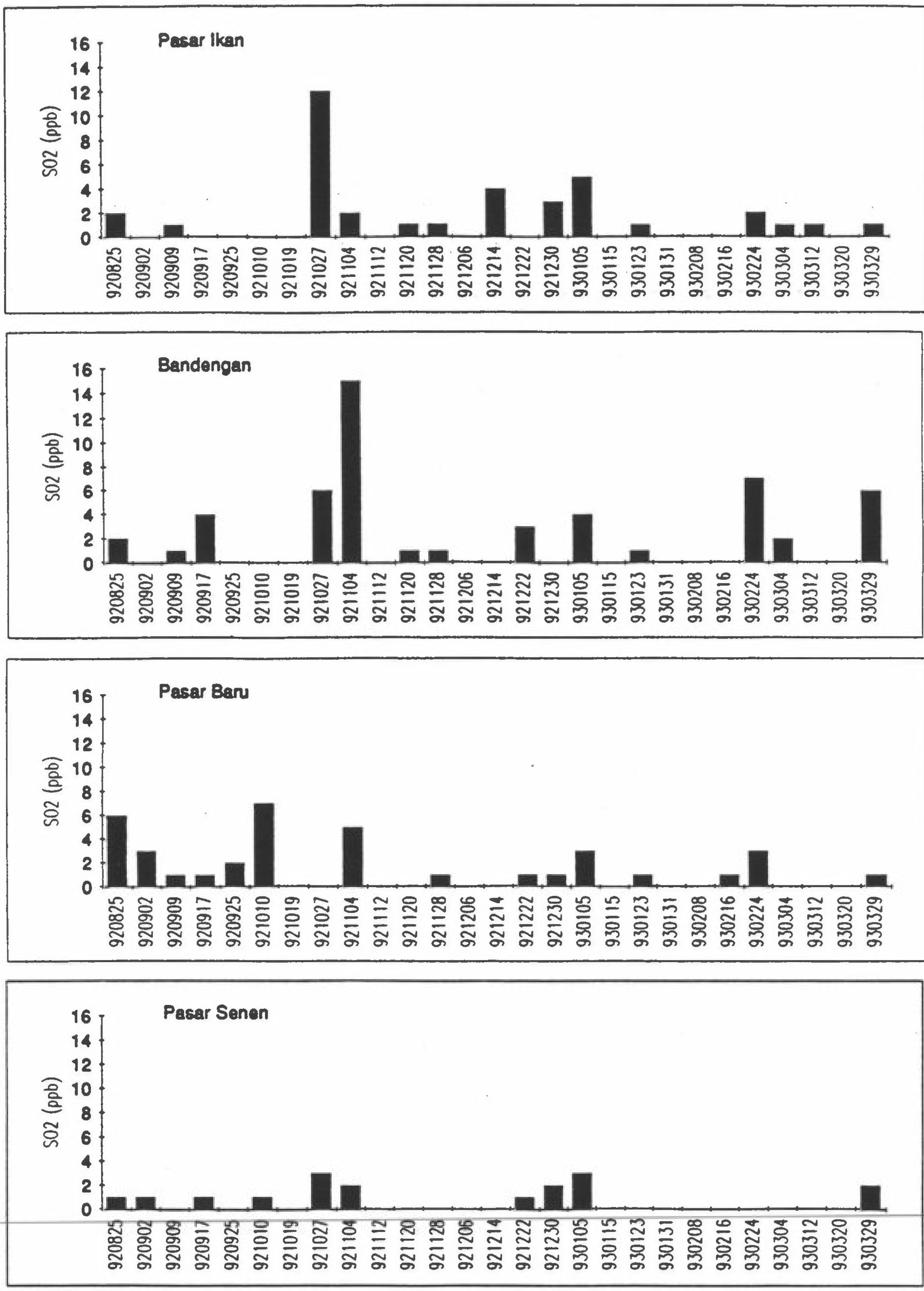


Figure 5: 24-hour mean values of SO_2 at selected sites during the measurement period 1992/1993 (ppb).

Recent data from the monitoring station at Jl M.H. Thamrin in April-June 1992 show daily mean values in the range 7.3-22 ppb (about 20-60 μg/m3) with an average of 12.8 ppb (about 35 μg/m3) (see Table 5). Hourly data from June 25 indicate SO_2 levels about 20 μg/m3 in the night and up to almost 200 μg/m3 during the day. The Jl M.H. Thamrin site SO_2 data may indicate that the 24-hour SO_2 data from the other stations are too low. Sampling procedures and analysis methods should be seriously checked.

Nitrogen dioxide (NO_2)

NO_x data for KPPL and BMG/health stations are presented in Table 4 and Table 7 respectively. NO_X is reported, but the main component would probably be NO (Kozak and Sudarmo, 1992c).

Table 7: Comparison of annual NO_x averages for 1986-1991 at BMG and Min. of Health air monitoring stations in Jakarta.

YEAR	NO_X (ppb)		
	BMG.HQ	Min. of Health	
		Kayu Manis	Pulo Gadung
1986	60	20	21
1987	130	18	15
1988	140	12	10
1989	140	12	10
1990	40	10	9
1991	29	23	23

The JMG (GEMS) reported annual mean NO_x concentrations of 2-4 μg/m3, and maximum 24-hour concentrations of 5-10 μg/m3 during 1986-1989. These stations are located away from the city centre and thus primarily reflect suburban ambient air pollution.

During 1989 and 1990 the average concentration at the Bandengan station in the city centre was (as low as) 28 μg NO_x/m3.

DKI-KPPL stations show a remarkable fall i NO_x concentrations from 113 μg/m3 in 1983 to 9.4 μg/m3 in 1986, and similarly, maximum 24-hour values fell from 395 μg/m3 to 15 μg/m3. This sudden drop in NO_x concentrations cannot be explained with the available information, but it seems likely that besides a possible improvement in air quality, the siting, sampling or instrumentation of the monitoring stations must have had a major influence (WHO/UNEP, 1992).

The DKI-KPPL stations show an increase again in the NO_x concentrations from 1986/1987 to 1990/1991 at all monitoring stations, while the SO_2 levels at the same stations fell considerably in the same period.

As shown in Table 4 NO_x levels were considerably higher during 1992/1993 than during 1990/1991. The mean values range from about 40 ppb to 80 ppb (80-

160 µg/m³). This remarkable difference in NO_x levels from year to year seems difficult to explain.

From April-June 1992 NO, NO_2 and NO_x data from the new monitoring station Jl M.H. Thamrin show mean values of 64 ppb NO_2 (about 120 µg/m³) and 169 ppb NO_x (about 320 µg/m³). NO_2 daily values ranged from 46 ppb (about 85 µg/m³) to 93 ppb (about 175 µg/m³). The highest values are above the proposed Indonesian ambient air quality standard of 150 µg/m³.

Hourly NO_2 values on 25 June 1992 ranged from 22 ppb (about 40 µg/m³) to 178 ppb (about 340 µg/m³). The highest values are not far below the proposed 1-hour national ambient air quality standard of 400 µg/m³.

The results from Jl M.H. Thamrin indicate that NO_2 concentrations in the most heavily trafficated areas in Jakarta may be above the WHO and Indonesian standards.

The Jl M.H. Thamrin NO_2 results indicate, as was the case with SO_2, that the 24-hour NO_x data from the other stations may be too low, especially at the more centrally located stations. Similarly to SO_2, the NO_x sampling procedures and analysis methods should be seriously checked.

Ozone (O_3)

O_3 is measured at the 8 DKI-KPPL stations. In 1986-1987 annual mean O_3 concentrations ranged from 2 µg/m³ at the Bandengan location to 15 µg/m³ at the Pasar Senen location. The latter station also had the highest 1-hour concentration with 85.8 µg/m³, while the highest 1-hour value at Bandengan was as low as 8.2 µg/m³. Thus all reported O_3 concentrations in Jakarta seem to be well below the proposed national ambient air quality standards.

The O_3 levels seem to be lower than expected, especially compared to the NO_x levels. If the O_3 levels are correct, the NO_x levels should be considerably higher than observed at the long term stations.

Unfortunately, O_3 is not monitored at the new Jl M.H. Thamrin location. Because of photochemical reactions of NO and O_3 to NO_2 and high observed NO_2 levels one would expect rather low O_3 levels at this site, especially during day time when the traffic volume is high. O_3 measurements with a continuous monitor is recommended at this site.

High O_3 concentrations have been measured outside the city. 100 ppb of oxidant is frequently measured at EMC in Serpong, 30 km southwest from central Jakarta (EMC, 1994).

Carbon monoxide (CO)

CO is measured at the DKI-KPPL network. 8-hour average CO levels were found to be around 3.5 mg/m^3 in a residential area and at a bus terminal (Cililitan site), but were up to 27 mg/m^3 at the Glodok station in a city centre commercial area. This value is well above the WHO guideline and the proposed national ambient air quality standard of 10 mg/m^3, indicating CO to be a problem in heavily traffic-exposed areas.

The new monitoring station at Jl M.H. Thamrin showed daily CO averages between 2.4-5.1 mg/m^3 in April-June 1992 (one sample every 7 days) with an average of 3.9 mg/m^3. Hourly values 25 June varied between 0.5 mg/m^3 in the night and 8.2 mg/m^3 in the afternoon. The highest 8-hour average this day was 7.1 mg/m^3, and the daily average value was 4.9 mg/m^3.

The Jl M.H. Thamrin air inlet is 4 m above ground level, about 10 m from the edge of a traffic circle (diameter of about 100 m). Very high traffic intensity is observed in the circle. Monitoring in a street canyon with heavy traffic would probably give higher CO levels than at the roundabout location. The wind often blows from the station to the traffic circle.

Lead (Pb)

Average lead concentrations at the DKI-KPPL stations usually range between 0.5-2 $\mu g/m^3$. Considering the locations of the stations, Pb concentrations well above the proposed national ambient air quality standard of 2 $\mu g/m^3$ for 24-hour average are to be expected in more heavily traffic-exposed areas.

A study in July 1985 showed monthly Pb concentrations at three sites between 0.3-3.6 $\mu g/m^3$. The values were strongly correlated to road traffic volume.

PM_{10} samples from the new road side monitoring station Jl M.H. Thamrin are analysed for Pb in Japan. However, no values have been released yet. These values will probably be by far the best to evaluate air lead pollution in densely trafficated areas in Jakarta.

The lead content in leaded gasoline in Indonesia is reported to be 0.44 g/l for 88 octane premium and 94 octane premix gasoline. During Summer 1995, unleaded gasoline was introduced in Jakarta, in relatively small amounts.

3. References

EMC (1994) Annual report on air quality monitoring and studies, vol. 1. Serpong, Environmental Management Center, Air Quality Laboratory in Indonesia.

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WHO (1976) Selected methods of measuring air pollutants. Geneve (WHO Offset Publications No. 24).

Appendix 2

Air Quality Guidelines

Air Quality Guidelines

National Ambient Air Quality Standards

The Air Quality Technical Committee, coordinated by KLH (State Ministry for Population and Development), and with members from the relevant national departments, DKI (District of Jakarta) and selected universities was formed in 1983. This group proposed ambient air quality standards for 9 parameters (KEPMEN, 1988). These standards are listed as "Existing standards" in Table 1.

The Technical Committee held a series of workshops/meetings at the beginning of August 1990 to consider and evaluate the information provided by EMDI (Environmental Management Development in Indonesia) and the members of the Committee on standards/objectives used by other countries and agencies. The existing National Ambient Air Quality standards from KEPMEN/1988 were used as the starting point for potential revisions, additions or deletions.

Revised National Ambient Air Quality Standards were drafted by the Technical Committee in January 1991, after a review which included documentation from a number of international agencies and jurisdictions. In particular, recent reviews prepared by the World Health Organization (WHO) were considered in detail and modified for the air pollutants SO_2, O_3, CO, TSP and Pb after discussion by the Technical Committee. In October 1991 it was proposed that a standard for hydrocarbons should be added to the list of parameters.

The National Ambient Air Quality Standards proposed in 1991 are also presented in Table 1 together with the existing standards. The primary purpose of the air quality standards is the protection of public health and other environmental receptors, such as vegetation, wildlife, material detoriation etc. against the adverse effects of air pollution. However, it is emphasized that the standards must also consider the prevailing exposure levels and environmental, social, economic and cultural conditions.

The standard measurement methods listed in Table 2 are essentially unchanged from KEPMEN (1988). The main reference for the measurement methods is the WHO document "Selected Methods of Measuring Air Pollutants" (WHO, 1976), which specifies standard methods that are similar to those used by US Environmental Protection Agency.

Table 1: Existing (Ex) and proposed (Pro) national ambient air quality standards for Indonesia

Measuring time		30 minutes		1 hour		3 hours		8 hours		24 hours		1 year	
Parameter	Unit	Ex	Pro	Ex	Pro	Ex	Pro	Ex	Pro	Ex	Pro	Ex	Pro
SO_2	µg/m³				900					260	300		60
CO	mg/m³				30			22,6	10				
NO_2	µg/m³				400					92.5[1]	150		100
O_3	µg/m³			200	160								
TSP	µg/m³									260	230		90
Lead	µg/m³									6	2		1
HC	µg/m³					160	160						
H_2S	µg/m³	42											
NH_3	µg/m³									1360			

1: "Nitrogen oxides"

Table 2: Standard measurement methods for the proposed national ambient air quality standards.

Parameter	Analysis method	Equipment for analysis	Sampling equipment
Sulphur dioxide	Colorimetric	Spectrometric	Gas sampler
Carbon monoxide	Non-dispersive infrared	Non-dispersive infrared analyzer	CO-analyzer
Nitrogen oxides as NO_2	Colorimetric	Spectrofotometer	Gas sampler
Oxidant as O_3	Colorimetric	Spectrofotometer	Gas sampler
Suspended particles	Gravimetric	Scale	High volume sampler
Lead	- Gravimetric - Destruction	Scale Atomic absorption	High volume sampler High volume sampler

WHO Air Quality Guidelines and Standards

WHO Air Quality Guidelines and standards are listed in Table 3.

For SO_2 the WHO guidelines are much lower than the proposed Indonesian standards for averaging periods 1 hour and 24 hours. The Indonesian CO values for 1 hour and 8 hours are equal to the WHO values. The Indonesian NO_2 1 hour value is the same as the WHO guideline. The proposed Indonesian O_3 1 hour guideline is within the WHO guideline range. The proposed 1 year value for lead is the same as the upper range WHO level. This is also the case for the proposed 24 hours and 1 year Indonesian guidelines for TSP.

Generally, the proposed Indonesian National Ambient Air Quality Guidelines follow the WHO guidelines, except the 1 hour and 24 hours values for SO_2.

No standards are proposed for PM_{10}, i.e. particulate matter less than 10 μm in aerodynamic diameter. This may be because of lack of monitoring equipment.

Table 3: WHO Air Quality Guidelines/Standards (WHO, 1977a, 1977b, 1978, 1979, 1987)

Parameter		10 minutes	15 minutes	30 minutes	1 hour	8 hours	24 hours	1 year	Year of standard
SO_2	µg/m^3	500			350		125^a	50^a	1987
SO_2	µg/m^3						100-150	40-60	1979
BS^b	µg/m^3						125^a	50^a	1987
BS^b	µg/m^3						100-150	40-60	1979
TSP	µg/m^3						120^a		1987
TSP	µg/m^3						150-230	60-90	1979
PM_{10}	µg/m^3						70^a		1987
Lead	µg/m^3							0.5-1	1987, 1977b
CO	mg/m^3		100	60	30	10			1987
NO_2	µg/m^3				400		150		1987
NO_2	µg/m^3				190-320^c				1977^b
O_3	µg/m^3				150-200	100-120			1987
O_3	µg/m^3				100-200				1978

Notes (WHO/UNEP 1992)

a Guideline values for combined exposure to sulphur dioxide and suspended particulate matter (they may not apply to situations where only one of the components is present).

b Application of the black smoke value is recommended only in areas where coal smoke from domestic fires is the dominant component of the particulates. It does not necessarily apply where diesel smoke is an important contributor.

c Not to be exceeded more than once per month.

Suspended particulate matter measurement methods (WHO/UNEP 1992)

BS = Black smoke; a concentration of a standard smoke with an equivalent reflectance reduction to that of the atmospheric particles as collected on a filter paper.

TSP = Total suspended particulate matter; the mass of collected particulate matter by gravimetric analysis divided by total volume sampled.

PM_{10} = Particulate matter less than 10 µm in aerodynamic diameter; the mass of particulate matter collected by a sampler having an inlet with 50 per cent penetration at 10 µm aerodynamic diameter determined gravimetrically divided by the total volume sampled.

TP = Thoracic particles (as PM_{10}).

IP = Inhalable particles (as PM_{10}).

References

KEPMEN (1988) National Ambient Air Quality Standards. The Decree of the State Minister for Population and the Environment. (KEP-02/MENKLM/I/1988).

WHO/UNEP (1992) Urban air pollution in megacities of the World. Earthwatch: Global environment monitoring system. Oxford, Blackwell.

WHO (1976) Selected methods for measuring air pollutants. Geneve (WHO Offset Publications no. 24).

Appendix 3

Air Pollution Laws and Regulations for Indonesia and DKI Jakarta

Regulations and Institutions in Air Pollution (1994)
An URBAIR report by Dr. Budirahardjo

REGULATIONS AND INSTITUTION IN AIR POLLUTION

1. GENERAL INFORMATION

Cities development all over the world give the consequences in transportation problems, due to the economic growth in the cities, causes the additional ownership of the vehicles and the increasing of number of population move to the surb urban area for the housing and located in the distance between residential are with the centre of the city and also job sites.

Jakarta for exmaple in 1985 was facing 14 million personal trips and based on the study of ARSDS, the projection is increasing to 24.9 million person trips in 2005 where the projected population is 12 million.

The annual increase of cars in Jakarta is around 11.76% in average, and there are alot of difficulties have faced to implement the limitation number of vehicles owned by citizens. It is understand able that the present tranffic condition mostly congested. Will become more critical if the counter measures are not being taken to overcome the situation especially in traffic problems.

The amount of vehicles on the roads and the traffic jam situation which are frequently happen is the source of emision of tail gas will cause the impact of worsening of ambient air quality.

2. REGULATIONS ON EMISION OF EXHAUST GAS HANDLING

In the field of traffic and land transportation, there are several regulations, among other:

2.1 Act number 14 of 1992 on: Traffic and Land Transportation, in Chapter 13 article (1) mentions:"Every motorized vehicle, trailler, box car and special vehicle which are on the roads subject to be tested"

Chapter 13 article (2): The testing as it is mean in the article (1) include the Type Approval and/or Periodic Test.

In Chapter 50 article (1): " To prevent air pollution and noise pollution form vehicle which might bring impact to the sustainability of Living Environment, every car(vehicle) obligatory to comply to the criteria of standard emision exhaust gas and noise level"

In Capter 50 article (2): "Every owner, manager of the Public Transportation, obligatory has to prevent the happening of air pollution and noise as what is mean in the article (1), as the results of the operationalization of vehiclas"

2.2 Government Regulation number 44 of 1993 on: Vehicles and drivers, in Chapter 127 article (1) among other mention : " Motorized vehicle has to comply with the requirement of Road Worthiness, which includes :

a. Emision of exhaust gas from motorized vehicle
b. The noise of main brake

In Chapter 127 article (3) mentions : " The criteria of road-worthiness which is mean in the article (1)a and b, will determined by Ministerial Decree who is responsible in the Living Environment after the consultation with Minister of transportation"

2.3 Decree of Ministery of Transportation number KM 71 of 1993 on : The periodical Test of Motorized Vehicle.
In Chapter 2 article (1) : Implementation of periodical test of motorized vehicle by mean of:

a. To guarantee of safety in the technical point of view in the using of motorized vehicle on the road.

b. To keep sustain environment from the possibility pollution due to the usage of the motorized vehicle on the road.

c. To serve the public servive to the society
In Chapter 3: Periodical test of motorized vehicle is done by Provincial Government and operatioanlly is done by Traffic and Transportation Servive in the Province, or can be delegated to Traffic and Transportation Service in Local Government Level.

In Chapter 12 mentioned: The equipment for testing of exhaust gases, include testing equipment for Carbon Monoxide (CO), Hydrocarbon (HC) and Smoke tester of the exhaust gases.

2.4 Decree of Ministrial of Transportation, number KM 8 of 1989 on: The criteria of standard limitation on the roadworthiness to the production of motorized vehicle, trailler, box car, body construction, truck body and each components, was decided the limit.

The decission about the exhaust gases, was decided in Chapter 3 and Chapter 4 as follow:

a. The content of CO and HC at emision of the exhaust motorized vehicle with Premium as the fuel with 87 RON has been decided maximum 4.5% for CO and 1200 ppm for HC.

b. The content of CO and HC at the emision gas of motorized vehicle in idling condition and during normal atmospheric condition.

c. The smoke content in the emision gas of motorized vehicle with compression ignition and with diesel fuel it was decided with maximum 50%.

d. The smoke level of the exhaust gas measured in free speed condition.

The criteria of noise level of horn belong to the motorized vehicle, was decided in Chapter 7 and 8 as follow:

a. The horn noise level of motorized vehicle was decided minimum 90 dB(A) dan maximum at 118 dB(A).

b. The decision of horn noise level of motorized vehicle be measured at the place where there is no noise with the reference noise level at the lower condition in the distant of 2 meters in front of vehicle.

2.5 Governor Jakarta Decree number 1222 of 1990, about "Standard emission of vehicle in Capital City of Jakarta"
In the Chapter 4, article (1) mentioned: The Traffic and High Way Service Department Jakarta is responsible to excercise Verification of vehicle emission in Capital City of Jakarta.
In the article (4) of the same Cahpter mentioned: The implementation of emission verification will be done at the same time with Road Worthiness test of the vehicle or separately.

2.6 Governor Jakarta Decree number 1236 of 1990 about operating procedure in implementing vehicle emission standard in Capital City of Jakarta.

In the Chapter 6, article (1) mentioned : The control toward implementation of vehicle emission will be done by related institution, includes:

- Provincial Planning Board of Jakarta (Bappeda0
- Bureau of Environment (BBLH)
- Urban Research and Environment Office (KPPL)
- Bureau of Economic Facilities Development(Bangsarekda)
- Bureau of Well-Order (Ro Ketertiban)
- Regional Invesment Board (BKPMD)
- Deparment of Health Servive (DKK)
- Department of Industry Service (Dinas Perindustrian)
- Department of Public Works Service (DPU)
- Department of City Planning Service (Dinas Tata Kota)
- Bureau of Law (Ro Hukum)

In Chapter 7, article (1) mentioned: Evaluation toward the emission standard will be done as follow:

a. Supervising in the emission parameters evaluation will be coordinated by Urban Research & Environmental Office

b. Supervising in the implementation evaluation will be coordinated by Bureau of Environment.

c. Supervising in the evaluation of regulation affair will be coördinated by Bureau of Law.

3. CONTROLLING AIR POLLUTION THROUGH EMISSION EXAMINATION

3.1 Procedure and Phasing of emission examination

The procedure which guides the air pollution programme in administrative border of Jakarta was mentioned in Governor Decree 1222 and 1236 of 1990.

In these decrees several items have to be underlined are as follow:

a. The vehicles that have to be examined are all kinds of vehicle which are operated in the public roads in Jakarta, includes Public cars, transportation cars, Passanger's cars, Buses, Trucks and Motor Cycles.

b. Every kind of vehicle in point a above, has to comply the satndard in the parameters as follow:

Table: 3.1

Type of Vehicle:	Fuel :	Standard Emission: CO-%Vol	NOx-ppm	HC-ppm	Smoke-%
Pessanger Car	Petrol	4.50	1,200	1,200	-
	Diesel	-	1,200	1,200	50
	Mixed	4.50	1,200	1,200	50
	CNG	3.00	-	-	-
Trucks;Pickup	Petrol	4.50	1,200	1,200	-
	Diesel	-	1,200	1,200	50
	CNG	3.00	-	-	-
Buses	Petrol	4.50	1,200	1,200	-
	Diesel	-	1,200	1,200	50
	CNG	3.00	-	-	-
Motor Cycles	Petrol	4.50	2,800	2,800	-
	Mixed	4.50	3,600	3,000	-

c. Transport & High Wagh Department Service is responsible in examination of emission in Jakarta, emission worthiness duration minimum 3(three) months and maximum

6 (six) months. The vehicle that fails to comply with emission standard is restricted to be operated in the public roads.

d. The phasing of implementation of standard emission:

1) Public en-lighting and educcation

2) The choice of appropriate testing equipment

3) Planning the needs of facilities

4) Testing Procedures and Certification

5) Cooperation with Private Sector

6) Supervising procedure between related institutions

3.2 The amount of vehicle compalcery to emission exam

The amont of vehicles compalcery to be emission examination and roadworthiness test in Jakarta based on the data upto the end of 1990 are as follow:

Table: 3.2

Amount of Vehicle:		Vehicle compalcery Exam.		
Type Vehicle	Amount	Type Of Vehicle	Amount	Exam
Public Car	40,522	Passanger Car	35,792	65,809
Private Car	553,755	Buses	26,759	21,110
Commercial	174,494	Cargo Car	134,719	197,097
Total:	1,531,645	Total:	197,270	285,016

With the assumtion of annual increase of vehicles that have to be examined as 8.72%, the projection will be 432,930 vehicles to be tested in the coming 5 (five) years.

At the same time based on the assumption of vehicle annual increasing rate is constant follow the rate in the period of 1986-1989, will give the estimation of vehicles which will be examined in 1995 (After stage I 1991-1994) are as follow:

Table: 3.3

Type of Vehicle	Annual increasing Rate (%)	Emission Exam 1990	Emission Exam 1995	Composition (%)
Private Cars	5.62	1,107,550	1,455,760	41.4
Cars compalcery to be exam-ed	8.72	285,016	432,930	12.3
Motor Cycles	1.34	1,525,748	1,630,740	46.3
Amount of Vehicles:		2,918,314	3,519,430	100.0

Assumption: Emission Exam 2 times/year

3.3 Examination of motorized vehicle emission

Principally the emission test is one of the component in Road Worthiness of the motorized vehicle, based on Decree of Minister of Transportation KM 8 of 1989.

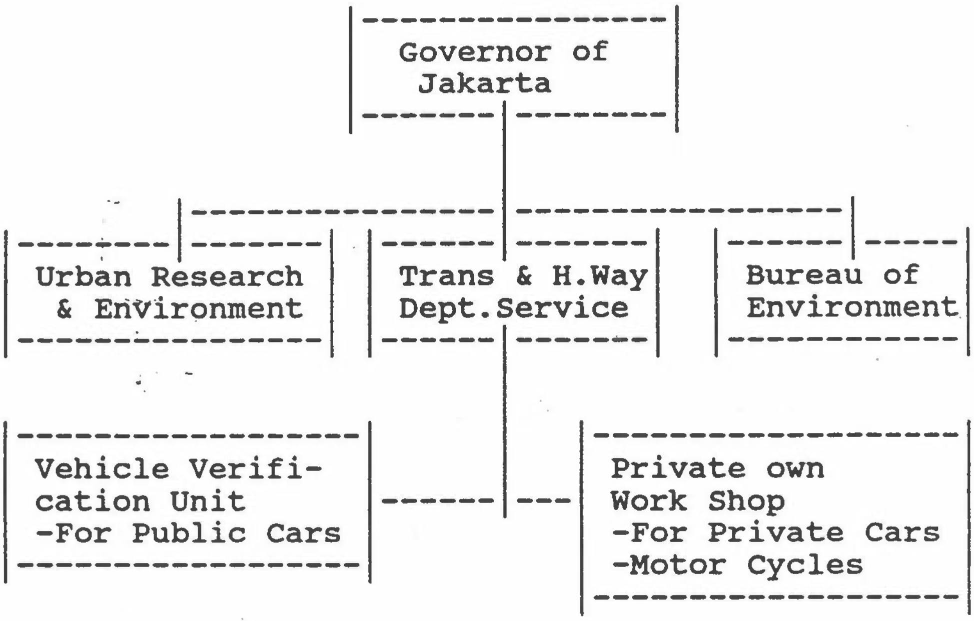
Due to the most of vehicles that have to be tested are private cars (87.7%) and mator cycles, this mean that most emission test facilities have to be prepared.

With the calculation of time needed for administrative affairs, at least 20 minutes for each testing. When the operation time of testing equipment is 6 hours, and 6 days week, and 50 weeks per year (2 weeks for maintenance and calibration), result of calculation is that every testing unit able to perform the testing for 1,800 hours/year or 5,400 cars per year. If the estimated amount of cars that have to be tested are 33 million in the year of 1995, the need og testing equipment is about 650 units.

This means the need of private sector participation.

3.4 Supervice of Emission Examination/Test

As it was mentioned in the Governor Decree number 1236 1990, the institution for vehicle emission test in Jakarta is as follow:



The related institutions in supervising verious activities and each related responsibility of vehicles emission test, was mentioned in the Chapter 2 above.

4. AIR POLLUTION CONTRO THROUGH TRAFFIC & TRANSPORTATION MGT

Air pollution control in the urbanized area might be supported by traffic management.

In the Provincial Government Act number 5 of 1984 about : Master Plan Jakarta up to the year 2005, in the policy guidline of Transportation Sector was mentioned the present of Restricted Zones in the center of the city.

The limitation of transportation was decided through the zoning.

The zoning in the center city, which surrounded by the rail way, the transportation limitation migh reach up to 75%, this means the residual 25% volume of transportation in this zone.

Zones surrounded by rial way ring up to inner ring road, the transportation limitation will be 50%.

Zones in between inner and outer ring road, the limitation will 25%, and zones outside outer ring road the limitation only 5-10%.

With this limitation of transportation means the amount of operated vehicles on the public road are decreasing, this will reduce amount of pollutant from tail gas of motorized vehicle. Beside the less of amount of vehicles means the average vehicle's speed on the public road also incraesing, and resulting less emission gases per unit lenghth of road.

The experiment of Restricted Area has been excercised by "Three in One" , since 20 th April 1992, in the Path of High Way Sudirman, Thamrin, Medan Merdeka Barat and Gatot Subroto from 6.30 - 10.00 AM. The private cars pass through the restricted zones have to be three ang more passangers.

The 14 months record on the results of "Three in One" are as follow:

- The private vehicles speed increas by 35%
- The Buses speed increase by 40%
- The volume of private vehicles increase by 2% but with increasing speed.
- The amount of buses increase by 99% (frequency of trips increase)
- The amount of buses passanggers increase by 89%.

The limitation of the usage of private cars has to be balanced by the public transportation service, as such that the people able to change to the public transportation rather than using their own cars. Special Bus lane has been tried since 1 March 1990 in several path of high way like Thamrin Sudirman from 07.00-09.00 and 16.00-19.00, and gradually will be followed in other high ways like: Sisingamangaraja, Medan Merdeka Barat, Gunung Sahari up to Jatinegara, Kramat Bunder to Suprpto, Pramuka-Pemuda, Panglima Polim Raya and Melawai Raya. In the year 1993 end wil be implemneted in Gajah Mada-Hayam Wuruk.

By the Special Bus Lane shows some improvemnt as follow:

- Average Bus speed increase by 32%
- Volume of Buses increase by 48%
- Passangers increase by 42%
- The amount of buses trips increase from 6 trips/day now up to 7.2 trips/day.

Mass Rapid Transportation still being considered by Central Government and Government of Jakarta Metropolitan. If the mode of Light Train or Sub Way was chosen, because both facilities are using electricity as power sources, this mean that the solution might bring the decrease of air pollution through Transportation Sector.

MRT which are presnt now is fly over rail way from Manggarai-Gambir, Rail way ring Kota-Senen-Jatinegara-Manggarai-Tanah Abang-Kota, to and fro. Also Electrially and diesel fuel Jabotabek Train. Electric wiring net work has been prepare and ready by now, excluded in Kebayoran Lama-Rangkas Bitung.

MRT also in the design state from Block M to City, to operate the facilities, an institution should be set up as Authority Agency to manage the facilities.

5. CONCLUSION

The land transportation has contribute domonantly to Air Pollution in the urban area/City as the results of emission gases, while the amount of vehicles are increasing.

* ~~At present the vehicle that compalsery to have emission test only limitted to public transportation and cargo truck and also buses,~~ And for private cars, motor cycle might invite the Private Sector to joint with the emission test activities.

"Three in One" shows a good result on air pollution abatement and should be broaden in the nears future.

MRT able to be the solution of transportation problem to limit the amount of private cars. and in the longrun also MRT in Jabotabek Region.

* According to the Regulation, all cars should undergo emission test. It will be implemented in phases, with cargo and public transportation getting first priority (Hadiwinoto, MEIP).

AIR POLLUTION CONTROL INSTITUTION

1. Dinas Lalu lintas dan Angkutan Jalan Raya (DLLAJR) = Road Traffic and Transportation Dept.

DLLAJR-DKI is a department of the Jakarta Provincial Government which is responsible for the control of road traffic and transportation, including the road worthiness of the motor vehicles and their emission.

The organization, tasks and procedures in the DLLAJR are defined in the Perda (Local Regulation) no. 2 / 1985. The head of the DLLAJR reports to the Governor, and he is under the administrative coordination of the Sekretaris Wilayah Daerah (Secretary of the Province).

The main tasks of DLLAJR are to execute/implement the planning, organizing, supervision, and control of the road traffic and transportation which are in the authority of the local / provincial government, and other tasks complying to the acts and regulations, to achieve a safe, orderly, and (smooth) traffic and transportation.

To execute the main tasks, the DLLAJR will:

(a). plan the road and transportation network;
(b). implement the techniques of traffic and transportation;
(c). implement the licencing of traffic and transportation;
(d). implement the vehicle inspection;
(e). control the traffic, transportation, and motor vehicles;
(f). control and ensure the safety of road transportation, terminals and transfer points;
(g). plan and construct terminal and transfer points.

The organization of DLLAJR comprises:

(a). Head of the DLLAJR
(b). Deputy Head of the DLLAJR
(c). Administration
(d). Accounting
(e). Personnels
(f). Planning and Programming
(g). Traffic Engineering
(h). Transport Services Development
(i). Traffic and Transportation Control
(j). Terminal and Transfer Points Development
(k). Vehicle Inspection
(j). Sub Department at the Municipality level.

Divisions which are related to the air pollution control are:

(a). Planning and Programming Division, responsible for data collection, programming, monitoring, evaluation and control, among others traffic counting on roads and intersections for all motor vehicles. Planning and Programming Division also conduct studies on traffic volume control, development of mass transit, the use of compressed natural gas, and development of passenger and goods transport routes.

(b). Traffic Engineering, responsible for road marking and signs, parking sites, traffic computers, crossing design, u-turns, medians, pedestrian bridge, etc.

(c). Transport Services Development Division, responsible for the development, licensing and control of transport services establishment, among others: licensing for the routes and operations of bus companies, and to implement/enforce the use of natural gas for public transportation.

(d). Traffic and Transportation Control Division, responsible for the coordination and formulation of control, enforcement, and information on traffic and transport system, development and supervision of driving-schools, garages/workshops, and emission control at the terminals.

(e). Car Inspection Division, responsible for the inspection of motor vehicles. Trucks, buses, and other public transport vehicles get the inspection each six months (twice yearly) including emission control. The inspections are carried out at the inspection office: Pulogadung for bus and passenger cars, and Ujung menteng for trucks. Also available are on-site inspections as requested by the car pools.

(f). The Sub-Departments at the Municipality level are responsible for the orderly functions of the traffic and transportation facilities, such as the control on bus, trucks, taxis, and the local traffic condition.

2. Badan Pengelola Terminal Angkutan Jalan= Road Transportation Terminal Authority.

The Head of the DLLAJ-DKI is an ex-officio head of the BPTAJ, because the functions are very closely related. The main task of BPTAJ is to optimize the capacity and outputs of all the terminal facilities to improve public service.

The organization comprises:
- Head of BPTAJ
- Deputy Head of BPTAJ
- Planning and Programming
- Development and Supervision
- Construction and Maintenance
- Security and Enforcement
- General Affairs
- Terminal Sites.

The divisions which are closely related to air pollution control are:
- Planning and Programming, which plans the operations and development of the terminals;
- Security and Enforcement, which control the transport services and emission discharge;
- Development and Supervision, which gives the guidelines,

motivate, and supervise the transport companies on condition of the vehicles;
- Terminal Sites, which conduct the daily control at the terminals, including the vehicle condition.

3. Biro Bina Lingkungan Hidup (BBLH)= Bureau of Environment.

BBLH is under the coordination of the Assistant of the Secretary for Social Welfare, at the Secretariate of the Province. Its main task is to prepare policies, coordination, and development on environmental affairs.

To implement the tasks, BBLH will:
(a). prepare policies, programs, and guidelines on environmental quality and environmental protection;
(b). coordinate, guide and encourage environmentally sound development;
(c). coordinate, plan and guide development of man-made environment;
(d). coordinate, plan, and guide implementation and enforcement of pollution control.

The organization of BBLH comprises:
(a). Human Settlements Division
(b). Man-made Environment Division
(c). Natural Environment Division
(e). Control Division.
There is no specific division for air pollution control, but it is included in the task of the Man-made Environment Division which is responsible for data collection, planning, programming and development of pollution abatement.
The Pollution Control Section in the Man-made Environment Division is in charge of:
(a). data collection, programming, and preparing guidelines for the development of pollution control;
(b). coordination for implementation of pollution control.

The structure is rather confusing and needs some adjustment.

4. Direktorat Jendral Perhubungan Darat (DJPD)= Directorate General for Land Transport

DJPD is a Directorate General under the Ministry of Transportation responsible for road transportation, railway, and ferry. The development of the Urban Mass Transit System (Sarana Angkutan Umum Massal = SAUM) will help reduce the air pollution in urban areas.

Without an adequate mass transit system the growing metropolis will depend only on road transportation, especially private cars. Traffic jams and air pollution has been worsening continuously. A breakthrough is critically needed to reduce traffic jams and air pollution, giving priority to public transport, especially the mass transit system.

The Organization Structure of the Bureau of Environment :

Secretary of the
Provincial Government

Assistant for
Social Welfare

Other
Assistants

Bureau of
Environment

Human Settlements Control Division	Man-made Env. Division	Natural Env. Division	Division
Planning Cleanliness Section	Env. impact Analysis	Conservation Section	& Slum impr
Development Section	Pollution Control	Rehabilitation Section	Water Supply
Administration Section	Education & Information	Natural Resources Section	

Appendix 4

Emission Survey for Jakarta

Contents

Emission Survey for Jakarta

1. Introduction

This emission survey is prepared to serve as input for model calculations for the Jakarta area, as a tool in developing an Air Quality Management Strategy (AQMS) for the area. In order to use it as a tool it is necessary to have correct information about the present emission situation (amounts and spatial distribution) and the effects of different development strategies. Model calculations together with air quality measurements will give a description of the present situation, and the model may be used later to range the different alternatives for the future.

An emission inventory should cover source groups as industrial point sources, small industry and domestic emissions and emissions from main road and local road traffic. It is impossible to calculate the emissions from each single source (house, stack, car), but using representative emission factors will normally give very good estimates. The emissions in a city may be grouped in three main groups: traffic, industrial and domestic activities. For model calculations it is necessary to calculate both total emissions for each group and the spatial distribution of the emissions.

This survey is not a complete emission survey for Jakarta. It is based upon data which are not satisfactory explained and errors may have been introduced. Many source groups are not included yet, and for other the calculations are based upon secondary information, specially for the spatial distribution. This means that many basic input data are still missing, and we have had to use other data than desired to calculate the distribution.

2. Map and emission grid

The emission calculations were intended to be made for a 1 km^2 grid of 32 x 32, using the UTM net according to "Peta Rubumesi Indonesia" 1:25 000, edition 1990. All road coordinates and references are given relative to these maps.

Figure 1 shows the DKI Jakarta Region and the grid net, which covers 1024 km^2. DKI Jakarta itself covers about 666 km^2, the rest is areas in Bekasi, Bogor, Tangerang and sea. The district borders in the figure are drawn directly from reduced copies of the maps.

For this study, basic data for calculating emissions for many source groups were not available in the first phase. For these we had to make use of data from Dr. Soedomos estimates of the emissions in Jakarta (Soedomo, 1992). He uses a grid network of about 1500 x 1500 m^2, and we found it difficult to transform his data to the km^2-grid. Instead it was decided to use the Soedomo grid for the calculations. In the UTM-system this corresponds to a zero-point in the lower left corner with UTM-co-ordinates ($^{6}86$, $^{92}95$).

As air pollution moves across all administrative boundaries, an emission survey has also to take into account activities in the surroundings of Jakarta, but the most dominant work has to be made for Jakarta itself. Near the border of Jakarta there are industrial activities, mainly along the main roads to the east, south and west of the metropol. The new Jakarta International Airport Soekarno-Hatta is also situated outside the border east of Jakarta, in Tangerang.

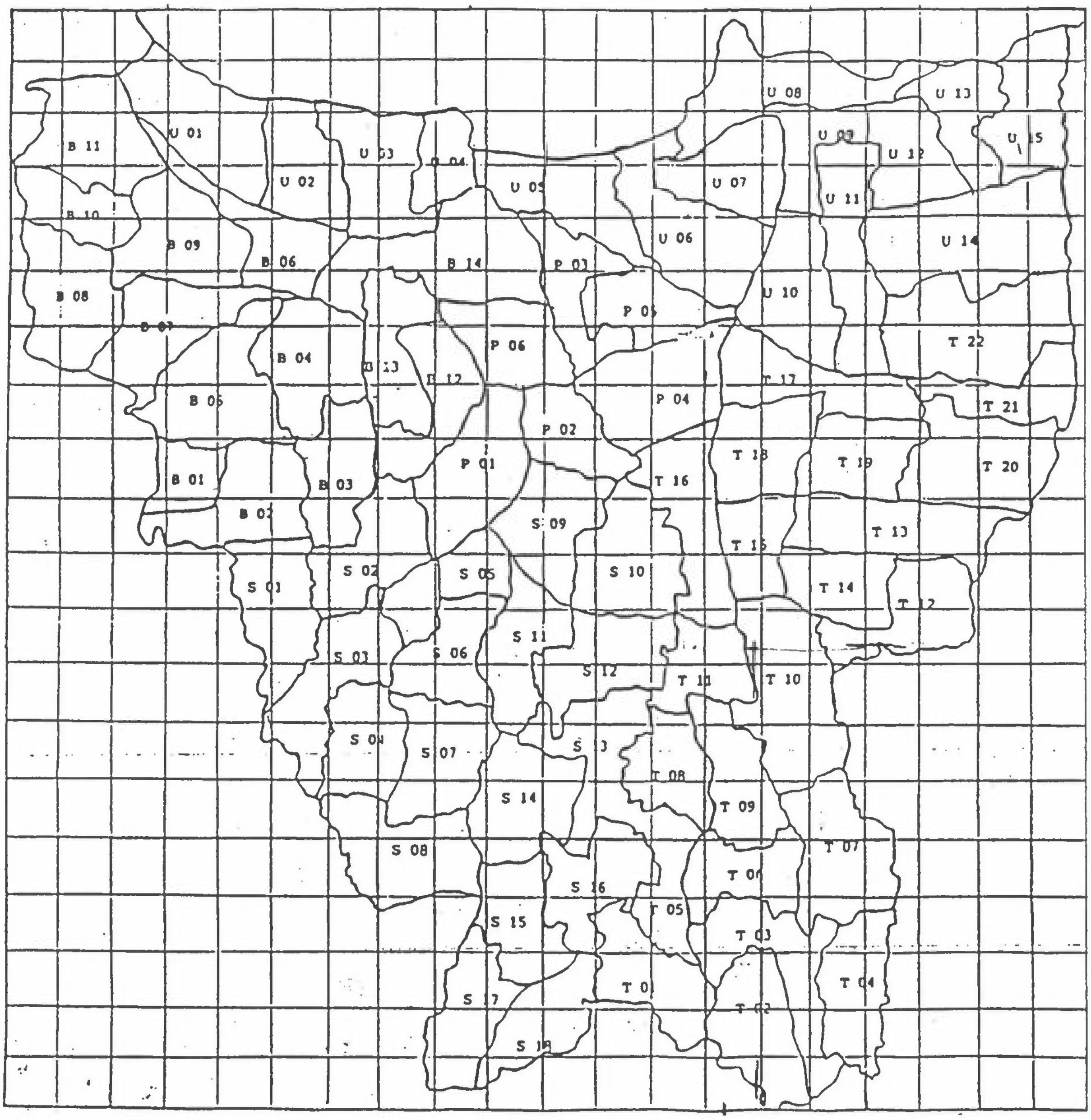


Figure 1: Districts in Jakarta and the Soedomo grid.
Legend: P: Central Jakarta, S: South Jakarta, T: East Jakarta, U: North Jakarta, B: West Jakarta.

3. Population distribution

Many of the emitting activities in a city are distributed according to the population distribution, and the exposure calculations use the population distribution directly.

The evaluation of the population distribution is based upon data from the census 1990 (Jakarta Statistical Office, JSO, 1991) and the Jakarta maps showing the borders of the different districts and sub-districts. For each sub-district there was evaluated a distribution code to the grid net, and the population within the sub-district allocated to the grid according to this.

This is a method which gives a fairly correct distribution; the more complete the information upon which the distribution code is based, the more correct will the result be. The errors will be of the order of locating some hundreds of inhabitants in one grid instead of the neighbouring grid. When the distribution code has been made, it is easy to make new distribution calculations with new population data, e.g. future projections. It is only when there have been (or are planned) major changes within a sub-district that the distribution code has to be revised.

The population in grid (I,J) within sub-district K will be:

$$POP(I,J) = INH(K)*COV(I,J,K),$$

where

INH(K) is the number of inhabitants in the sub-district K
COV(I,J,K) is the coverage of grid (I,J) to sub-district K
$\Sigma COV(I,J,K) = 1.0$

In different data sets for the population of Jakarta the area of each region and sub-region varies, often considerably, from data-source to data-source. It is not known whether this has to do with new administrative borders or different reference maps. Table 1 shows the land area and the population for the districts (kecamatans) in Jakarta according to different sources. There are large differences between the data sets which cannot be explained only by migration or development. To produce a correct population distribution it is necessary to check the background for the input data very strictly. In the calculations we have used data from JSO 1991; for some of the kelurahans we have used areas according to the map and other sources. Figure 2 shows the calculated population distribution for Jakarta 1990.

Table 1: Population in the regions of Jakarta according to different sources. Data sources: 1987: Bachrun et al., 1991; 1990: Soedomo, 1993; 1990stat: JSO 1991. kel.: number of kelurahans

Central Jakarta (Jakarta Pusat)					
	km2	kel.	1987	1990	1990 stat
Tanah Abang	9.30	7	229,896	192,152	203,975
Menteng	6.53	5	116,581	90,774	117,415
Senen	4.23	6	134,547	112,589	130,256
Cempaka Putih	4.69	3	84,400	92,497	88,242
Johar Baru	2.38	4	112,850	122,866	106,847
Sawah Besar	6.22	5	152,040	124,482	146,455
Gambir	7.80	6	129,493	112,864	127,021
Kemayoran	8.21	8	206,107	226,528	228,457
Jakarta Pusat	49.36	44	1,165,914	1,074,752	1,148,669
Jakarta East (Jakarta Timur)					
	km2	kel.	1987	1990	1990 stat
Pasar Rebo	12.95	5	80,366	119,517	99,431
Cipayung	27.21	8	55,939	100,860	71,449
Ciracas	16.09	5	94,709	157,674	122,372
Kramat Jati	13.34	7	159,711	211,757	175,521
Makasar	21.64	5	117,989	146,532	134,224
Jatinegara	10.64	8	253,682	277,578	266,335
Duren Sawit	23.13	7	205,068	290,246	241,577
Matraman	4.85	6	176,205	165,372	179,595
Pulo Gadung	15.71	7	229,115	279,103	251,313
Cakung	42.43	7	119,112	315,826	191,284
Jakarta Timur	187.99	65	1,491,896	2,064,465	1,733,101
Jakarta West (Jakarta Barat)					
	km2	kel.	1987	1990	1990 stat
Kebon Jeruk	17.87	6	144,399	261,605	165,479
Kembangan	24.64	5	81,043	157,233	99,856
Cengkareng	30.10	6	130,868	367,969	178,087
Kalideres	27.39	5	94,147	175,496	102,712
Grogol Petamburan	11.39	6	224,316	242,015	221,188
Palmerah	7.54	5	186,090	217,065	191,625
Tambora	5.48	11	243,242	263,607	266,499
Taman Sari	4.36	8	155,534	130,326	152,205
Jakarta Barat	128.77	52	1,259,639	1,815,316	1,377,651
South Jakarta (Jakarta Selatan)					
	km2	kel.	1987	1990	1990 stat
Kebayoran Lama	19.31	6	210,805	260,764	262,722
Pesanggrahan	13.46	5	89,891	153,715	125,705
Pasar Minggu	22.71	7	224,038	231,848	203,519
Jagakarsa	25.51	5	111,812	143,072	127,505
Mampang Prapatan	7.73	5	127,758	148,665	125,242
Pancoran	8.23	6	112,786	141,373	123,333
Kebayoran Baru	12.75	10	199,175	186,865	198,033
Setia Budi	9.05	8		179,405	185,959
Tebet	9.53	7		248,493	273,961
Cilandak	18.35	5	166550	172,036	147,706
Jakarta Selatan	146.63	64		1,866,236	1,773,685

Table 1: Contd.

Jakarta North (Jakarta Utara)					
	km2	kel.	1987	1990	1990 stat
Penjaringan	35.48	5		155,630	158,798
Pademangan	9.91	3	118,203	90,505	120,317
Tanjung Priok	25.22	7	250,024	277,372	284,654
Koja	11.38	6	226,160	241,833	246,975
Kelapa Gading	16.12	3	59,253	67,305	71,604
Cilicing	43.29	7	161,879	177,214	178,628
Pulau Seribu	11.80	4	14,467	14,246	14,276
Jakarta Utara	153.20	35		1,024,105	1,075,252
Total	665.95	260		7,844,874	7,108,358

The same procedure may be used for distributing other types of data, using demographic or socio-economic data. For example the use of different fuels may be a function of social standard.

```
MAP FOR INHABITANT  UNIT: PERSON
HIGHEST VALUE IS  1.2044E+05, IN ( 11 , 15)
SUM= 7.10835E+06SCALE:  1.0E+02
GRID SIZE: 1500 METER
```

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
J=20	.	.	1.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3.	6.
J=19	39.	47.	23.	5.	2.	4.	.	.	.	.	.	.	.	76.	162.	63.	173.	63.	41.	9.
J=18	64.	107.	104.	32.	7.	39.	157.	255.	255.	.	.	195.	139.	426.	822.	673.	398.	217.	28.	10.
J=17	51.	72.	117.	130.	94.	22.	123.	558.	528.	540.	390.	100.	392.	493.	772.	278.	351.	306.	42.	24.
J=16	78.	97.	87.	106.	145.	202.	469.	459.	790.	898.	1045.	397.	147.	147.	131.	137.	39.	39.	39.	29.
J=15	72.	110.	116.	92.	92.	356.	635.	722.	565.	395.	1204.	855.	635.	316.	122.	132.	65.	43.	37.	26.
J=14	43.	105.	84.	69.	111.	193.	370.	828.	651.	228.	813.	895.	638.	356.	199.	151.	96.	45.	35.	90.
J=13	.	.	35.	49.	49.	189.	370.	778.	730.	1098.	489.	486.	499.	636.	392.	231.	252.	127.	104.	97.
J=12	.	.	40.	190.	112.	225.	227.	974.	758.	763.	585.	945.	865.	708.	520.	194.	155.	81.	81.	37.
J=11	.	.	59.	97.	116.	250.	260.	348.	565.	729.	682.	768.	933.	682.	384.	341.	341.	325.	169.	.
J=10	.	.	.	.	.	129.	263.	291.	313.	407.	399.	888.	863.	840.	711.	357.	268.	211.	209.	.
J= 9	.	.	.	.	.	79.	240.	298.	445.	402.	139.	557.	452.	527.	513.	66.	175.	153.	112.	.
J= 8	.	.	.	.	.	29.	303.	159.	380.	396.	118.	672.	319.	425.	369.	66.	31	.	.	.
J= 7	.	.	.	.	.	47.	199.	129.	204.	257.	253.	313.	208.	228.	268.	62.	52	.	.	.
J= 6	.	.	.	.	.	.	82.	123.	258.	213.	200.	228.	304.	255.	272.	177.	63.	16.	.	.
J= 5	.	.	.	.	.	.	.	73.	105.	112.	144.	188.	207.	287.	181.	164.	76.	32.	.	.
J= 4	.	.	.	.	.	.	.	.	23.	25.	67.	155.	237.	252.	49.	82.	60.	32	.	.
J= 3	.	.	.	.	.	.	.	.	.	44.	91.	78.	137.	132.	94.	55.	32.	12	.	.
J= 2	.	.	.	.	.	.	.	.	10.	55.	64.	56.	.	88.	89.	58.	33.	11	.	.
J= 1	.	.	.	.	.	.	.	.	6.	41.	25.	.	.	.	30.	66.	20.	7	.	.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Figure 2: Population in Jakarta 1990 (in hundreds of inhabitants) (Source: JSO, 1991).

4. Exhaust emissions from traffic

Total traffic work

To make an estimate of total traffic work and emissions from traffic a normal approach is to use the number of registered cars of different categories together with an estimate of an average annual driving distance (AADD) for each vehicle category as the basis for the estimates. In many cases, however, AADD is not known and estimates shows large differences from city to city.

The following estimate for the annual average daily traffic (AADT) in Jakarta is instead based upon data for the yearly gasoline consumption, 1175 x 10^3 m^3 in 1990 (JSO, 1991). Soedomo has reported counts of different vehicle categories for morning (07-09), daytime (12-14) and afternoon (16-18) traffic at 22 different roads in Jakarta (Soedomo, 1993), and from the sum of all counts for each vehicle category an average vehicle distribution is calculated, as shown in Table 2.

Table 2: Distribution of vehicle categories in the urban traffic of Jakarta. The values are normalized with respect to the total traffic intensity.

Sedan + Taxi	Pickup	Bus	Microlet + Metro Mini	Truck	Truck Gandeng	MC	Bajaj
.5083	.0524	.0216	.0425	.0138	.0002	.3189	.0423

This traffic composition is based upon counts at only a few roads, many of them with restrictions for certain vehicle types. The main road network in Jakarta should be classified into different road classes and for each road class separate vehicle distributions should be calculated. Also, hourly counts should be performed for 24 hours at several (10 or more) roads, in order to study the representativity of short-time counts.

The EPA reports the following fuel consumption for Indonesian vehicles (Bosch, 1991), taken from the Highway Transport Planning Project 1986:
(Assumed average speed is 30-40 km/h)

Car: .171 l/km (80% gasoline/ 20% diesel)

Truck:
- Pickup .171 l/km (50% gasoline/ 50% diesel)
- Medium .181 l/km (20% gasoline/ 80% diesel)
- Heavy .236 l/km (0% gasoline/100% diesel)

Bus:
- General .191 l/km (0% gasoline/100% diesel)
- Oplet/Sudaco .181 l/km (31% gasoline/ 69% diesel)

Motorcycle: .020 l/km(100% gasoline/ 0% diesel)

Becak: .020 l/km(100% gasoline/ 0% diesel)

This gives a gasoline consumption for each group as shown in Table 3.

Table 3: Specific gasoline consumption in Jakarta.

Vehicle group	Fraction of traffic	Gasoline fraction	Consumption l/km	Consumption l/year
Sedan/Taxi	.5083	0.8	.171	.06953 * AAT*
Pickup	.0524	0.5	.181	.00474 * AAT
Truck, med.	.0138	0.2	.200	.00055 * AAT
Bus, small	.0425	0.31	.181	.00238 * AAT
Bajaj/MC	.3612	1.0	.02	.00722 * AAT
SUM	0.810		1175 * 10^6 l**	.08443 * AAT

* The total traffic work for the gasoline cars.

** Total annual consumption

Compared with the total gasoline consumption this gives the total traffic work for the gasoline cars.

> AAT = 13,917 * 10^9 car-km/year and the annual average daily gasoline traffic AADT = 38.129 * 10^6 car-km/day.

According to Table 3 the gasoline cars represent 81% of the total traffic work, and this gives a total traffic work of 17.181*10^9 car-km/y or 47.073*10^6 car-km/day. The validity of this approach is dependent upon correct consumption figures for gasoline, accepted consumption factors, correct statistical data for gasoline/diesel composition for each vehicle group and a traffic composition based upon sufficiently complete traffic counts. As explained, there are however, shortcomings in the data basis that needs to be improved, e.g. more counts and data for traffic compositions.

Following the same procedure for diesel, we get a diesel consumption factor of 0.0336 l/km, which should give a diesel consumption of 110*10^3 m^3/year. For the industry there will often be an uncertainty in the data on the consumption of different similar fuel types. Diesel and similar fuels are used both for heating, in industry and in traffic, and the uncertainties may be high. Normally the export/import of gasoline use across city boundaries may be neglected. This means that vehicles filling within the area and driving outside the area compensate for cars driving into the area from outside.

Emission factors

In several recent studies in Indonesia, the emissions from car traffic have been estimated for various areas:

A joint Indonesian German Energy Strategy Study (BPPT/KFA, 1991). In this study, the emissions from 364 different vehicles were measured under different driving conditions, and overall emission factors were extracted,

an air quality study in Medan (Bosch, 1991),

an energy conservation study for Surabaya (IIEC, 1991).

The emission factors used in the studies are listed in Table 4.

Table 4: Emission factors (g/km) for different vehicle classes, used in recent studies in Indonesia.

	Passenger cars		Trucks and buses	Small trucks and buses		Motor cycles
	Gasoline	diesel	diesel	gasoline	diesel	
CO						
VWS, 1991	24	5.2	2.5	41	5.3	20/17 (4/2-stroke)
Bosch, 1991	57	3.1	8.8	58		24 (MC + Bajaj)
IIEC, 1991						
- uncontrolled (Techn. II)	62	1.9	12	62	1.9	31/26 (4/2-stroke)
- controlled (Techn. IV)	23	1.4	10	23	1.4	22/18 (4/2-stroke)
NO_x						
VWS	6.9	1.3	11	9.1	1.5	0.15/0.08 (4/2-stroke)
Bosch	2.2	1.3	17	2.6		0.18
IIEC						
-Techn. II	2.0	1.4	20	2.0	1.4	0.2
-Techn. IV	1.0	1.1	13	1.0	1.1	0.4/0.2 (4/2-stroke)
HC						
VWS	2.2	0.5	1.6	3.9	0.5	1.8/9.9 (4/2-stroke)
Bosch	8.5	1.3	3.0	9.7		8.9
IIEC						
-Techn. II	8.3	0.7	3.7	8.3		8.2/19 (4/2-stroke)
-Techn. IV	3.0	0.6	1.9	3.0	0.6	3.7
Particles (combustion)						
VWS			0.36			0.029/0.21 (4/2-stroke)
Bosch	0.16		1.2			
SO_x						
VWS		0.57	0.85			0.014/0.024 (4/2-stroke)
Bosch	0.13	0.38	1.75			0.019

VWS factors: Overall emission factors, Java driving conditions
Bosch factors: Urban driving conditions, Medan
IIEC factors: Uncontrolled vehicles (Techn. II)
Controlled " (Techn. IV)
Factors for various driving speeds were given. Those presented in this table are for 24 km/h, i.e. urban driving.

The emission factors used in this URBAIR calculation for Jakarta were selected on the basis of following sources of data:

- US EPA emission factors from the AP42 publication.
- Emission factors from the WHO publication: “Assessment of Sources of Air, Water and Land Pollution”, Part I: Rapid Inventory Techniques in Environmental Pollution (Geneva, 1993).
- Emission factors for suspended particles from road vehicles described in Appendix 5.

The selected emission factors for road vehicles are shown in Table 5.

Table 5: Emission factors used for URBAIR, Jakarta.

	TSP (g/km)	NO_x (g/km)
Gasoline		
Passenger cars	0.2	2.7
Pick-up etc.	0.33	2.7
Truck medium, bus	0.68	8.0
Bajaj, MC	0.50	0.07
Diesel		
Passenger cars	0.6	1.0
Pick-up etc.	0.9	1.0
Truck, bus	2.0	13
Bus, Coplet etc.	0.9	13

Based upon estimates for the total traffic and with emission factors from Table 5 above, Table 6 shows the emissions of NO_x (as NO_2) and TSP in Jakarta from different vehicles.

Table 6: Emissions of NO_x (as NO_2) and TSP in Jakarta from different vehicle groups.

Gasoline	AADT 10^6 car-km/a	Emission factor g NO_x/km	Emission factor g TSP/km	Emission ton/year NO_x	Emission ton/year TSP
Sedan/Taxi	5659	2.7	0.2	15279	1132
Pickup	365	2.7	0.33	986	120
Truck, medium	38	8.0	0.68	304	26
Bus, Oplet/Sundaco	183	8.0	0.68	1464	124
Bajaj	589	0.07	0.5	41	295
MC	4438	0.07	0.5	311	2219
Sum gasoline	11272	1.63	0.347	18385	3916
Diesel	AADT 10^6 car-km/a	Emission factor g NO_x/km	Emission factor g TSP/km	Emission ton/year NO_x	Emission ton/year TSP
Sedan/Taxi	1415	1.0	0.6	1415	849
Pickup	365	1.4	0.9	511	329
Truck, medium	154	13.0	2.0	2002	308
Truck, heavy	1	13.0	2.0	20	3
Bus, Oplet/Sundaco	408	13.0	0.9	5304	367
Bus general	301	13.0	2.0	3913	602
Sum diesel	2644	4.98	0.93	13165	2458
Total	13916	2.267	0.35	31550	4866

Spatial distribution of traffic emissions

To evaluate the spatial distribution of the traffic emissions it is necessary to start with the distribution of the traffic work. This consists of traffic on the main roads and local roads. Normally the traffic work on the local roads is in the order of 15-20% of the total. Due to other driving conditions on the local roads than on the main roads the emissions, particularly of CO, might be much higher.

Main road network and local roads

From Jakarta maps a main road network was defined. At the beginning this was a coarse network, but as the work proceeded the network was gradually made finer. The coordinates for all crossings in this network were measured and transformed to the grid net. Figure 3 shows the main road network used in Jakarta. We had traffic data only for a few major roads, so we had to use the data very extensively. From other reports from Jakarta there seems to exist more data, but these have not been available in this work.

From a road map for Jakarta (FALK-plan: Street atlas and index, 1992) the main roads were grouped into four classes, based upon the map's representation of the roads, and these were later subdivided according to other maps. Finally the groups were given values for AADT (Annual Average Daily Traffic) from 140,000 to about 20,000. From this road network the total road length and the traffic work were calculated within each grid. This gave a total of 569 km roads and 38.5 mill. car-km/day ($14 * 10^9$ car-km/a). By this method we got an over-estimate of the traffic work. The calculated traffic work on the main road network only gave about the same value as for the total traffic work (incl. local roads) which was calculated on the basis of the data for total and specific fuel consumption, and vehicle composition. The traffic data for the road network was therefore reduced, except for roads near places with counts, where the counts were still used. In this way the estimate of the traffic work on the main roads was reduced to about $10*10^9$ car-km/a, some 70% of the total traffic activity. The rest of the traffic, traffic on local roads, estimated to about $4*10^9$ car-km/a, was distributed according to the population distribution. This is probably not correct since much of the population in the densest populated areas does not own motor vehicles. When more accurate data for the traffic on the main road net is available, the spatial distribution of the traffic and the traffic emissions can be calculated more correctly.

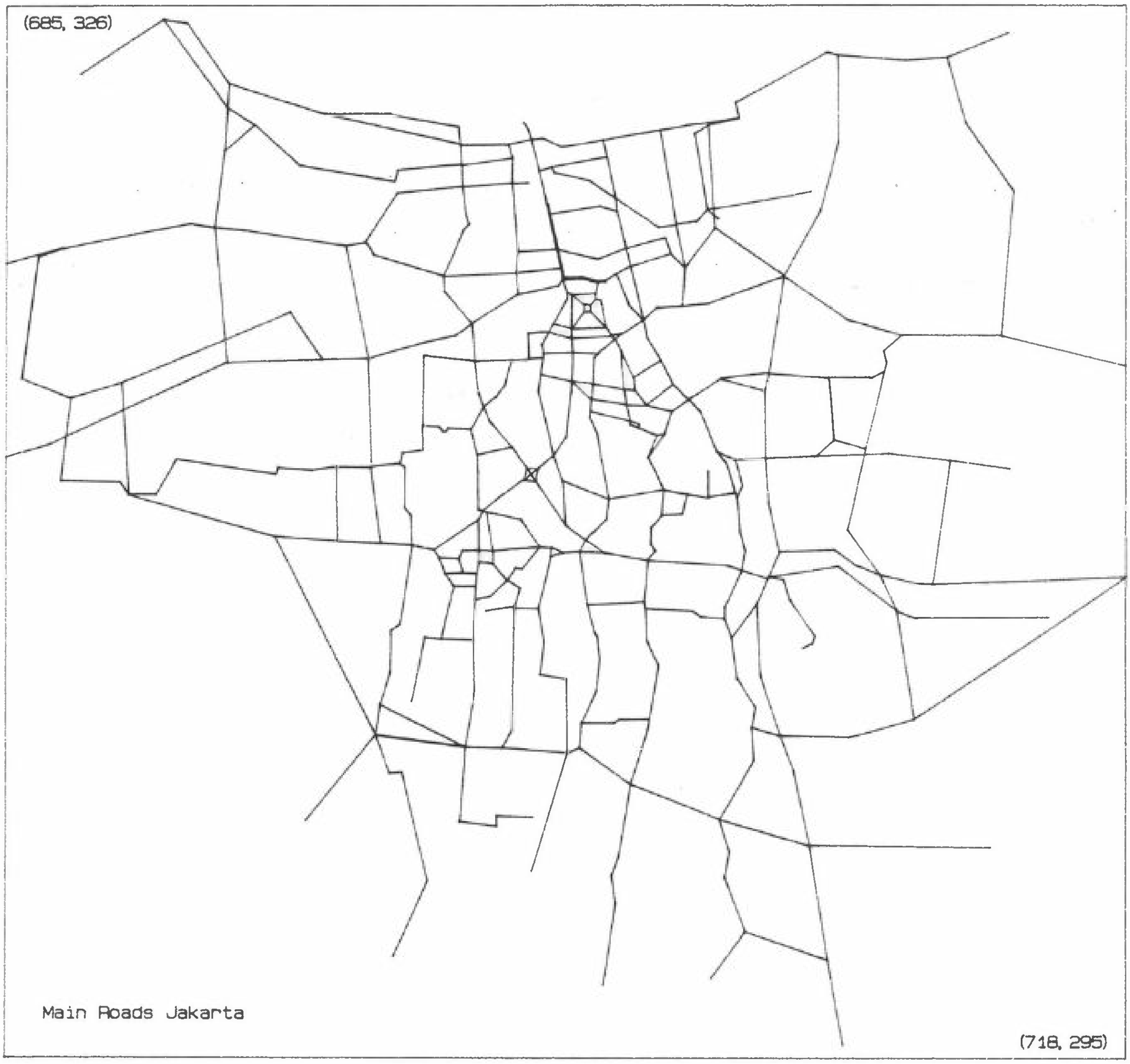


Figure 3: Main road network in Jakarta.

Figure 4 shows a map of the total traffic work for Jakarta, and figures 5 and 6 show the emissions of NO_x and TSP from car traffic in Jakarta.

```
MAP OF   : TRAFFIC   UNIT : CAR-KM/Y  SOURCE    : POP
 PERIOD : 1990       PLACE: JAK       GRID SIZE: 1500 METER
 CREATED: 1995/07/28 17.41

MAXIMUM VALUE IS  2.9004E+08, IN (11,16)
SUM= 1.71176E+10     SCALE FACTOR:  1.0E+05
```

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
J=20	31.	112.	31.	165.	15.	0.	0.	0.	0.	0.	0.	0.	0.	0.	418.	808.	386.	127.	73.	6.
J=19	38.	47.	23.	85.	181.	174.	240.	241.	143.	130.	16.	396.	459.	725.	189.	615.	170.	64.	82.	9.
J=18	63.	105.	102.	101.	52.	120.	277.	667.	1298.	775.	544.	689.	321.	475.	809.	1245.	392.	214.	67.	30.
J=17	70.	272.	316.	387.	492.	332.	559.	550.	950.	866.	1168.	962.	722.	702.	908.	841.	345.	301.	41.	419.
J=16	281.	96.	86.	164.	143.	287.	1116.	1170.	1354.	1690.	2900.	1555.	364.	340.	1206.	202.	38.	38.	360.	102.
J=15	70.	108.	114.	248.	150.	386.	927.	1128.	1742.	727.	2584.	2286.	1068.	546.	680.	531.	590.	436.	755.	290.
J=14	93.	183.	212.	337.	662.	762.	1226.	1270.	1411.	1050.	1860.	1810.	1371.	908.	1192.	762.	766.	45.	35.	230.
J=13	119.	92.	51.	48.	48.	186.	660.	1235.	1596.	1556.	1479.	1182.	1172.	872.	939.	946.	677.	126.	103.	96.
J=12	100.	310.	123.	247.	176.	319.	409.	1382.	1067.	2099.	1175.	1660.	1403.	1987.	1460.	699.	996.	594.	478.	50.
J=11	0.	11.	366.	403.	442.	571.	511.	942.	1608.	1313.	1737.	1131.	1212.	1073.	942.	646.	416.	479.	166.	0.
J=10	0.	0.	0.	0.	151.	283.	287.	878.	1662.	1133.	1667.	1799.	1430.	1688.	1944.	1188.	1255.	557.	162.	81.
J= 9	0.	0.	0.	0.	77.	285.	455.	786.	919.	841.	984.	964.	943.	1301.	845.	460.	741.	671.	552.	636.
J= 8	0.	0.	0.	0.	28.	348.	485.	676.	786.	568.	1164.	314.	828.	794.	634.	30.	80.	317.	194.	97.
J= 7	0.	0.	0.	0.	46.	196.	661.	572.	831.	651.	991.	655.	278.	513.	1028.	348.	308.	248.	0.	0.
J= 6	0.	0.	0.	0.	0.	324.	310.	298.	368.	197.	350.	798.	325.	603.	750.	62.	16.	0.	0.	0.
J= 5	0.	0.	0.	0.	0.	127.	72.	164.	249.	191.	204.	503.	336.	611.	436.	584.	196.	164.	82.	0.
J= 4	0.	0.	0.	0.	0.	0.	0.	86.	25.	79.	152.	538.	248.	214.	81.	617.	32.	0.	0.	0.
J= 3	0.	0.	0.	0.	0.	0.	10.	55.	44.	89.	77.	434.	130.	292.	158.	619.	12.	0.	0.	0.
J= 2	0.	0.	0.	0.	0.	0.	0.	9.	54.	63.	56.	164.	86.	170.	58.	614.	11.	0.	0.	0.
J= 1	0.	0.	0.	0.	0.	0.	0.	6.	40.	25.	0.	0.	0.	30.	65.	431.	7.	0.	0.	0.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Figure 4: Traffic work in Jakarta.

In the calculations of the traffic work we had no specific information about the traffic composition on each road, or variations in the traffic composition in various parts of Jakarta. This means that for calculating the emission field for traffic we had to make use of the average, weighed emission factors from Table 5, 2.27 g NO_x/km and 0.45 g TSP/km. This gives traffic emission fields for NO_x and TSP shown in figures 5 and 6.

```
MAP OF   : NOx traf  UNIT : kg/h  SOURCE    : Traffic
 PERIOD : 1990       PLACE: JAK   GRID SIZE: 1500 METER
 CREATED: 1995/07/28 17.41

MAXIMUM VALUE IS  7.5062E+01, IN (11,16)
SUM= 4.43003E+03    SCALE FACTOR:  1.0E-02
```

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
J=20	80.	290.	81.	427.	39.	.	.	.	.	.	.	.	.	.	1082.	2091.	999.	329.	190.	14.
J=19	100.	121.	59.	220.	468.	449.	621.	624.	370.	336.	41.	1025.	1188.	1877.	490.	1591.	440.	165.	213.	23.
J=18	163.	272.	264.	260.	134.	312.	718.	1725.	3358.	2006.	1408.	1784.	830.	1229.	2094.	3223.	1015.	553.	173.	78.
J=17	180.	705.	819.	1001.	1273.	860.	1447.	1423.	2459.	2241.	3022.	2490.	1867.	1817.	2350.	2178.	894.	780.	105.	1085.
J=16	727.	248.	222.	424.	371.	744.	2888.	3028.	3503.	4375.	7506.	4023.	942.	880.	3122.	522.	100.	100.	933.	265.
J=15	182.	281.	295.	641.	388.	1000.	2400.	2919.	4507.	1881.	6686.	5917.	2765.	1414.	1759.	1374.	1528.	1129.	1953.	750.
J=14	241.	475.	550.	873.	1713.	1971.	3174.	3286.	3652.	2718.	4815.	4684.	3549.	2351.	3085.	1971.	1981.	116.	90.	595.
J=13	308.	238.	131.	123.	123.	481.	1709.	3195.	4131.	4026.	3826.	3060.	3033.	2256.	2429.	2447.	1753.	325.	266.	248.
J=12	259.	802.	318.	640.	456.	826.	1058.	3578.	2762.	5433.	3041.	4297.	3632.	5142.	3778.	1809.	2579.	1538.	1238.	128.
J=11	.	28.	947.	1043.	1144.	1477.	1322.	2438.	4161.	3398.	4496.	2928.	3137.	2777.	2438.	1672.	1077.	1240.	431.	.
J=10	.	.	.	.	392.	733.	743.	2273.	4301.	2931.	4314.	4655.	3700.	4369.	5030.	3075.	3248.	1442.	419.	210.
J= 9	.	.	.	.	200.	739.	1177.	2034.	2378.	2176.	2547.	2495.	2439.	3366.	2186.	1190.	1917.	1737.	1429.	1646.
J= 8	.	.	.	.	73.	901.	1256.	1748.	2035.	1470.	3012.	812.	2142.	2055.	1640.	78.	207.	820.	502.	251.
J= 7	.	.	.	.	119.	507.	1712.	1481.	2149.	1684.	2565.	1695.	720.	1328.	2661.	901.	797.	642.	.	.
J= 6	.	.	.	.	.	838.	802.	771.	952.	511.	907.	2066.	840.	1560.	1940.	159.	41.	.	.	.
J= 5	.	.	.	.	.	329.	186.	425.	645.	494.	529.	1303.	870.	1582.	1129.	1512.	506.	424.	212.	.
J= 4	.	.	.	.	.	.	.	222.	64.	205.	395.	1393.	643.	553.	209.	1598.	82.	.	.	.
J= 3	.	.	.	.	.	.	26.	142.	113.	231.	199.	1123.	336.	755.	410.	1603.	31.	.	.	.
J= 2	.	.	.	.	.	.	.	24.	140.	163.	144.	424.	223.	439.	149.	1589.	28.	.	.	.
J= 1	.	.	.	.	.	.	.	14.	104.	64.	.	.	.	77.	168.	1117.	18.	.	.	.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Figure 5: Emissions of NO_x from car traffic in Jakarta.

```
MAP OF   : TSP traf    UNIT: kg/h   SOURCE     : Traffic
 PERIOD : 1990        PLACE: JAK   GRID SIZE: 1500 METER
 CREATED: 1995/07/28 17.41

MAXIMUM VALUE IS  1.2835E+02, IN (11,16)
SUM= 7.57521E+03    SCALE FACTOR:  1.0E-01
```

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
J=20	14.	50.	14.	73.	7.	.	.	.	.	.	.	.	.	.	185.	358.	171.	56.	32.	2.
J=19	17.	21.	10.	38.	80.	77.	106.	107.	63.	58.	7.	175.	203.	321.	84.	272.	75.	28.	36.	4.
J=18	28.	47.	45.	44.	23.	53.	123.	295.	574.	343.	241.	305.	142.	210.	358.	551.	174.	95.	30.	13.
J=17	31.	121.	140.	171.	218.	147.	247.	243.	420.	383.	517.	426.	319.	311.	402.	372.	153.	133.	18.	185.
J=16	124.	42.	38.	72.	63.	127.	494.	518.	599.	748.	1284.	688.	161.	151.	534.	89.	17.	17.	160.	45.
J=15	31.	48.	50.	110.	66.	171.	410.	499.	771.	322.	1143.	1012.	473.	242.	301.	235.	261.	193.	334.	128.
J=14	41.	81.	94.	149.	293.	337.	543.	562.	624.	465.	823.	801.	607.	402.	528.	337.	339.	20.	15.	102.
J=13	53.	41.	22.	21.	21.	82.	292.	546.	706.	689.	654.	523.	519.	386.	415.	418.	300.	56.	46.	42.
J=12	44.	137.	54.	109.	78.	141.	181.	612.	472.	929.	520.	735.	621.	879.	646.	309.	441.	263.	212.	22.
J=11	.	5.	162.	178.	196.	253.	226.	417.	711.	581.	769.	501.	536.	475.	417.	286.	184.	212.	74.	.
J=10	.	.	.	.	67.	125.	127.	389.	735.	501.	738.	796.	633.	747.	860.	526.	555.	247.	72.	36.
J= 9	.	.	.	.	34.	126.	201.	348.	407.	372.	436.	427.	417.	576.	374.	204.	328.	297.	244.	281.
J= 8	.	.	.	.	13.	154.	215.	299.	348.	251.	515.	139.	366.	351.	281.	13.	35.	140.	86.	43.
J= 7	.	.	.	.	20.	87.	293.	253.	368.	288.	439.	290.	123.	227.	455.	154.	136.	110.	.	.
J= 6	.	.	.	.	.	143.	137.	132.	163.	87.	155.	353.	144.	267.	332.	27.	7.	.	.	.
J= 5	.	.	.	.	.	56.	32.	73.	110.	84.	90.	223.	149.	271.	193.	258.	87.	73.	36.	.
J= 4	.	.	.	.	.	.	.	38.	11.	35.	67.	238.	110.	95.	36.	273.	14.	.	.	.
J= 3	.	.	.	.	.	.	4.	24.	19.	40.	34.	192.	57.	129.	70.	274.	5.	.	.	.
J= 2	.	.	.	.	.	.	.	4.	24.	28.	25.	73.	38.	75.	25.	272.	5.	.	.	.
J= 1	.	.	.	.	.	.	.	2.	18.	11.	.	.	.	13.	29.	191.	3.	.	.	.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Figure 6: Emissions of TSP from car traffic in Jakarta.

5. Emissions from industry

Industrial emissions will normally consist of process emissions and emissions from combustion of fossil fuels. To have a good emission survey it is necessary to collect data about consumption, production and emitting conditions. It is desirable to estimate the emissions from measurements, and this is done in many cases. The results of such measurements are used to develop emission factors, which give the emissions f.ex. from the combustion of one ton of coal or from production of one ton of steel. Emission factors will only give average estimates; individual analyses are required for accurate values.

In this study we have no information available about individual industrial activities in Jakarta. Bosch has estimated emissions of TSP for different industries in Medan at Sumatra, as shown in Table 7 for TSP.

Table 7: Emission factors for industry (from Bosch, 1991)

	Number of establishments	Employment	Mg TSP* per est.	kg TSP per employee
Food and tobacco	129	21765	10	59
Textiles	32	2866	25	279
Wood and furniture	50	4972	25	251
Paper, Printing	40	2849	25	351
Non-metallic minerals	100	12556	25	199
Basic metals	23	1424	50	808
Metal works	4	1081	50	185
Chemicals, Oil Plastics	94	8866	10	106

* Average estimates only; individual analyses are required for accurate values.

The industrial emissions of TSP for Jakarta are estimated by using statistical data for Jakarta combined with Bosch's data. Table 8 shows the number of medium and large establishments, the number of workers and estimated emissions of TSP for 1989, separated into 9 classes of industry.

Table 8: Industrial emissions of TSP.

	Number of establishments	Workers	Factor kg/a. employee	Emissions tons/year
Food, beverage and tobacco	222	14724	59	869
Textiles	717	87620	279	24446*
Wood and wood prod.	131	9250	251	2322
Paper and paper prod.	193	14684	351	5154
Industrial chemicals	380	36022	106	3818*
Non-metallic mineral products	38	8884	199	1768
Iron and steel basic industry	17	2796	808	2259**
Mineral products, machines and equipment	361	54471	185	10077
Other	41	3745		
Total	2100	232196		50713

* appears too high

** appears much too low, considering data from Cowiconsult.

According to Table 8, 2,100 medium and large enterprises employ more than 200,000 production workers. Each of these enterprises employing more than 100 production workers emits an average of 25 tons TSP/year.

Considering the two last groups in Table 8 (except "other"), 378 medium and large enterprises employing more than 57,000 production workers, it is assumed that each enterprise emits an average of 30 tons TSP/year. Based upon these assumptions Table 9 shows average emissions from industrial processes in Jakarta.

Table 9: TSP emissions from industrial processes in Jakarta. Unit: ton/year.

	Number of establishments	TSP emissions tons/year
Food, beverage, tobacco and textiles	939	9400
Wood and wood prod.	131	2300
Paper and paper prod.	193	5200
Industrial chemicals	380	3800
Non-metallic mineral products	38	1700
Iron, steel, mineral products etc.	378	9500
Sum		31900

Large differences are expected to be found between individual factories, and information about location and emissions from polluting factories is needed before air quality guidelines are enforced. Referring to the list of 100 industries which may qualify for assistance (World Bank, 1992) a number of industries in Jakarta emitting $(2\text{-}8)*10^6$ kg TSP per year are identified and the cost of pollution abatement is estimated.

Spatial distribution of industrial emissions

As already mentioned we have had no information about the location of the industries in Jakarta, so we had to use an unorthodox method: From two different maps of Jakarta with symbols of industries we have counted the number of industrial symbols within each grid, with a total of 207 "industry" symbols, and the emissions are distributed according to this. Figure 7 shows the distribution of industry symbols.

MAP FOR FACTORIES UNIT: NUMBERS
HIGHEST VALUE IS 12, IN (18 , 14)
SUM= 207
GRID SIZE: 1500 METER

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
J=20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.	.	.	3.	1.
J=19	.	.	1.	1.	.	.	.	.	.	.	.	.	.	.	.	7.	5.	1.	4.	.
J=18	.	.	.	.	.	1.	2.	.	3.	.	.	.	3.	.	.	4.	1.	2.	1.	.
J=17	.	.	.	.	.	1.	.	1.	.	2.	1.	.	.	2.	3.	.	.	4.	.	.
J=16	2.	.	2.	3.	.	2.	.	.	.	.	.	.	.	.	3.	1.	.	5.	.	1.
J=15	.	.	1.	1.	.	.	.	.	.	.	.	.	.	1.	3.	2.	2.	5.	4.	3.
J=14	.	.	.	.	.	.	.	.	.	.	.	.	.	2.	3.	5.	6.	12.	9.	8.
J=13	.	.	.	.	.	.	.	.	.	.	.	1.	.	2.	3.	5.	7.	8.	4.	2.
J=12	.	.	.	.	.	.	.	.	.	.	.	.	.	1.	3.	3.	3.	.	.	.
J=11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J=10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J= 9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.	.	.	.	.	.
J= 8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J= 7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J= 6	.	.	.	.	.	.	.	.	.	2.	.	.	.	1.	.	.	.	.	.	.
J= 5	.	.	.	.	.	.	.	.	.	.	.	.	3.	.	.	.	.	.	.	.
J= 4	.	.	.	.	.	.	.	.	.	.	.	.	.	2.	1.	.	.	.	.	.
J= 3	.	.	.	.	.	.	.	.	.	.	.	.	.	2.	1.	.	.	.	.	.
J= 2	.	.	.	.	.	.	.	.	.	.	.	.	3.	4.	.	.	.	.	.	.
J= 1	.	.	.	.	.	.	.	.	.	.	.	.	2.	2.	.	.	.	.	.	.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Figure 7: Industry symbols on Jakarta map.

The total emission of NO_x from industrial processes is estimated to 1784 tons/year, and the "industry" file is multiplied by 0.9838 to give an average NO_x emission field as shown in Figure 8.

```
MAP OF : NOx IND               UNIT : KG/H              SOURCE    : Industry
 PERIOD : 1990                 PLACE: Jakarta           GRID SIZE: 1500 METER
 CREATED: 1995/09/27 12.15

     MAXIMUM VALUE IS  1.1812E+01, IN (18,14)
                 SUM= 2.03653E+02    SCALE FACTOR:  1.0E-02
```

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
J=20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	98.	.	.	295.	98.
J=19	.	.	98.	98.	.	.	.	.	.	.	.	.	.	.	.	689.	492.	98.	394.	.
J=18	.	.	.	.	.	98.	197.	.	295.	.	.	.	295.	.	.	394.	98.	197.	98.	.
J=17	.	.	.	.	.	98.	.	98.	.	197.	98.	.	.	197.	295.	.	.	394.	.	.
J=16	197.	.	197.	295.	.	197.	.	.	.	.	.	.	.	.	295.	98.	.	492.	.	98.
J=15	.	.	98.	98.	.	.	.	.	.	.	.	.	.	98.	295.	197.	197.	492.	394.	295.
J=14	.	.	.	.	.	.	.	.	.	.	.	.	.	197.	295.	492.	590.	1181.	885.	787.
J=13	.	.	.	.	.	.	.	.	.	.	.	98.	.	197.	295.	492.	689.	787.	394.	197.
J=12	.	.	.	.	.	.	.	.	.	.	.	.	.	98.	295.	295.	295.	.	.	.
J=11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J=10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J= 9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	98.	.	.	.	.	.
J= 8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J= 7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J= 6	.	.	.	.	.	.	.	.	.	197.	.	.	.	98.	.	.	.	.	.	.
J= 5	.	.	.	.	.	.	.	.	.	.	.	.	295.	.	.	.	.	.	.	.
J= 4	.	.	.	.	.	.	.	.	.	.	.	.	.	197.	98.	.	.	.	.	.
J= 3	.	.	.	.	.	.	.	.	.	.	.	.	.	197.	98.	.	.	.	.	.
J= 2	.	.	.	.	.	.	.	.	.	.	.	.	295.	394.	.	.	.	.	.	.
J= 1	.	.	.	.	.	.	.	.	.	.	.	.	197.	197.	.	.	.	.	.	.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Figure 8: Average industrial emissions of NO_x in Jakarta. Unit: 0.01 kg NO_x/h.

From Figure 1 in Appendix 7 the emissions of TSP from industrial processes and fuel combustion are estimated to 32,068 tons/year. When the "industry" file is multiplied by 17.685 we get an average TSP emission field as shown in Figure 9.

```
MAP OF : TSP IND            UNIT : KG/H           SOURCE    : Industry
 PERIOD : 1990              PLACE: Jakarta        GRID SIZE: 1500 METER
 CREATED: 1995/09/27 12.15

     MAXIMUM VALUE IS  2.1865E+02, IN (18,14)
                 SUM= 3.77009E+03    SCALE FACTOR:  1.0E-01
```

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
J=20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	182.	.	.	546.	182.
J=19	.	.	182.	182.	.	.	.	.	.	.	.	.	.	.	.	1275.	911.	182.	729.	.
J=18	.	.	.	.	.	182.	364.	.	546.	.	.	.	546.	.	.	729.	182.	364.	182.	.
J=17	.	.	.	.	.	182.	.	182.	.	364.	182.	.	.	364.	546.	.	.	729.	.	.
J=16	364.	.	364.	546.	.	364.	.	.	.	.	.	.	.	.	546.	182.	.	911.	.	182.
J=15	.	.	182.	182.	.	.	.	.	.	.	.	.	.	182.	546.	364.	364.	911.	729.	546.
J=14	.	.	.	.	.	.	.	.	.	.	.	.	.	364.	546.	911.	1093.	2186.	1639.	1457.
J=13	.	.	.	.	.	.	.	.	.	.	.	182.	.	364.	546.	911.	1275.	1457.	729.	364.
J=12	.	.	.	.	.	.	.	.	.	.	.	.	.	182.	546.	546.	546.	.	.	.
J=11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J=10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J= 9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	182.	.	.	.	.	.
J= 8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J= 7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J= 6	.	.	.	.	.	.	.	.	.	364.	.	.	.	182.	.	.	.	.	.	.
J= 5	.	.	.	.	.	.	.	.	.	.	.	.	546.	.	.	.	.	.	.	.
J= 4	.	.	.	.	.	.	.	.	.	.	.	.	.	364.	182.	.	.	.	.	.
J= 3	.	.	.	.	.	.	.	.	.	.	.	.	.	364.	182.	.	.	.	.	.
J= 2	.	.	.	.	.	.	.	.	.	.	.	.	546.	729.	.	.	.	.	.	.
J= 1	.	.	.	.	.	.	.	.	.	.	.	.	364.	364.	.	.	.	.	.	.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Figure 9: Average industrial emissions of TSP in Jakarta.
Unit: 0.1 kg TSP/h.

6. Emission from fuel combustion in small industries/domestic activities

From Figure 2 in Appendix 7 the NO_x-emissions from fuel combustion in homes/small industry are estimated to 8176 tons NO_x/year. This is distributed according to the population distribution, and the population file is multiplied by 1.313E-4 to give an average NO_x emission field as shown in Figure 10. From Figure 1 in Appendix 7 the TSP-emissions are estimated to 10,536 tons TSP/year, and the population file is multiplied by 1.660E-4 to give an average TSP emission field as shown in Figure 11.

```
MAP OF : NOx DOM    UNIT : KG/H         SOURCE    : DOMESTIC
 PERIOD : 1990      PLACE: JAK          GRID SIZE: 1500 METER
 CREATED: 1995/07/28 17.41

     MAXIMUM VALUE IS  1.5807E+01, IN (11,15)
                 SUM= 9.33326E+02    SCALE FACTOR:  1.0E-02
```

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
J=20	0.	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.	8.
J=19	51.	62.	30.	7.	3.	5.	0.	0.	0.	0.	0.	0.	0.	100.	213.	83.	227.	83.	54.	12.
J=18	84.	140.	137.	42.	9.	51.	206.	335.	335.	0.	0.	256.	182.	559.	1079.	884.	523.	285.	37.	13.
J=17	67.	95.	154.	171.	123.	29.	161.	733.	693.	709.	512.	131.	515.	647.	1014.	365.	461.	402.	55.	32.
J=16	102.	127.	114.	139.	190.	265.	616.	603.	1037.	1179.	1372.	521.	193.	193.	172.	180.	51.	51.	51.	38.
J=15	95.	144.	152.	121.	121.	467.	834.	948.	742.	519.	1581.	1123.	834.	415.	160.	173.	85.	56.	49.	34.
J=14	56.	138.	110.	91.	146.	253.	486.	1087.	855.	299.	1067.	1175.	838.	467.	261.	198.	126.	59.	46.	118.
J=13	0.	0.	46.	64.	64.	248.	486.	1021.	958.	1442.	642.	638.	655.	835.	515.	303.	331.	167.	137.	127.
J=12	0.	0.	53.	249.	147.	295.	298.	1279.	995.	1002.	768.	1241.	1136.	930.	683.	255.	203.	106.	106.	49.
J=11	0.	0.	77.	127.	152.	328.	341.	457.	742.	957.	895.	1008.	1225.	895.	504.	448.	448.	427.	222.	0.
J=10	0.	0.	0.	0.	169.	345.	382.	411.	534.	524.	1166.	1133.	1103.	933.	469.	352.	277.	274.	0.	0.
J= 9	0.	0.	0.	0.	104.	315.	391.	584.	528.	182.	731.	593.	692.	674.	87.	230.	201.	147.	0.	0.
J= 8	0.	0.	0.	0.	38.	398.	209.	499.	520.	155.	882.	419.	558.	484.	87.	41.	0.	0.	0.	0.
J= 7	0.	0.	0.	0.	62.	261.	169.	268.	337.	332.	411.	273.	299.	352.	81.	68.	0.	0.	0.	0.
J= 6	0.	0.	0.	0.	0.	108.	161.	339.	280.	263.	299.	399.	335.	357.	232.	83.	21.	0.	0.	0.
J= 5	0.	0.	0.	0.	0.	0.	96.	138.	147.	189.	247.	272.	377.	238.	215.	100.	42.	0.	0.	0.
J= 4	0.	0.	0.	0.	0.	0.	0.	30.	33.	88.	203.	311.	331.	64.	108.	79.	42.	0.	0.	0.
J= 3	0.	0.	0.	0.	0.	0.	0.	0.	58.	119.	102.	180.	173.	123.	72.	42.	16.	0.	0.	0.
J= 2	0.	0.	0.	0.	0.	0.	0.	13.	72.	84.	74.	0.	116.	117.	76.	43.	14.	0.	0.	0.
J= 1	0.	0.	0.	0.	0.	0.	0.	8.	54.	33.	0.	0.	0.	39.	87.	26.	9.	0.	0.	0.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Figure 10: NO_x-emissions from domestic activities/small industry in Jakarta. Unit: 0.01 kg TSP/h.

```
MAP OF : TSP DOM            UNIT : KG/H          SOURCE    : DOMESTIC
 PERIOD : 1990              PLACE: JAK           GRID SIZE: 1500 METER
 CREATED: 1995/07/28 17.41

     MAXIMUM VALUE IS  1.9985E+01, IN (11,15)
                 SUM= 1.17999E+03    SCALE FACTOR:  1.0E-02
```

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
J=20	0.	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	5.	10.
J=19	65.	78.	38.	8.	3.	7.	0.	0.	0.	0.	0.	0.	0.	126.	269.	105.	287.	105.	68.	15.
J=18	106.	178.	173.	53.	12.	65.	261.	423.	423.	0.	0.	324.	231.	707.	1364.	1117.	661.	360.	46.	17.
J=17	85.	120.	194.	216.	156.	37.	204.	926.	876.	896.	647.	166.	651.	818.	1281.	461.	583.	508.	70.	40.
J=16	129.	161.	144.	176.	241.	335.	778.	762.	1311.	1491.	1735.	659.	244.	244.	217.	227.	65.	65.	65.	48.
J=15	120.	183.	193.	153.	153.	591.	1054.	1198.	938.	656.	1998.	1419.	1054.	525.	203.	219.	108.	71.	61.	43.
J=14	71.	174.	139.	115.	184.	320.	614.	1374.	1081.	378.	1349.	1486.	1059.	591.	330.	251.	159.	75.	58.	149.
J=13	0.	0.	58.	81.	81.	314.	614.	1291.	1212.	1823.	812.	807.	828.	1056.	651.	383.	418.	211.	173.	161.
J=12	0.	0.	66.	315.	186.	373.	377.	1617.	1258.	1266.	971.	1569.	1436.	1175.	863.	322.	257.	134.	134.	61.
J=11	0.	0.	98.	161.	193.	415.	432.	578.	938.	1210.	1132.	1275.	1549.	1132.	637.	566.	566.	539.	281.	0.
J=10	0.	0.	0.	0.	214.	437.	483.	520.	676.	662.	1474.	1432.	1394.	1180.	593.	445.	350.	347.	0.	0.
J= 9	0.	0.	0.	0.	131.	398.	495.	739.	667.	231.	925.	750.	875.	852.	110.	290.	254.	186.	0.	0.
J= 8	0.	0.	0.	0.	48.	503.	264.	631.	657.	196.	1115.	529.	705.	612.	110.	51.	0.	0.	0.	0.
J= 7	0.	0.	0.	0.	78.	330.	214.	339.	427.	420.	520.	345.	378.	445.	103.	86.	0.	0.	0.	0.
J= 6	0.	0.	0.	0.	0.	136.	204.	428.	354.	332.	378.	505.	423.	451.	294.	105.	27.	0.	0.	0.
J= 5	0.	0.	0.	0.	0.	0.	121.	174.	186.	239.	312.	344.	476.	300.	272.	126.	53.	0.	0.	0.
J= 4	0.	0.	0.	0.	0.	0.	0.	38.	41.	111.	257.	393.	418.	81.	136.	100.	53.	0.	0.	0.
J= 3	0.	0.	0.	0.	0.	0.	0.	0.	73.	151.	129.	227.	219.	156.	91.	53.	20.	0.	0.	0.
J= 2	0.	0.	0.	0.	0.	0.	0.	17.	91.	106.	93.	0.	146.	148.	96.	55.	18.	0.	0.	0.
J= 1	0.	0.	0.	0.	0.	0.	0.	10.	68.	41.	0.	0.	0.	50.	110.	33.	12.	0.	0.	0.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Figure 11: TSP-emissions from domestic activities/small industry in Jakarta. Unit: 0.01 kg/TSP/h.

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Appendix 5

Emission Factors, Particles

Contents

Emission Factors, Particles

1. Introduction

Emission factors (emitted amount of pollutant per quantity of combusted fuel, or per km driven, or per produced unit of product) are important input data to emission inventories, which again are essential input to dispersion modelling.

The knowledge of emission factors representative for the present technology level of Asian cities is limited. For the purpose of selecting emission factors for the URBAIR study, references on emission factors were collected from the open literature and from studies and reports from cities in Asia.

This appendix gives a brief background for the selection of emission factors for particles used in the air quality assessment part of URBAIR.

2. Motor vehicles

The selection of emission factors for motor vehicles for use in the URBAIR project to produce emission inventories for South-East Asian cities, was based on the following references:

- WHO (1993)
- US EPA (EPA AP42 report series) (1985)
- Vehicles Emission Control Project (VECP), Manila (Baker, 1993)
- Indonesia (Bosch, 1991)
- Williams et al. (1989)
- Motorcycle emission standard and emission control technology (Weaver and Chan, 1993)

Table 1 gives a summary of emission factors from these references for various vehicle classes. From these, the emission factors given in Table 2 were selected, for use as a basis for URBAIR cities.

Taking into account the typical vehicle/traffic activity composition, the following vehicle classes give the largest contributions to the total exhaust particle emissions from traffic:

- Heavy duty diesel trucks
- Diesel buses
- Utility trucks, diesel
- 2-stroke 2- and 3-wheelers.

Thus, the emission factors for these vehicle classes are the most important ones.

Table 1: Emission factors (g/km) for particle emissions from motor vehicles, relevant as a basis for selection of factors to be used in South-East Asian cities.

Fuel and Vehicle	Particles g/km	Reference
Gasoline		
Passenger cars	0.33	USEPA/WHO
	0.10	VECP, Manila
	0.16	Indonesia (Bosch)
	0.07	Williams
Trucks, utility	0.12	VECP, Manila
	0.33	USEPA
		USEPA
Trucks, heavy duty	0.33	USEPA
3-wheelers, 2 stroke	0.21	USEPA/WHO
MC 2/4 stroke	0.21/	USEPA/WHO
	2.00/	VECP, Manila
	0.21/0.029	Indonesia VWS
	0.28/0.08	Weaver and Chan
Diesel		
Car, taxi	0.6	VECP, Manila
	0.45	USEPA/WHO
	0.37	Williams
Trucks, utility	0.9	VECP, Manila
	0.93	EPA
Trucks, heavy/bus	0.75	WHO
	1.5	VECP, Manila
	0.93	USEPA
	1.2	Bosch
	2.1	Williams

Table 2: Selected emission factors (g/km) for particles from road vehicles used in URBAIR.

Vehicles class	Gasoline	Diesel
Passenger cars/taxies	0.2	0.6
Utility vehicles/light trucks	0.33	0.9
Motorcycles/tricycles	0.5	
Trucks/buses		2.0

Comments

It is clear that there is not a very solid basis in actual measurements on which to estimate particle emission factors for vehicles in South-East Asian cities. The given references represent the best available basis. Comments are given below for each of the vehicle classes.

Gasoline:

Passenger cars:	Fairly new, normally well maintained cars, engine size less than 2.5 l, without 3-way catalyst, running on leaded gasoline (0.2-0.3 g Pb/l), have an emission factor of the order of 0.1 g/km. Older, poorly maintained vehicles may have much larger emissions. The US EPA/WHO factor of 0.33 g/km can be used as an estimate for such vehicles.
Utility trucks:	Although the VECP study (Manila) uses 0.12 g/km, the EPA factor of 0.33 g/km was selected for such vehicles, taking into account generally poor maintenance in South-East Asian cities.
Heavy duty trucks:	Only the USEPA have given an estimate for such vehicles, 0.33 g/km, the same as for passenger cars and utility trucks.
3-wheelers, 2 stroke:	The USEPA and WHO suggest 0.2 g/km for such vehicles.
Motorcycles, 2 stroke:	The Weaver report supports the 0.21 g/km emission factor suggested by USEPA/WHO. In the VECP Manila study a factor of 2 g/km is suggested. This is the same factor as for heavy duty diesel trucks, which seems much too high. Visible smoke emissions from 2-stroke 2- and 3-wheelers is normal in South-East Asian cities. Low-quality oil as well as worn and poorly maintained engines probably both contribute to the large emissions. The data base for selecting a representative emission factor is small. In the data of Weaver and Chan (1993), the highest emission factor is about 0.55 g/km. For URBAIR, we choose a factor of 0.5 g/km. Realizing that this is considerably higher than the factor suggested by US EPA, we also take into consideration the factor 2 g/km used in the VECP study in Manila, which indicates evidence for very large emissions from such vehicles.
Motorcycles, 4-stroke:	The emission factor is much less than for 2-stroke engines. The Weaver report gives 0.08 g/km, while 0.029 g/km is given by the VWS study in Indonesia (Bosch, 1991).

Diesel:

Passenger cars, taxis: The factor of 0,6 g/km given by the VECP Manila is chosen, since it is based on measurements of smoke emission from vehicles in traffic in Manila. The 0,45 g/km of USEPA/WHO was taken to represent typically maintained vehicles in Western Europe and USA, as also measured by Larssen and Heintzenberg (1983) on Norwegian vehicles. This is supported by Williams' factor of 0,37 g/km for Australian vehicles.

Utility trucks: The USEPA and the VECP Manila study give similar emission factors, about 0,9 g/km.

Heavy duty trucks/ buses: The factors in the table range from 0,75 g/km to 2,1 g/km.

It is clear that "smoking" diesel trucks and buses may have emission factors even much larger than 2 g/km. In the COPERT emission data base of the European Union factors as large as 3-5 g/km are used for "dirty" city buses. Likewise, based on relationships between smoke meter reading (e.g. Hartridge smoke units, HSU) and mass emissions, it can be estimated that a diesel truck with a smoke meter reading of 85 HSU, as measured typically on Kathmandu trucks and buses (Rajbahak and Joshi, 1993), corresponds to an emission factor of roughly 8 g/km!

As opposed to this, well maintained heavy duty diesel trucks and buses have an emission factor of 0,7-1 g/km.

As a basis for emission calculations for South-East Asian cities we choose an emission factor of 2 g/km. This corresponds to some 20% of the diesel trucks and buses being "smoke belchers". A larger fraction of "smoke belchers", such as in Kathmandu, will result in a larger emission factor.

3. Fuel combustion

Oil

The particle emission factors suggested by USEPA (AP 42) are taken as a basis for calculating emissions from combustion of oil in South-East Asian cities. The factors are given in Table 3.

Table 3: Emission factors for oil combustion (Ref.: US EPA, AP 42). (kg/m³)

	Emission factor	
	Uncontrolled	Controlled
Utility boilers		
Residual oil[a)]		
Grade 6	1.25(S)+0.38	×0.008 (ESP)
Grade 5	1.25	×0.06 (scrubber)
Grade 4	0,88	×0.2 (multicyclone)
Industrial/commercial boilers		
Residual oil	(as above)	×0.2 (multicyclone)
Distillate oil	0.24	
Residential furnaces		
Distillate oil	0.3	

S: Sulphur content in % by weight

a): Another algorithm for calculating the emission factors is as follows: 7,3xA kg/m³, where A is the ash content of the oil.

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Appendix 6

Population Exposure Calculations

Population Exposure Calculations

Methodology

Data for population exposure in Jakarta are estimated for annual average TSP-values. The measured values specify the pollution level at the measuring stations. Dispersion calculations are used to specify the spatial distribution of concentration values over the urban area. The dispersion calculations are based on data for wind, dispersion conditions and for emission distribution over the city. The input data for dispersion calculations should be improved in the future regarding the following points:

- Emission from industry including emissions from the power plant should be measured and emission conditions are important for the local air quality.

- Emissions due to resuspension and due to refuse burning (Bosch, 1991) should be controlled by measurements in Jakarta.

- The relationship between emission conditions and measured concentration values in the northern part of Jakarta should be clarified.

- The data on dispersion conditions should be improved and a wind model accounting for coastal effects may be important for discussing effects of emission reductions in air pollution episodes.

To give a first estimate for considering cost/effect relationships only annual average concentrations were considered.

To specify the annual urban scale pollution level, average concentration in grid squares covering 1.5 x 1.5 km^2 was calculated.

The following groups of sources were considered:

1. Car traffic including resuspension.
2. Fuel combustion including refuse burning.
3. Industrial processes.
4. Miscellaneous, including airports, harbour and construction.

The spatial population distribution is calculated as follows:

- The number of inhabitants in each subdistrict (Kelurahan) was established (reference: 1990 census in Jakarta. Jakarta statistical office, 1991). **A distribution key** was estimated to transform the data on population in "kelurahans" to data on population in the grid system. To develop the distribution key a detailed map of Jakarta was used (Peta Rupabumir Indonesia, 1990 1:25 000) to take into account the location of residential areas. To take account of polluted areas along roads with high traffic intensities the locations of the main roads were specified as shown in Figure 1.

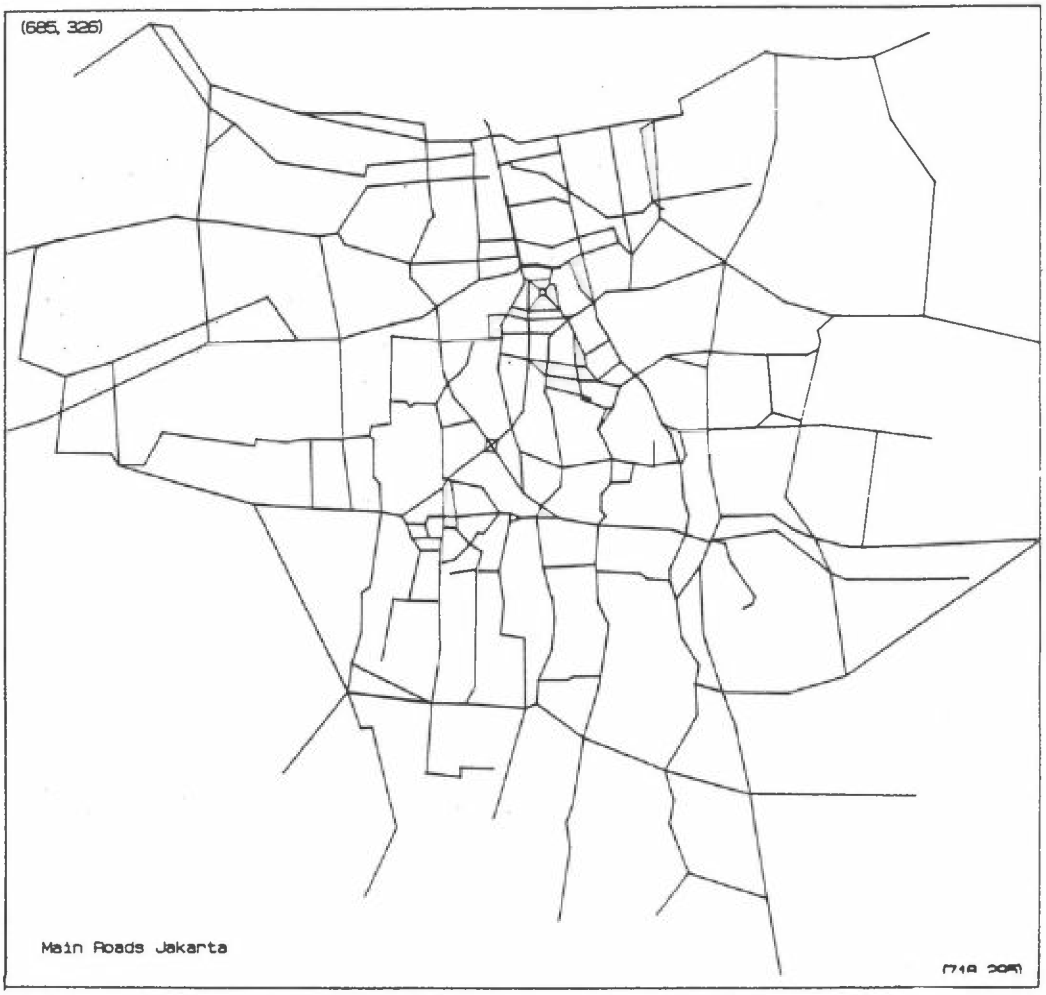

Figure 1: The network of main roads.

- The length of main roads in each grid square is determined and an additional concentration is estimated for people living in 30 m zones on each side of the road starting from a distance of 10 m from the edge of the road. The population density in this zone is assumed to be equal to the average density in the grid square. We have not taken into account double exposure from crossing roads.

- The distribution of population exposure is calculated by counting the number of people living in each grid square and the number of people living along roads in each grid square separately, considering the respective concentration levels.

The calculated concentration in each grid square consists of contributions from four source groups:

- car traffic
- industry and commercial
- domestic
- extra-urban background concentration.

Each of the contributions is calculated separately, and a source reduction influences the respective contribution proportionally to the amount of the source reduction in question.

The effect on the exposure curve of the source reductions is calculated for a 25 and 50 per cent source reduction for each group.

Calculation of exposure to air pollution in Jakarta

Table 1 shows the exposure distribution and the effect of source reduction in three main sources groups.

In each of the annual concentration classes a quantified damage by pollution may be determined. This may be below certain exposure levels and the total damage may be determined by integrating the damage function over the exposure distribution.

$$D_{T,O} = \sum_k \Delta N_k \cdot D_{k,O}$$

ΔN_k : the number of people in each concentration class k

D_k : the specific damage function for the annual average concentration class k.

The total damage function D_T may be determined for different source reduction schemes.

Additional exposure due to the activity pattern of the population

The exposure is first calculated for people staying at home. When people's activity pattern is better known additional exposure may be calculated accordingly. The following groups should be considered when the damage function is further developed.

Considering exposure in traffic environments:

- commuters
- drivers/policemen.

It is estimated that approximately 30% of the population in Jakarta make regular trips along roads every day and spend 1-2 hours close to roads with high traffic intensity every day. This means an addition of 15-30 µg/m³ to their home exposure. Drivers and street workers spend approximately 8 hours in traffic environments every day, i.e. the additional exposure amounts to

$$(400\,\mu g\, TSP / m^3 - C_{HOME}) \cdot 6 = 25 - 75\,\mu g\, TSP / m^3$$

Table 1: Number of residents in Jakarta exposed to different levels of TSP-concentrations outside their homes.

$C\varepsilon[C_1$	$C_2]$	$N_c > C_2$	ΔN	P	ΔP	Traffic reduction		Industry reduction		Domestic reduction	
µg/m³		µg/m³	inh.	%	%	25%	50%	25%	50%	25%	50%
80.0	90.0	6 458 608	0	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
90.0	100.0	6 454 574	4 034	99.938	0.062	0.225	0.792	0.062	0.314	0.062	0.062
100.0	110.0	6 400 467	54 107	99.100	0.838	1.458	3.741	0.987	1.257	0.838	0.838
110.0	120.0	6 272 124	128 343	97.113	1.987	3.794	11.120	2.494	3.398	2.190	2.439
120.0	130.0	6 024 203	247 921	93.274	3.839	7.485	19.039	4.437	5.806	3.976	4.065
130.0	140.0	5 668 254	355 949	87.763	5.511	11.207	19.477	6.873	8.571	5.170	5.357
140.0	150.0	5 106 759	561 495	79.069	8.694	13.964	30.877	9.416	9.281	8.973	9.366
150.0	160.0	4 454 121	632 638	68.964	10.105	13.167	10.570	11.598	9.683	10.190	11.491
160.0	170.0	3 835 884	618 237	59.392	9.572	13.172	1.774	7.440	9.383	10.115	8.430
170.0	180.0	3 320 573	515 311	51.413	7.979	23.949	0.059	9.870	11.354	7.511	8.270
180.0	190.0	2 478 595	841 978	38.377	13.037	6.219	0.000	9.175	9.476	12.597	11.305
190.0	200.0	1 446 275	1 032 320	22.393	15.984	1.522	0.000	8.926	18.088	18.792	18.792
200.0	210.0	807 480	638 795	12.502	9.981	0.000	0.000	7.784	4.611	7.083	7.700
210.0	220.0	424 136	383 344	6.567	5.935	0.000	0.000	4.370	3.676	5.935	5.318
220.0	230.0	329 558	94 578	5.103	1.464	0.000	0.000	1.464	0.000	1.464	1.464
230.0	240.0	329 558	0	5.103	0.000	0.000	0.000	0.000	0.000	0.000	0.000
240.0	250.0	329 558	0	5.103	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250.0	260.0	329 557	1	5.103	0.000	0.000	0.009	0.000	0.000	0.000	0.000
260.0	270.0	329 276	281	5.098	0.004	0.015	0.049	0.006	0.012	0.004	0.008
270.0	280.0	328 246	1 030	5.082	0.016	0.055	0.226	0.019	0.039	0.016	0.012
280.0	290.0	325 169	3 077	5.035	0.048	0.130	0.473	0.075	0.069	0.048	0.059
290.0	300.0	317 409	7 760	4.915	0.120	0.296	1.034	0.132	0.169	0.132	0.136
300.0	310.0	304 915	12 494	4.721	0.193	0.482	0.640	0.292	0.337	0.194	0.236
310.0	320.0	283 503	21 412	4.390	0.332	0.620	0.119	0.356	0.523	0.358	0.348
320.0	330.0	249 940	33 563	3.870	0.520	1.378	0.001	0.611	0.629	0.509	0.539
330.0	340.0	203 937	46 003	3.158	0.712	0.679	0.000	0.516	0.609	0.684	0.606
340.0	350.0	125 549	78 388	1.944	1.214	0.172	0.000	1.496	1.510	1.425	1.425
350.0	360.0	73 132	52 417	1.132	0.812	0.000	0.000	0.664	0.573	0.600	0.670
360.0	370.0	14 852	58 280	0.230	0.902	0.000	0.000	0.707	0.633	0.902	0.832
370.0	380.0	0	14 852	0.000	0.230	0.000	0.000	0.230	0.000	0.230	0.230
380.0	390.0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
390.0	400.0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

$C\varepsilon[C_1, C_2]$: concentration interval $N_C > C_2$: cumulative concentration dist. ΔN: number of people in each pollution

P: cumulative concentration distribution in percent of total population. ΔP: percentage of population in each concentration interval.

Emission reduction: Percentage of population in each concentration interval after emission reduction.

Approximately 300 000 "road workers" are exposed to this annual average additional pollution stress.

The low end of the range applies for the people living in the center and the high end applies for the people living in the suburbs.

Considering industrial exposure:

- pollution concentration in factories
- subgrid pollution at the work location.

According to the statistical survey of Jakarta, 290 000 people work in industry and some of them are exposed to an additional pollution load in their occupational environment. In some industrial environments the air will be more polluted than air close to the main roads. The number of people exposed to this additional stress is probably quite small.

The exposure calculations are based upon annual average TSP-concentrations. To evaluate the PM_{10}-exposure the fraction PM_{10}/TSP should be estimated for each source group, and the TSP-values transformed to PM_{10}-values **before** the exposure calculations. This procedure was followed in the URBAIR Kathmandu study. In Jakarta PM_{10}-concentrations were assumed to be 55% of the TSP-concentrations.

Appendix 7

Spreadsheets for Calculating Effects of Control Measures on Emissions

Spreadsheet for Calculating Effects of Control Measures on Emissions

1. Emissions spreadsheet

The spreadsheet is shown in Figure 1 and Figure 2. (Examples: TSP and NO_x emissions, DKI Jakarta, Base Case Scenario, 1990.) Figure 3 shows TSP emission contributions in absolute and relative terms.

The purpose of the spreadsheet is to calculate modified emission contributions, due to control measures, such as:

- new vehicle technology
- improved emission characteristics, achieved by measures on existing technology
- reduced traffic activity/fuel consumption
- other.

The emissions are calculated separately for large point sources (with tall stacks) and for area sources and smaller distributed point sources. The reason is that air pollution concentrations and population exposures are calculated differently for these two types of source categories.

The columns and rows of the worksheet are as follows:

Columns

a)	q	Emission factor, g/km for vehicles, kg/m^3 or kg/ton for fuel combustion and process emissions. For vehicles, emission factors are given for "existing" and "new" technology.
b)	F,T	Amount of "activity" F (m^3 or ton) for fuel consumption in industrial production. T (vehicle km) for traffic activity
c)	qF qT	Base case emissions, tons, calculated as product of columns a) and b).
d)	fq fF fT f-	Control measures. Relative reduction of emission factor (fq), amount (fF, fT) or other (f-) resulting from control measures.

TOTAL ANNUAL EMISSIONS, JAKARTA
Particles, scenario: 1990

	Emission factor	Amount	Base-case Emissions	Control measures			Modified emissions	Relative emissions per category	Relative emissions total
LARGE POINT SOURCES									
	q (kg/m3)	F (10E3m3)	qF (10E6 kg)	fq	fF	f-	qF fq fF f- (10E6 kg)	d(qF fq fF f-) (percent)	d(qF fq fF f-)tot (percent)
Power plants			0,00	1,00	1,00	1,00	0,00		#DIV/0!
							0,00		#DIV/0!
							0,00		#DIV/0!
Sum large point sources			**0,00**				**0,00**		**#DIV/0!**
Modified emissions/emissions, point sourc.							#DIV/0!		
AREA SOURCES AND DISTRIBUTED POINT SOURCES									
Vehicles	q (g/km)	T (10E6 km/y)	qT (10E3 kg/y)	fq	fT	f-	qT fq fT f- (10E3 kg)	d(qT fq fT f-) (percent)	d(qT fq fT f-) (percent)
Gasoline									
Pass. cars	0,20	5659	1132	1	1	1	1132	3,3	1,2
Pick-up etc.	0,33	365	120	1	1	1	120	0,4	0,1
Truck medium	0,68	38	26	1	1	1	26	0,1	0,0
Bus	0,68	183	124	1	1	1	124	0,4	0,1
Bajaj	0,50	589	295	1	1	1	295	0,9	0,3
MC	0,50	4438	2219	1	1	1	2219	6,5	2,3
Sum gasoline		11272	3916				3916	11,4	4,0
Modified emissions/emissions, gasoline							1,00		
Diesel									
Pass. cars	0,6	1415	849	1	1	1	849	2,5	0,9
Pick up etc.	0,9	365	329	1	1	1	329	1,0	0,3
Truck medium	2	154	308	1	1	1	308	0,9	0,3
Truck heavy	2	1	2	1	1	1	2	0,0	0,0
Bus, Coplet etc.	0,9	408	367	1	1	1	367	1,1	0,4
Bus regular	2	301	602	1	1	1	602	1,8	0,6
Sum diesel		2644	2457				2457	7,2	2,5
Modified emissions/emissions, diesel							1		
Resuspension	2	13916	27832	1	1	1	27832	81,4	28,8
Modified emissions/emissions resuspension							1		
Sum total vehicles			**34205**				**34205**	100,0	**35**
Modified emissions/emissions, total vehicles							1,00		
Fuel combustion	q (kg/m3)	F (10E3m3)	qF (10E3 kg)	fq	fF	f-	qF fq fF f- (10E3 kg)	d(qF fq fF f-)fuel (percent)	d(qF fq fF f-)tot (percent)
Industrial/commercial									
Distillate fuel	0,3	618,0	185,4	1,00	1,00	1,00	185,4	1,8	0,2
Coal	7,50	0,1	0,4	1,00	1,00	1,00	0,4	0,0	0,0
Coke	5,00	2,5	12,5	1,00	1,00	1,00	12,5	0,1	0,0
Gas	0,048	63,0	3,0	1,00	1,00	1,00	3,0	0,0	0,0
Domestic/small industry									
Fuel oil	1,40	1202,0	1682,8	1,00	1,00	1,00	1682,8	16,0	1,7
Distillate fuel	1,40	1155,0	1617,0	1,00	1,00	1,00	1617,0	15,3	1,7
Gas	0,048	163,0	7,8	1,00	1,00	1,00	7,8	0,1	0,0
Open burning	8,00	878,4	7027,0	1,00	1,00	1,00	7027,0	66,7	7,3
Sum fuel combustion			**10535,9**				**10535,9**	100,0	**10,9**
Modified emissions/emissions, fuel							1,00		
Industrial processes	q (10E3 kg/y)	F (n. of est.)	qF	fq	fF	f-	qF fq fF f-	d(qF fq fF f-)ind. (percent)	d(qF fq fF f-)tot (percent)
Food and textile	10,0	939	9390	1	1	1	9390	29,5	9,7
Wood and prod.	17,6	131	2306	1	1	1	2306	7,2	2,4
Paper and pr.	27,0	193	5211	1	1	1	5211	16,4	5,4
Chemicals	10,0	380	3800	1	1	1	3800	11,9	3,9
Non met. mineral prod	45,0	38	1710	1	1	1	1710	5,4	1,8
Iron and steel	25,0	378	9450	1	1	1	9450	29,7	9,8
Sum industrial processes			**31867**				**31867**	100,0	**32,9**
Modified emissions/emissions, ind. proc.							1,00		
Miscellaneous	q (kg/LTD)	M (LTD)	qM	fq	fM	f-	qM fq fM f-	d(qM fq fM f-)misc (percent)	d(qM fq fM f-)tot (percent)
Airports	0,355	73411	26	1	1	1	26	0,1	0,0
Construction			20000	1	1	1	20000	99,4	20,7
Harbour			100	1	1	1	100	0,5	0,1
Sum miscellaneous			**20126**				**20126**	100,0	**20,8**
Modified emissions/emissions, misc.							1,00		
"Background"									
Unknown									
Sum total, excl. "Background"			**96733**				**96733**		**100**
Modified emissions/emissions, total							1,00		

Figure 1: URBAIR spreadsheet for emissions calculations.

TOTAL ANNUAL EMISSIONS, JAKARTA
NOx, scenario: 1990

	Emission factor	Amount	Base-case Emissions	Control measures			Modified emissions	Relative emissions per category	Relative emissions total
LARGE POINT SOURCES									
	q (kg/m3)	F (10E3m3)	qF (10E6 kg)	fq	fF	f-	qF fq fF f- (10E6 kg)	d(qF fq fF f-) (percent)	d(qF fq fF f-)tot (percent)
Power plants			0,00	1,00	1,00	1,00	0,00		#DIV/0!
							0,00		#DIV/0!
							0,00		#DIV/0!
Sum large point sources			**0,00**				**0,00**		**#DIV/0!**
Modified emissions/emissions, point sourc.							#DIV/0!		
AREA SOURCES AND DISTRIBUTED POINT SOURCES									
Vehicles	q (g/km)	T (10E6 km/y)	qT (10E3 kg/year)	fq	fT	f-	qT fq fT f- (10E3 kg)	d(qT fq fT f-) (percent)	d(qT fq fT f-) (percent)
Gasoline									
Pass. cars	2,70	5659	15279	1	1	1	15279	48,4	35,5
Pick-up etc.	2,70	365	986	1	1	1	986	3,1	2,3
Truck medium	8,00	38	304	1	1	1	304	1,0	0,7
Bus, Coplet etc.	8,00	183	1464	1	1	1	1464	4,6	3,4
Bajaj	0,07	589	41	1	1	1	41	0,1	0,1
MC	0,07	4438	311	1	1	1	311	1,0	0,7
Sum gasoline		11272	18385				18385	58,3	42,7
Modified emissions/emissions, gasoline							1,00		
Diesel									
Pass. cars	1	1415	1415	1	1	1	1415	4,5	3,3
Pick up etc.	1,4	365	511	1	1	1	511	1,6	1,2
Truck medium	13	154	2002	1	1	1	2002	6,3	4,7
Truck heavy	13	1	13	1	1	1	13	0,0	0,0
Bus, Coplet etc.	13	408	5304	1	1	1	5304	16,8	12,3
Bus regular	13	301	3913	1	1	1	3913	12,4	9,1
Sum diesel		2644	13158				13158	41,7	30,6
Modified emissions/emissions, diesel							1		
Sum total vehicles			**31543**				**31543**	100,0	**73**
Modified emissions/emissions, total vehicles							1,00		
Fuel combustion	q (kg/m3)	F (10E3m3)	qF (10E3 kg/y)	fq	fF	f-	qF fq fF f- (10E3 kg)	d(qF fq fF f-)fuel (percent)	d(qF fq fF f-)tot (percent)
Industrial/commercial									
Distillate fuel	2	618	1483	1,00	1,00	1,00	1483	15,1	3,4
Coal	11	0	1	1,00	1,00	1,00	1	0,0	0,0
Coke	10	3	26	1,00	1,00	1,00	26	0,3	0,1
Gas	2,24	63	141	1,00	1,00	1,00	141	1,4	0,3
Domestic/small industry									
Fuel oil	2	1202	2404	1,00	1,00	1,00	2404	24,5	5,6
Distillate fuel	2	1155	2772	1,00	1,00	1,00	2772	28,2	6,4
Gas	2,24	163	365	1,00	1,00	1,00	365	3,7	0,8
Open burning	3	878	2635	1,00	1,00	1,00	2635	26,8	6,1
Sum fuel combustion			**9827**				**9827**	100,0	**22,8**
Modified emissions/emissions, fuel							1,00		
Industrial processes	q (10E3 kg/y)	F (n. of est.)	qF	fq	fF	f-	qF fq fF f-	d(qF fq fF f-)ind. (percent)	d(qF fq fF f-)tot (percent)
			0	1	1	1	0	#DIV/0!	0,0
			0	1	1	1	0	#DIV/0!	0,0
			0	1	1	1	0	#DIV/0!	0,0
			0	1	1	1	0	#DIV/0!	0,0
			0	1	1	1	0	#DIV/0!	0,0
			0	1	1	1	0	#DIV/0!	0,0
Sum industrial processes			**0**				**0**	#DIV/0!	**0,0**
Modified emissions/emissions, ind. proc.							#DIV/0!		
Miscellaneous	q (kg/LTD)	M (LTD)	qM	fq	fM	f-	qM fq fM f-	d(qM fq fM f-)misc (percent)	d(qM fq fM f-)tot (percent)
Airports	9	73411	661	1	1	1	661	39,8	1,5
Harbour			1000	1	1	1	1000	60,2	2,3
Sum miscellaneous			**1661**				**1661**	100,0	**3,9**
Modified emissions/emissions, misc.							1,00		
"Background"									
Unknown									
Sum total, excl. "Background"			**43030**				**43030**		**100**
Modified emissions/emissions, total							1,00		

Figure 2: Total annual emissions, DKI Jakarta. NO_x. Scenario: 1990.

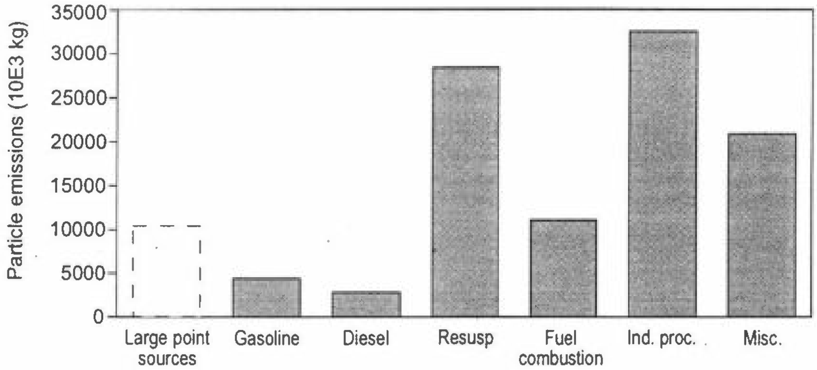

Figure 3: Emissions contributions from various source categories.

e) qF fq fF f- Modified emissions, due to control measures.

f) d(qF fq fF f-) Relative emission contributions from each source, per source category:
- vehicles
- fuel combustion
- industrial processes
- miscellaneous

g) d(qF fq fF f-) Relative emissions contributions, all categories summed.

Rows

a) Separate rows for each source type and category, "existing" and "new" technology.

b) "Background" : Fictitious emissions, corresponding to an extra-urban background concentration.

c) Modified emission/emissions : Ratio between modified and base case emissions.

Appendix 8

Meteorology and Dispersion Conditions in Jakarta

Meteorology and Dispersion Conditions

1. General description of dispersion and effects of topography/climate in Jakarta region

In general, the atmospheric circulation over Indonesia is affected by the meridional circulation termed Hadley circulation or trade wind. When the sun moves toward the southern hemisphere, the north east trade wind is attracted to the south, crossing the equator and becomes west or northwest monsoon in the rainy season (January - June). On the contrary, when the sun moves toward the northern hemisphere the east or southeast monsoon is created (the dry season, July-December). Normally, Indonesia experiences relatively low wind speeds. In the coastal regions of Indonesia local land or sea breeze may cause stagnation in the air when it is directed against the monsoon. Seasonal variations may occur with stagnation in the mornings during the rainy season and in the evenings during the dry season. The dispersion of pollutants may therefore vary with season and time of day.

The topography of Indonesia is dominated by the volcanic belt which runs from the western tip of Sumatra to the eastern Irian Jaya and from the northern tip of Sulawesi to the southern part. In the western and central parts of Java the topography has an important effect on the dispersion conditions.

The climate of Indonesia belongs to the tropical maritime continent type and is described as one of the most humid regions of the world. The humidity varies between 70 - 90%.

2. Geography, topography and climate in Jakarta

Jakarta is the biggest city in Indonesia, and is located on the mouth of the Ciliwung river. The city is located 6°12'S and 106°48'E. The area is very smooth with no local topography that can affect the dispersion conditions (average height 7 m a.s.l.). The climate is very hot and humid. Because Jakarta lies so close to the equator, the solar heating during the day and the earth cooling during the night may produce local land-sea breeze. When the land-sea breeze is working against the monsoon, it causes a stagnation of the airmasses, allowing pollutant concentrations to build up significantly.

The Agency of Meteorology and Geophysics (BMG) is running six weather stations spread in the DKI Jakarta and BOTABEK area. The measurements consist of:

- air temperature
- air humidity
- wind speed
- wind direction
- cloudiness
- barometric pressure
- rainfall
- rainy days

- The mixing height is derived from upper air measurement by means of the rawindsonde. The upper air data are obtained from the Soekarno Hatta International Airport.

- Two-way frequency distribution of wind speed and direction is derived for the six weather stations in the DKI Jakarta area. The wind is categorized into 8 directions and 4 classes of speed (0; 1-3 knots; 4-6 knots; and 7 knots and more.

- Atmospheric stability is derived from upper air measurement by means of the tethered radiosonde. The atmospheric stability is classified according to Pasquill's classification. The applicability of different methods of classification in Jakarta should be investigated. Neutral conditions were used for the calculations of yearly average concentrations.

Wind speed and direction
The wind roses from the six stations in DKI Jakarta, Figure 2 and 3 show similar patterns. The distance between the adjacent existing weather stations is not significant. The weather station that is located at the BMG office is used as a representative station.

The DKI Jakarta area is situated in the coastal region, consequently it is affected by the local winds, especially sea and land breeze. Although the local winds often affect the wind pattern, the prevailing wind in the DKI Jakarta is still governed by the monsoon. These two winds reinforce each other when they blow in the same direction and weaken each other when they blow in the opposite direction.

The sea breeze occurs at the coastline on sunny days, due to the warming of the land and a temperature gradient from sea to land is developing. The sea breeze may penetrate several kilometres into the inland (more than 40 km) when the temperature difference between sea and land is sufficiently large. In general the sea breeze starts to blow around 10 o' clock in the morning and it reaches its maximum when the inland air temperature is at its maximum. The local sea breeze comes from the north east direction. In the rainy season the sea breeze is weaker than in the dry season due to the effect of clouds on the solar warming.

The annual isotachs (iso-curves for wind speed) of the region, shown in Figure 4, show that the wind speed is weakest at Ciledug. The weather station in Ciledug is affected by local forcing. This may be due to a channel effect through the street canyons.

The dominant wind direction in Jakarta during the southern summer is from west to north. When the prevailing winds come from the northwest, the dominant wind direction at Ciledug is from the north. In July during the southern winter, the prevailing winds in Jakarta come from northeast to east. The station in Ciledug is affected by local forcing with dominant wind direction east west. The location of the Ciledug weather station should be evaluated with respect to local effects.

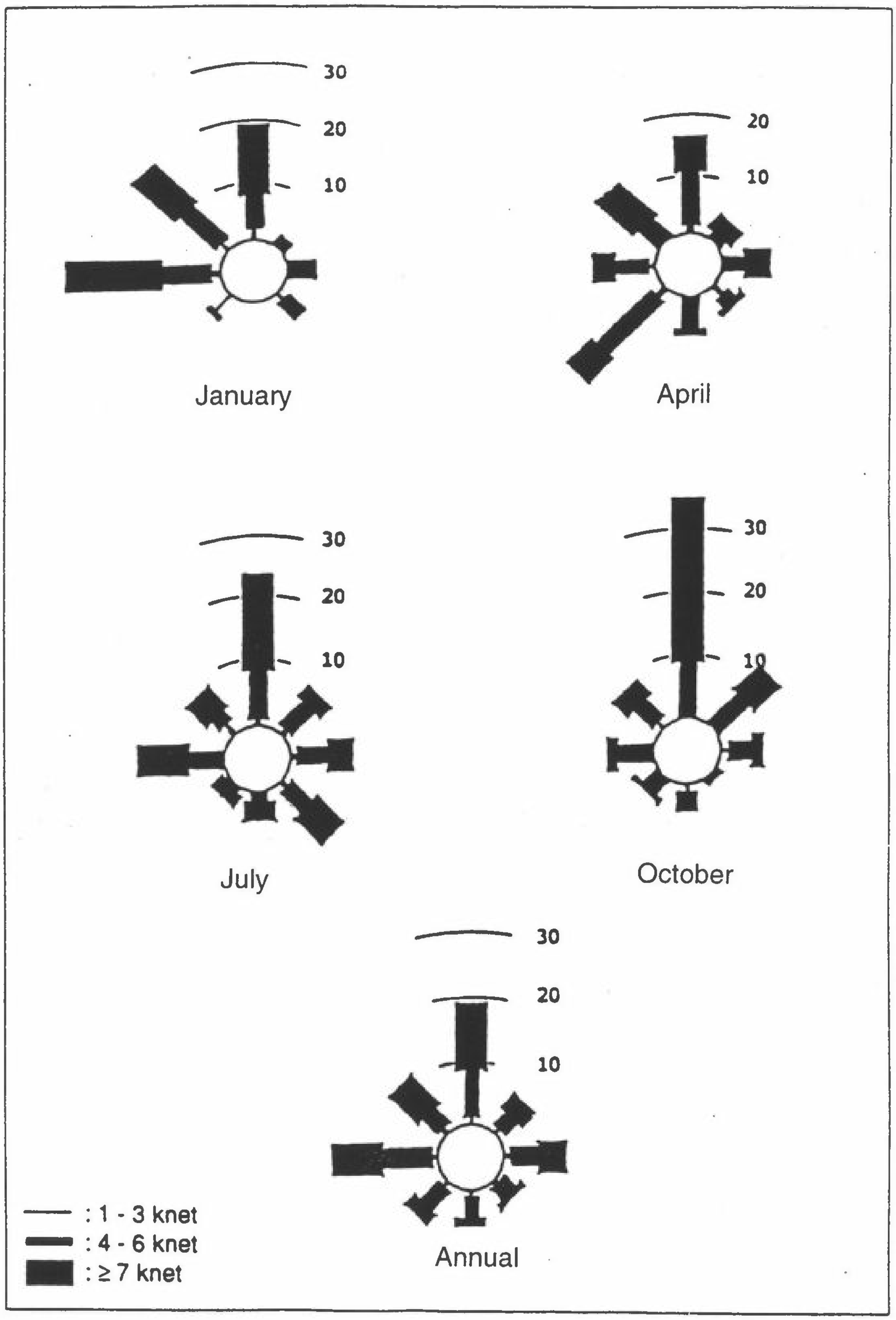

Figure 1: *Seasonal variation of the frequency of wind direction and wind speed for the BMG weather station in the DKI Jakarta area.*

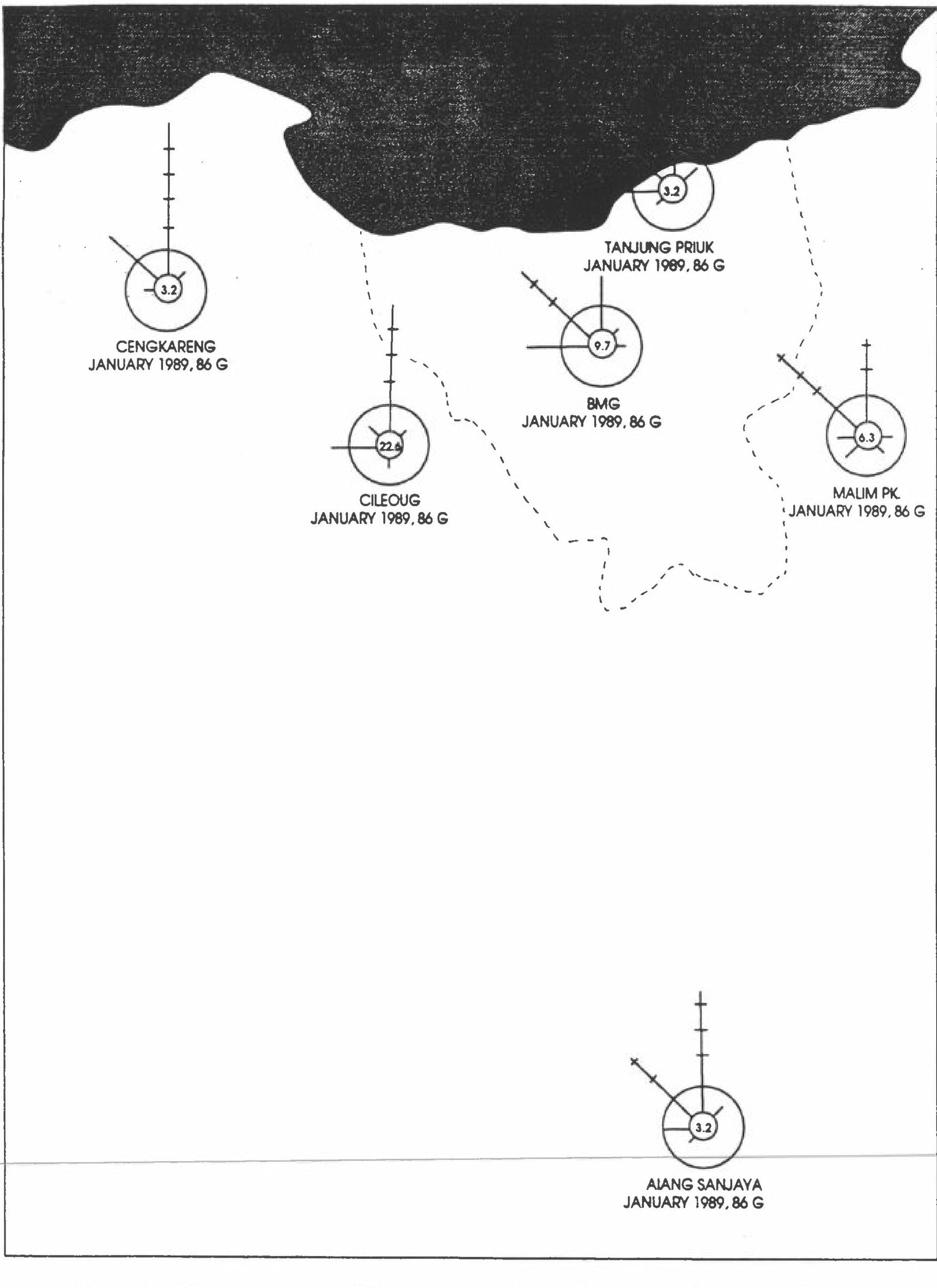

Figure 2: Map over the DKI Jakarta area with windroses from the six weather stations in January (0600 GMT, 1300 local time).

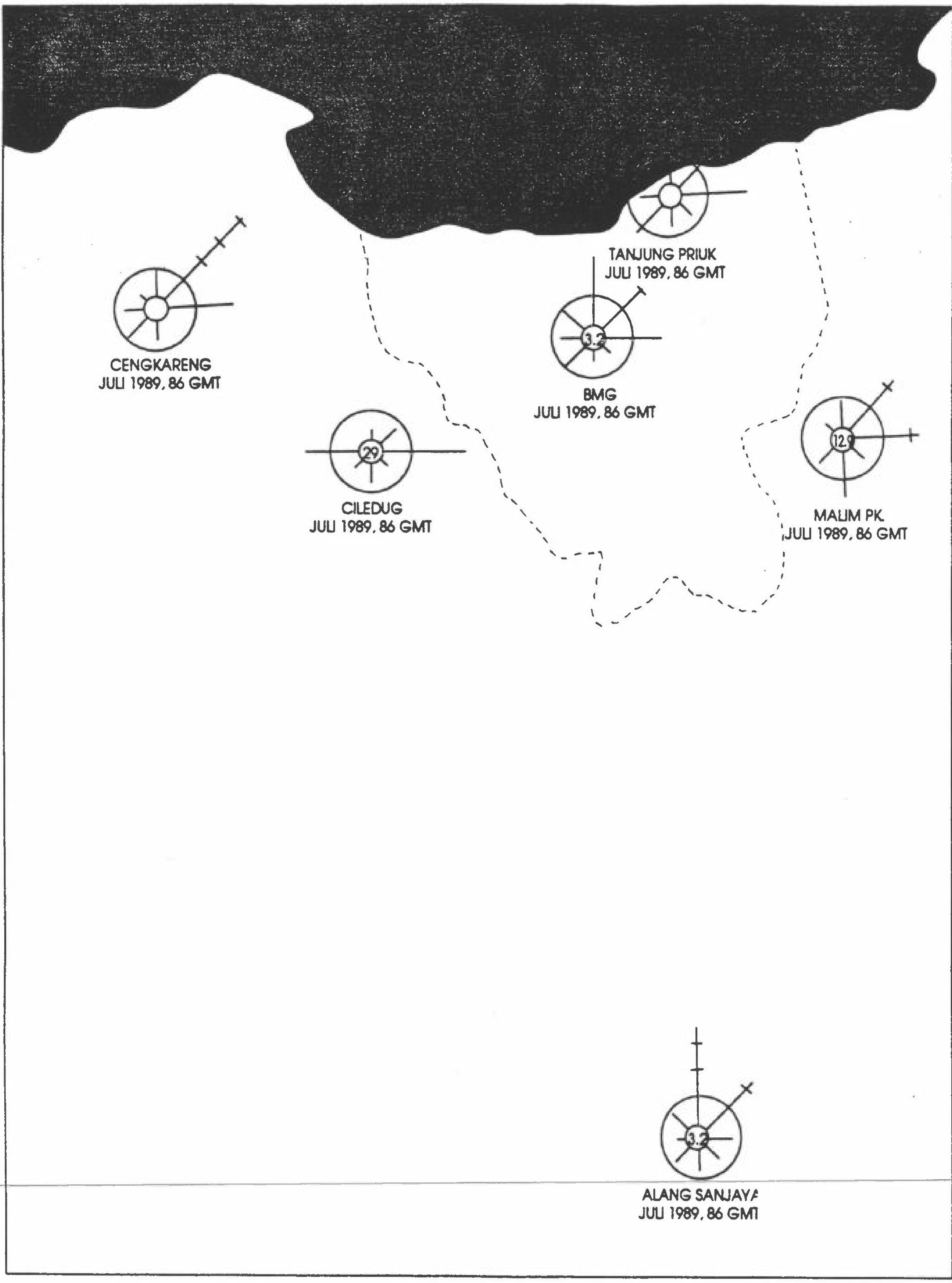

Figure 3: *Map over the DKI Jakarta area with windroses from the six weather stations in July (0600 GMT, 1300 local time).*

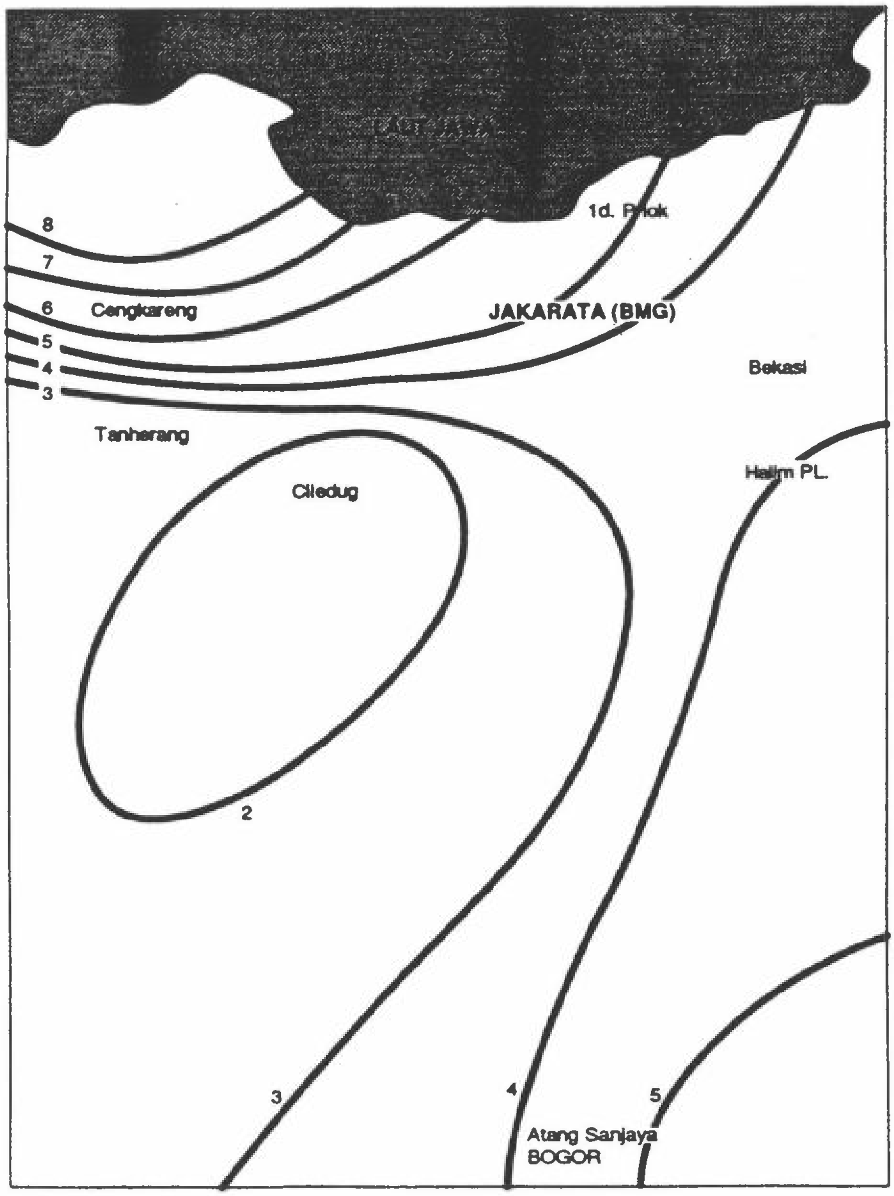

Figure 4: Average annual isotachs in the DKI Jakarta area.

The winds are generally from calm to weak in the morning while in the afternoon the winds are from weak to strong. This is due to the land-sea breeze. The local winds modify the monsoon winds.

The wind speed pattern varies through Jakarta. To the northwest there are sharp gradients of the wind speed from Cengkareng to Ciledug that lies in an area with calm winds (annual average about 2 knots). The main station Jakarta BMG lies in the strong gradient field between the calm area in Ciledug and the harbour area that is strongly affected by the sea breeze during the day. The annual average wind speed for Jakarta BMG is about 4-5 knots. In the southern part of Jakarta, at Atang Sanjaya, the wind speed is about the same as at BMG, and stronger than at Ciledug.

The mixing height

The mixing height is a parameter that describes the level where an air parcel, after being heated, will continue to rise until its temperature equals the surrounding air temperature. The airmass under the mixing height is well mixed and therefore often referred to as the mixing layer. The mixing heights for the DKI Jakarta region are given in Table 1.

Table 1: Mean mixing height (m) in the DKI Jakarta

Months	Area					Average mixing height in DKI Jakarta
	Jakarta Pusat	Jakarta Selatan	Jakarta Timur	Jakarta Utara	Jakarta Barat	
January	565	495	495	596	481	526.4
February	496	429	452	582	388	469.4
March	952	712	840	1 033	840	891.4
April	820	714	741	965	661	780.2
May	1 007	961	944	1 159	927	999.6
June	1 020	958	925	1 134	886	984.6
July	1 149	1 074	1 053	1 226	995	1 099.4
August	1 213	1 199	1 155	1 252	1 049	1 173.6
October	1 091	1 058	1 059	1 178	1 091	1 095.4
November	848	815	872	927	794	851.2
December	814	738	738	857	738	777.2

Source: BMG Jakarta 1989

The mixing height depends on the maximum air temperature and the weather conditions. The monthly average mixing height in the DKI Jakarta varies from 469 m to 1 174 m and the annual average mixing height is 902 m.

Atmospheric stability

The atmospheric stability plays an important role in the dispersion of pollutants. The atmospheric stability is determined by vertical temperature profiles. The vertical lapse rate is classified according to Pasquill as follows

A: Extremely unstable conditions
B: Moderately unstable conditions
C: Slightly unstable conditions
D: Neutral conditions
E: Slightly stable conditions
F: Moderately stable conditions

In the east of Jakarta (Pulo Gadung and Halim Perdana Kusumah) the frequency distribution of the atmospheric stability was in May 1990 33% extremely unstable, 43% neutral and 14% slightly stable.

The daily variation of the atmospheric stability in East Jakarta is given in Table 2.

Table 2: The diurnal variation of stability in the eastern part of the DKI Jakarta area.

Time	Stability		
	Extremely unstable conditions	Neutral conditions	Slightly stable conditions
0700	9	38	28
1000	18	23	28
1300	45	16	-
1600	18	23	44

Source: BMG Jakarta, 1990

The table shows that the stable conditions occur during the morning and evening and the unstable conditions are at a maximum in the middle of the day. The frequency of neutral conditions varies only slightly as function of time of day.

Temperature

The average annual temperature in Jakarta is about 27°C. The temperature in Jakarta has only got a slight annual variation, about 1-1.5°C variation. This is caused by the tropical monsoon near the equator.

Rainfall

The annual rainfall is approximately 2000 mm. The amount of rainfall varies significantly within the DKI Jakarta region. The annual range of rainfall variation in Central Jakarta is 362 mm, in South Jakarta 313 mm, in East Jakarta 336 mm, in North Jakarta 478 mm, and in West Jakarta 396 mm.

There are four seasons in Jakarta: the rainy season, the first transition season, the dry season and the second transition season. The rainy season is characterized by west or northwest monsoon and the dry season by east or southeast monsoon. For both west and east monsoons the amount of rainfall and number of rainy days increase toward the south region (Bogor). The orographic effect and the local sea and valley breeze contribute to the cloud and rain formation on the windward side. The rain in DKI Jakarta is dominated by the west monsoon. The amount of rainfall and the number of rainy days is much greater in December-February than in June-August.

3. Adverse meteorological situations in Jakarta

Studies in the Jakarta area indicate weak and short-lived inversions. The inversions break up as soon as the sun rises.

One meteorological situation that can lead to high ground level concentrations will be when the local land-sea breeze blows against the monsoon, and the local wind is faster than the monsoon. This could happen during the early mornings when the sky is clear, when the airmass in the inland is cooled from below by ground infrared radiation. The airmass will tend to follow the topography towards the coast. In the Jakarta area the wind will probably follow the river valleys from south to north. When the northwest monsoon is blowing, the local wind and the monsoon can lead to stagnation of the airmasses, leading to pollutant build-up.

The combination of the weak wind speed and unstable atmospheric conditions in the daytime can lead to high ground level concentrations near point sources (stack emissions) due to the vertical turbulent motions. The plume may not be much diluted before the downdrafts move the plume towards the ground.

Appendix 9

Project Description, Local Consultants

Contents

Page

Project Description Regarding Air Quality Assessment

18 May 1993 ANNEX 2

Project Description

Information shall be collected regarding the items described below. The information to be collected shall go beyond the information contained in the material referenced in the Draft Report from NILU and Institute of Environmental Studies (IES) of the Free University of Amsterdam prepared for the Workshop, and summarized in that report.

Available information shall be collected regarding the following items, and other items of interest for Air Quality Management Strategy Development in DKI Jakarta:

- Meteorological measurements in and near the city
- Activities/population data for DKI Jakarta:

Fuel consumption data:	Total fuel consumption - per type (high/low sulphur oil, coal, gas, firewood and other biomass fuels, other) - per sector (industry, commercial, domestic)
Industrial plants:	- Location (on map), type/process, emissions, stack data (height, diameter, effluent velocity and temp.)
Vehicle statistics:	- No. of vehicles in each class (passenger cars, trucks (small, med., large), buses, MC (2 and 3-wheels, 2 and 4 stroke - Age distribution - Average annual driving distance per vehicle class
Traffic data:	Definition of the main road network marked on map. Traffic data for the main roads: - annual average daily traffic (vehicles/day) - traffic speed (average, and in rush hours) - vehicle composition (pass.cars, MCs, trucks/buses)
Population data:	Per city district (as small districts as possible) - total population - age distribution

- Air pollution emissions — Emission inventory data (annual emissions)
  - per compound (SO_2, NO_x, particles (in size fractions: <2 µm, 2-10 µm, >10 µm), (VOC, lead)
  - emissions per sector (industry, transport, domestic, etc.)

- Air pollution data:
  - concentration statistics per monitoring station: annual average, 98-percentile, maximum concentrations (24 hr, 1 hr)
  - trend information
  - methods description, and quality control information on methods

- Dispersion modelling: Reports describing studies and results

- Air pollution laws and regulations: Summary of existing laws and regulations

- Institutions: Description of existing institutions working in, and with responsibilities within, the air pollution sector, regarding:
  - monitoring
  - emission inventories
  - law making
  - enforcement

  The information shall include:
  - the responsibilities and tasks of the institutions
  - authority
  - manpower
  - expertise
  - equipment (monitoring, analysis, data hard/software)
  - funds

It is important that the gathering of information is <u>as complete as possible</u> regarding each of the items, so that we have a basis of data which is as updated and complete as possible. Remember that this updated completed information data base is to form the basis for an action plan regarding Air Quality Management in DKI Jakarta. Such an action plan will also include the need to collect more data. In that respect, it is very important that the gathering of existing data is <u>complete</u>.

Project Description Regarding Damage Assessment and Economic Valuation

Project Description

URBAIR

Topics for research

A. Physical Impacts

1. Describe available studies on relations between air pollution and health.

2. Decide on the acceptability of dose - effect relationships from USA (tables 5.7 - 5.9).
   a. Mortality: 10 µg/m^3 TSP leads to 0.682 (range: 0.48-0.89) percentage change in mortality.
   b. Work loss days (WLD): 1 µg/m^3 TSP leads to 0.00145 percentage change in WLD.
   c. Restricted activity days (RAD): 1 µg/m^3 TSP leads to 0.0028 percentage change in RAD per year.
   d. Respiratory hospital diseases (RHD): 1 µg TSP leads to 5.59 (range: 3.44-7.71) cases of RHD per 100,000 persons per year.
   e. Emergency room visits (ERV): 1 µg/m^3 TSP leads to 12.95 (range: 7.1-18.8) cases of ERV per 100,000 persons per year.
   f. Bronchitis (children): 1 µg/m^3 TSP leads to 0.00086 (range: 0.00043-0.00129) change in bronchitis.
   g. Asthma attacks: 1 µg/m^3 TSP leads to 0.0053 (range: 0.0027-0.0079) change in daily asthma attacks per asthmatic person.
   h. Respiratory symptoms days (RSD): 1 µg/m^3 TSP leads to 1.13 (range: 0.90-1.41) RSD per person per year.
   i. Diastolic blood pressure (DBP): change in DBP = 2.74 ([Pb in blood]$_{new}$ - [Pb in blood]$_{old}$) with [Pb in blood] is blood lead level (µg/dl).
   j. Coronary heart disease (CHD): change in probability of a CHD event in the following ten years is $[1 + \exp - \{ - 4.996 + 0.030365(DBP_1)\}]^{-1}$ –

$$[1 + \exp - \{ - 4.996 + 0.0030365 \ (DBP_0) \}]^{-1}$$

   k. Decrement IQ points: IQ decrement = 0.975* change in air lead (µg/m^3).

Calculation example.

Let population be 10 million people.

Let threshold value of TSP be 75 µg/m³ (the WHO standard).

Let the concentration TSP be 317 µg/m³.

--> Concentration - threshold = 317 - 75 = 242 = 24.2 10 µg/m³.

--> Change in mortality = 24.2 * 0.682 = 16.5%.

Let crude mortality be 1% per year.

--> Crude mortality = 100,000 people per year.

--> Change in mortality due to TSP = 16.5% of 100,000 people = 16,500 people per year.

3. For those close -effect relationships that are acceptable, base value must be gathered, e.g.:
   a. crude mortality
   b. present work days lost
   etc.

B. Valuation

1. Mortality.
   a. Willingness to pay.
   In USA research has been carried out on the relation between risks of jobs and wages. It appeared that 1 promille of change in risk of mortality leads to a wage difference of ca. $1000. If this figure is applicable to all persons of a large population (say 10 million), the whole population values 1 promille change in risk of mortality at $1000 * 10 * 10⁶ = $ 10 billion. An increase in risk of 1 promille will lead to ca. 10,000 death cases, so per death case the valuation is $ 1 million. It should be decided if in other countries, e.q. cities, this valuation should be corrected for wage differences (e.g. if the average wage is 40 times lower than in USA, the valuation of 1 death case is $25,000). If this approach is acceptable, the only information needed is average wage.
   b. Production loss.
   If the approach of willingness to pay is not acceptable, the alternative is valuing human life through production loss, i.e. foregone income of the deceased. Again,

the information needed is average wage. Moreover, information is needed on the average number of years that people have a job. However, those without a job should also be assigned a value. An estimate of the income from informal activities can be an indication. Otherwise a value derived from the wages (e.g. half the average wage) can be a (somewhat arbitrary) estimation.

2. Morbidity.
Estimates are needed, for all cases of morbidity, of the duration of the illness, so as to derive an estimation of foregone production due to illness. Just as in the case of mortality (B. 1.b.) wages can be used for valuation of a lost working day. Moreover, the hospital costs and other medical costs are to be estimated. These costs still do not yet include the subjective costs of illness, which can be estimated using the willingness to pay to prevent a day of illness.

3. Willingness to pay to prevent a day of illness.
Valuation in USA, based on surveys among respondents, indicate that the willingness to pay to prevent a day of illness is ca. $15. This amount could, just like the amount of willingness to pay for risk to human health, be corrected for wage differences. The acceptability of such a procedure is, perhaps, somewhat lower.

4. IQ points.
Loss of IQ of children may lead to a lower earning capacity. A USA estimate is ca. $4600 per child, per IQ point, summed over the child's lifetime. If this is acceptable, the figure could be corrected for wage differences between USA and the city.

C. Other impacts

1. Buildings.
An estimate by Jackson et al, (see URBAIR report table 5.18) is that prevented cleaning costs per household per year are $42 for a reduction in TSP concentration: from 235 $\mu g/m^3$ to 115 $\mu g/m^3$. This would imply a benefit of $0.35 per household per $\mu g/m^3$ reduction. This figure could be corrected for wage differences between USA and the city. If that is acceptable, the information needed is the number of households in the city.

2. **Monuments.**

It is difficult to say which value is attached to monuments, as they are often unique and their value is of a subjective character. Nevertheless, the restoration and cleaning costs of monuments could be an indication of the order of magnitude of damage to monuments. Revenue of tourism might also give a certain indication of the valuation of future damage to monuments.

D. **Remark**

In most cases, the valuation of damage is not very precise, and certainly not more than an indication of the order of magnitude.

E. Technological Reduction Options

To give a reliable estimate of the costs of technological reduction options, one needs a reliable emission inventory in which is included the currently used technologies and the age and replacement period of the installed equipment. In the absence of this, the study by the city team might wish to concentrate on a case study (e.g. traffic, fertilizer industry, large combustion sources).

The first step is to identify options. Cooperation with IES is possible, once a case study is identified.

The second step is to estimate the costs, i.e. investment costs and O&M (operation and maintenance) costs. Based on the economic lifetime of the invested equipment, the investment costs can be transformed to annual costs, using writing-off procedures. Costs will often depend to a large extent on local conditions. Corrections of the costs are described in chapter 6 of the URBAIR report.

The third step is to estimate the emission reductions of the various reduction options.

The fourth step is to rank the options according to cost-effectiveness. For this purpose the various types of pollution have to be brought under a common denominator. A suggestion could be to calculate a weighed sum of the pollutants, using as weights the amount by which ambient standards are exceeded on average.

The calculation of the cost-effectiveness consists then of the calculation of the ratio of reduction over annual cost (R/C). The options with the highest ration R/C are the most cost-effective ones.

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ABSTRACT

The main report describes the development of an action plan for air quality improvement in DKI Jakarta, based upon the assessment of emissions and air quality in the metropolitan area, exposure and health effects (damage), the assessment of costs related to the damage and to a number of proposed abatement measures, and a cost-benefit analysis.

This report contains appendices on air quality measurements, emissions factors and inventory, exposure calculations, etc.

NORWEGIAN TITLE

KEYWORDS		
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ABSTRACT (in Norwegian)

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