JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ENVIRONMENTAL IMPACT MANAGEMENT AGENCY (BAPEDAL)
THE REPUBLIC OF INDONESIA

THE STUDY ON THE INTEGRATED AIR QUALITY MANAGEMENT FOR JAKARTA METROPOLITAN AREA

FINAL REPORT

EXECUTIVE SUMMARY

JUNE 1997

NIPPON KOEI CO., LTD.
SUURI KEIKAKU CO., LTD.

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LIST OF REPORTS

(This Volume is indicated by [ ])

Executive Summary	
Volume 1	Main Report
Volume 2	Supporting Report
Volume 3	Data Book

Currency Equivalents		
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J. Yen 1.00	=	Rp. 19.97

(As of Mid. January 1997)

PREFACE

In response to the request from the Government of the Republic of Indonesia, the Government of Japan decided to conduct the Study on the Integrated Air Quality Management for Jakarta Metropolitan Area and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Indonesia a study team headed by Mr. Shonosuke Ezoe, Nippon Koei Co., Ltd. associated with Suuri Keikaku Co., Ltd., five times between November 1994 and June 1997.

The team held discussions with the officials concerned of the Government of Indonesia, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Indonesia for their close cooperation extended to the team.

June, 1997

Kimio Fujita
President
Japan International Cooperation Agency

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

June, 1997

LETTER OF TRANSMITTAL

Dear Sir,

We have pleasure of submitting to you the Final Report of "The Study on the Integrated Air Quality Management for Jakarta Metropolitan Area".

This report presents the results of the study that was carried out for a total period of 32 months from November 1994 to June 1997 by the Study Team composed of Nippon Koei Co., Ltd. and Suuri Keikaku Co., Ltd., in accordance with the contract concluded with your Agency.

The report consists of (1) the results of meteorological survey, air quality monitoring, pollution source survey, socio-economic survey and institutional aspects survey, (2) the integrated countermeasures to satisfy the draft ambient air-quality standards in 2010 in consideration of the current and future air quality and to manage air quality for the Jakarta Metropolitan Area, and (3) the action plans until 2000 for three selected countermeasures.

On this occasion, we would like to express our deep appreciation and sincere gratitude to all those who extended their kind assistance and cooperation to the Study Team, in particular the officials concerned from the Environmental Impact Management Agency (BAPEDAL), the Environmental Management Center of BAPEDAL, the Agency of Meteorology & Geophysics, and the Institute of Urban Planning & Environment of DKI Jakarta. We also would like to extend our acknowledgments to the officials of your Agency, the Ministry of Foreign Affairs, the Environment Agency, and the Embassy of Japan in Indonesia.

We hope the report will realistically contribute to the future sustainable development in Jakarta Metropolitan Area.

Sincerely yours,

Shonosuke Ezoe
Study Team Leader

SUMMARY

1. Framework

(1) Study Area: Jabotabek Area extending over DKI Jakarta, Bogor, Tangerang, and Bekasi (6,070 km^2 in total)

(2) Target Year: - 2010 for the Air Pollution Control Strategy
- 2000 for the Action Plan

(3) Population:

Year	1995	2000	2010
Pop. (person)	20,160,000	23,500,000	28,760,000

(4) GRDP:

Year	1995	2000	2010
Rp. /person	1,500,000	2,100,000	4,500,000
(Jap.¥/person)	(75,000)	(105,000)	(225,000)

(5) Fuel Consumption:

Year	1995	2010
Oil (kl/yr)	2,790,000	12,000,000
Coal (t/yr)	1,650,000	7,130,000
Natural Gas (×10^6m^3/yr)	4,700	20,300

(6) Running Kilometers of Automobile:

Year	1995	2010
Running Km (×10^6km/yr)	39,000	80,000

2. Existing Air Quality

Automatic continuous air quality monitoring was carried out at six stations from January 1st to November 30th in 1996. Average values of the monitoring result are summarized below.

Items	Unit	EMC	Pulo Gadung	Pluit	Thamrin	KPPL	Cibinong	National Standard
SO_2	ppb	3.7	4.7	4.7	9.4	4.0	-	20
NO	ppb	3.0	27.3	27.9	109.4	35.0	-	-
NO_2	ppb	7.7	18.6	10.0	29.1	25.5	-	50
NOx	ppb	10.7	45.9	37.9	138.5	60.5	-	-
CO	ppb	440	1,490	1,000	2,790	1,840	-	8,100*
SPM	$\mu g/m^3$	53.0	116.1	84.4	81.5	87.8	46.6	60*
T-HC	ppbc	2,515	4,322	3,770	4,366	3,511	-	240

Note : 1) T-HC were observed from 6:00 to 9:00.
2) Standard of SPM is the standard value of DKI Jakarta.
3) SPM: Suspended Particulate Matters, T-HC: Total Hydrocarbon.

3. Simulation of Air Quality in 2010

(1) Air Quality without Countermeasures

The area with high SO_2 concentration exceeding the standards widely spread in the north of DKI Jakarta, Tangerang, Bekasi, and Cibinong. Total number of the grids exceeding the standards is 441 of 6682. The main cause of the high SO_2 concentrations is the factories like power plants, cement, and so on.

The area with high NO_2 concentration exceeding the standards mainly appear in DKI Jakarta, Kota Tangerang, and Kota Bekasi. Total number of the grids exceeding the standards is 47 of 6682. The main cause of high NO_2 concentration is automobiles at heavy traffic roads.

CO concentrations are below the standard even in 2010.

(2) Air Quality with Planned Countermeasures by BAPEDAL

SO_2 concentrations decrease with the planned countermeasures. Number of grids with high SO_2 concentrations exceeding the standards decrease from 441 to 107. More than one hundreds of grids remain exceeding the standards in the area of DKI Jakarta, Tangerang, and Cibinong.

NO_2 concentrations degrease with the planned countermeasures and number of grids with high NO_2 concentrations exceeding the standards decrease from 47 to 16. However, the countermeasures are not sufficient to solve the NO_2 problem perfectly at the heavy traffic roads.

(3) Air Quality with Additional Countermeasures

As a result of application of full countermeasures, the standards of SO_2 and NO_2 will be satisfied in the whole Jabotabek area.

4. Air Pollution Control Strategy

(1) Goal of Control Plan

The control plan aims at overall compliance with the national air quality standards within the Jabotabek area.

(2) Countermeasures for Air Pollution Control

Considering simulation results of future air quality in case of without conditions, the following countermeasures are proposed to attain the goal mentioned above.

1) Common to Stationary & Mobile Source Control

- Supervisory Agency : Environmental Impact Management Agency (BAPEDAL), Indonesian Ministry of Health (MOH), L-PU
- Implementation Agency : BAPEDAL, L-BLH, BLK, Agency of Meteorology and Geophysics (BMG)
- Proposed Countermeasures
  - Monitoring HC Concentration in Ambient Air (1-A),
  - Reduction of HC Emissions (1-B),
  - Reduction of Particulate Matter in Ambient Air (1-C), and
  - Strengthening of Ambient Air Monitoring (1-D).

2) Stationary Source Control

- Supervisory Agency : BAPEDAL, L-BLH, Indonesian Ministry of Industry (PERIND), BAKOREN, Indonesian Ministry of Mining and Energy (TAM)
- Implementation Agency : BAPEDAL, L-BLH, PERIND, PELAKSANA, National Mining and Oil Company (PERTAMINA)
- Proposed Countermeasures
  - Stationary Source Inventory (2-A),
  - Enforcement of Emission Standard Decree (2-B),
  - Total Emission Reduction Plan (2-C),
  - Emission Management System (2-D),

- Combustion Control System (2-E),
- Fuel Conversion (2-F), and
- District Stack Gas Control (2-G).

3) Mobile Source Control

- Supervisory Agency : PERIND, BAPEDAL, Indonesian Ministry of Transport (HUB), BAPENAS
- Implementation Agency : HUB, DLLAJK, BAPEDAL, L-BLH, PELAKSANA, PERTAMINA
- Proposed Countermeasures
  - Preparation of Mobile Source Inventory in Jabotabek (3-A),
  - Introduction of New Regulations on Vehicle Emission Gas (3-B),
  - Strengthening of Vehicle Inspection Program (3-C),
  - Promotion of Unleaded Gasoline Usage (3-D),
  - Acceleration of Turn-over Rate of Aged Vehicles (3-E),
  - Promotion of Low-pollution Vehicles (3-F), and
  - Suppression of Diesel Use in Vehicles (3-G).

(3) Verification of Effectiveness of the Proposed Countermeasures

The effectiveness of the proposed countermeasures is verified by the simulation model. It is concluded that the goal is to be attained by taking all countermeasures in 2010.

(4) Selection of Countermeasures to be commenced in early stage

Priority of implementation of the proposed countermeasures are decided from the viewpoints of "Institutional and Legislative Necessity" and "Commencement Year for Preparation Stage" as shown in Figure 1.

Further, three countermeasures, namely i) Strengthening of Ambient Air Monitoring System (1-D), ii) Preparation of Stationary Source Inventory (2-A), and iii) Preparation of Mobile Source Inventory in Jabotabek (3-A) are selected for the action plans from the viewpoint of grasping the most important and basic data in order to manage the air quality in Jabotabek effectively, and evaluation of the proposed countermeasures as shown in Table 1. This selection simply reflects current lacking situation of basic data, which will be essentially important to accelerate the other proposed countermeasures.

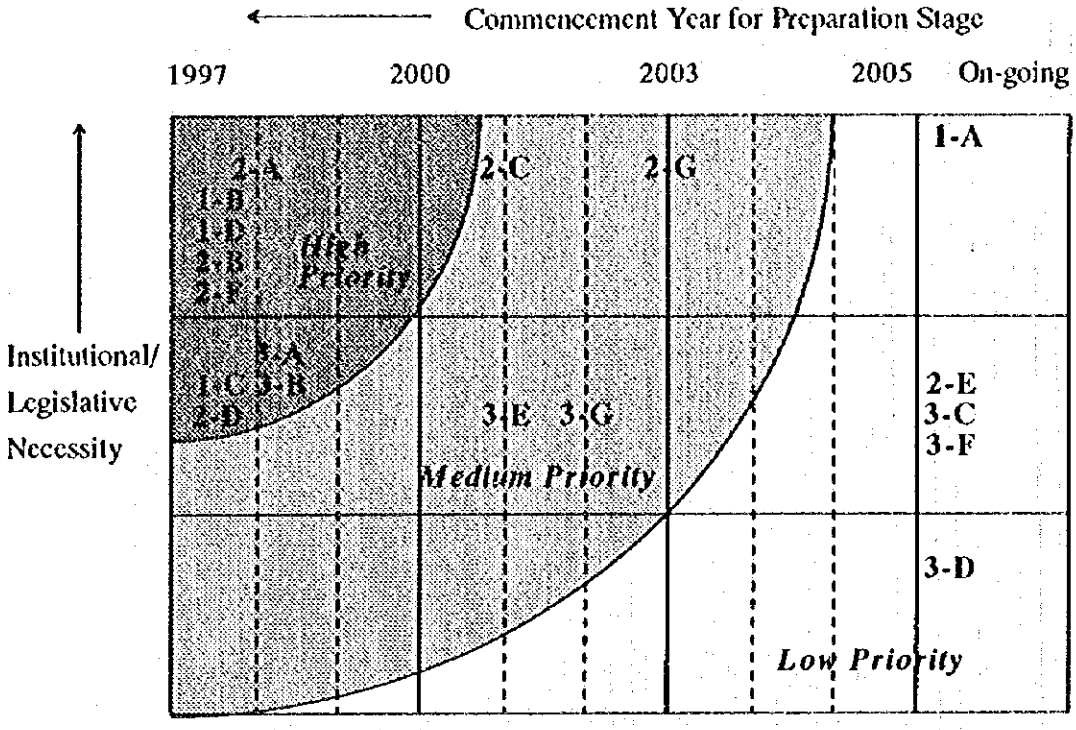


Figure 1 Priority of Countermeasures

5. Action Plan of Air Pollution Control

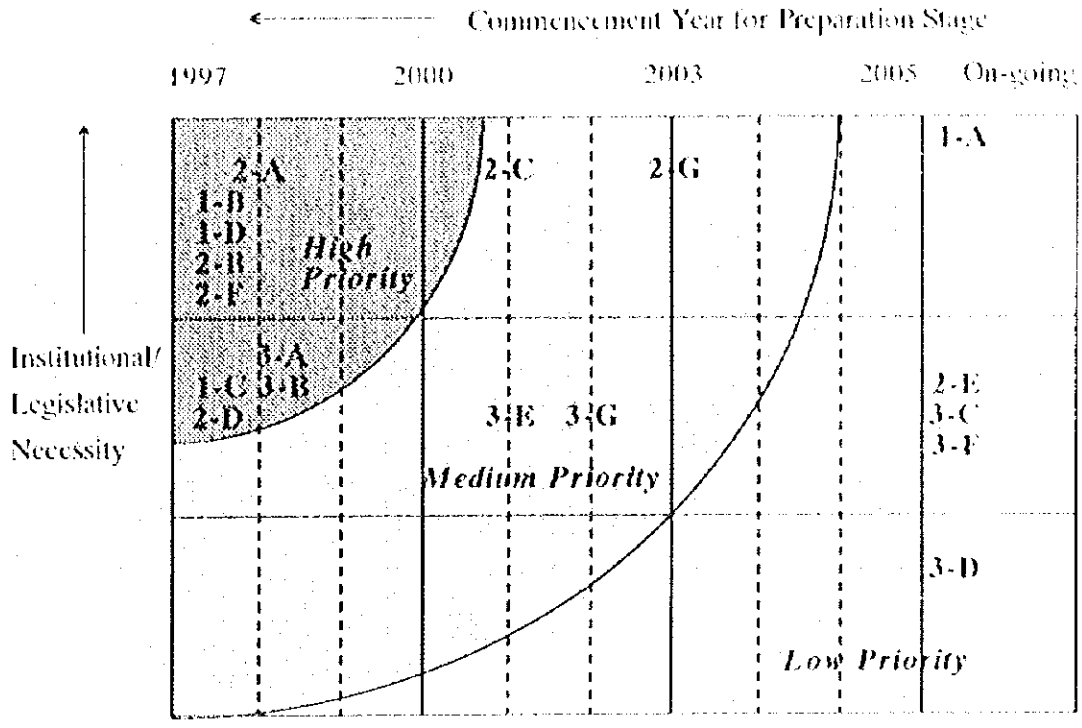
Formulated action plans for the selected three countermeasures are summarized below.

(1) Strengthening of Ambient Air Monitoring System (1-D)

1) Contents

19 additional ambient air monitoring stations (4 in DKI Jakarta, 6 in Bogor, 5 in Tangerang, and 4 in Bekasi) need to be established for implementation of this project. Principal tasks of this project are as follows;

- Determination of monitoring station sites,
- Arrangement for legal support,
- Installation of monitoring system,
- Organization of human resources, and
- Preparation of operation and maintenance.



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- Determination of monitoring station sites,
- Arrangement for legal support,
- Installation of monitoring system,
- Organization of human resources, and
- Preparation of operation and maintenance.

2) Schedule

Preparation work starts in 1997, and implementation commences in 1999.

3) Cost

Total cost of equipment is estimated at Rp.17,300,000,000 (Jap.¥865,000,000).

4) Institutional Necessity

This project requires 28 personnel including 3 members from BAPEDAL, 2 from EMC, 8 from DKI Jakarta and 5 from each district.

(2) Preparation of Stationary Source Inventory (2-A)

1) Contents

The action plan is formulated focusing on a preparation of stationary source inventory considering its urgency. Principal tasks of this project are as follows;

- Review of previous studies,
- Identification of stationary sources,
- Arrangement for legal support,
- Questionnaire survey,
- Training of technicians for emission measurement,
- Procurement of measurement equipment,
- Measurement of pollutant emissions at sites, and
- Compilation of stationary source inventories.

2) Schedule

Preparation work starts in 1998, and implementation commences in 2001.

3) Cost

Total cost of equipment is estimated at Rp.1,430,000,000 (Jap.¥72,000,000).

4) Institutional Necessity

This project requires 16 personnel including staff members from DKI Jakarta and local government.

(3) Preparation of Mobile Source Inventory in Jabotabek (3-A)

1) Contents

The action plan is formulated focusing on an preparation of mobile source inventory in Jabotabek considering its urgent need. Important tasks consist of the following 13 ones:

- Organization of a Task Force Team,
- Update of Vehicle Market Information,
- Monitoring of Traffic Volume,
- Preparation of a Test Plan for Drive Cycle Establishment,
- Road Test,
- Development of Jabotabek Test Cycle Modes,
- Purchase of Chassisdynamometer (C.D.),
- Installation of C.D.,
- Operator Training of C.D.,
- Calculation of Major Emission Factors,
- Estimation of Other Emission Factors,
- Determination of Average Emission Factors, and
- Assessment of Mobile Source Inventory

2) Schedule

Preparation work starts in 1998, and implementation commences in 1999.

3) Cost

Total cost for initial investment for C.D. as well as construction and foreign consultant fee was estimated at Rp.10,205,000,000 (Jap.¥510,000,000).

4) Institutional Necessity

This project requires two BAPEDAL staff to be involved in formulation work of the inventory, and 2 chief engineer, 1 emission gas analyst and 6 C.D. operators to be hired on a full-working basis.

6. Recommendation

BAPEDAL is urged to implement all proposed countermeasures in order to satisfy the ambient air quality standards, against the increasing emission of air pollutants in Jabotabek area. Such efforts will significantly benefit the public health condition in the future. In particular, the three action plans need to be launched urgently as these plans will provide basic information essential to execute effective air quality control administration.

Table 1 Results of Evaluation of Countermeasures

Control Measures		Institutions & Legislations					Commencement Year		Average Annual Cost from1997 to 2000 (million Rp.)	Priority
		Existing Bodies for Preparation	Existing Bodies for Implementation	Existing Legislations and Programs	Reinforcement of staff in charge	Enactment	Preparation	Implementation		
(1) *Common to Stationary & Mobile Sources*	1-A. *Monitoring of Hydrocarbon Concentration in Ambient Air*	BAPEDAL	BAPEDAL, L-BLH	• *Industrial Act* • AMDAL	BAPEDAL and L-BLH	*Air Pollution Control Law*	—	*already commenced*	—	Low
	1-B Reduction of Hydrocarbon Emissions	BAPEDAL	BAPEDAL, L-BLH	• Industrial Act • AMDAL	BAPEDAL and L-BLH	Air Pollution Control Law	1997	1998	2,370	High
	1-C. Reduction of Particulate Matter in Ambient Air	MOH, BAPEDAL	L-BLH	• Waste Act • Revised Environment Act	L-BLH	—	1997	1997	1,060	High
	1-D. Strengthening of Ambient Air Monitoring System	BAPEDAL	BAPEDAL, L-BLH, BLK, BMG, L-PU	• Revised Environment Act	L-BLH, BPPI and L-PU	Air Pollution Control Law	1997	1999	150 (17,310)	High
(2) Stationary Sources	2-A. Preparation of Stationary Source Inventory	BAPEDAL	BAPEDAL, L-BLH	• Industrial Act • AMDAL	BAPEDAL and L-BLH	Air Pollution Control Law	1998	2001	70 (1,420)	High
	2-B. Enforcement of Emission Standards Decree	BAPEDAL	BAPEDAL, L-BLH, BPPI	• Industrial Act • Blue Sky Program • Emission Gas Standard, • Revised Environment Act	L-BLH	Air Pollution Control Law	1997	2002	40	High
	2-C. *Total Emission Reduction Plan*	*BAPEDAL, L-BLH*	*L-BLH*	• *Industrial Act,* • Revised Environment Act	*BAPEDAL and L-BLH*	*Air Pollution Control Law*	*2001*	*2006*	*No cost up to 2000*	*Medium*
	2-D. Emission Management System	BAPEDAL, PERIND	BAPEDAL, PERIND	• AMDAL • Industrial Act • Blue Sky Program	—	Pollution Control Manager System	1997	2002	—	High
	2-E. Combustion Control System	BAPEDAL, BAKOREN	BPPI, L-BLH, PELAKSANA, Indonesia Bank	• Industrial Act • Environmental Soft Loan Program	BAPEDAL, BPPI and L-BLH	Energy Saving Act	—	already commenced	—	Low
	2-F. Fuel Conversion	TAM, BAPEDAL	L-BLH, BPPI, PERTAMINA	—	L-BLH and BPPI	Air Pollution Control Law	1997	2006	— (136,000)	High
	2-G. Direct Stack Gas Control	BAPEDAL	BAPEDAL, PELAKSANA, Indonesia Bank	• Soft Loan Program	BAPEDAL	Air Pollution Control Law	2003	2006	No cost up to 2002	Medium
(3) Mobile Sources	3-A. Preparation of Mobile Source *Inventory in Jabotabek*	BAPEDAL	BAPEDAL	—	BAPEDAL	—	1998	2000	30 (10,210)	High
	3-B. Introduction of New Regulations for Vehicle Emission Gas	BAPEDAL	HUB	• Industrial Act • Blue Sky Program	—	Road Transport & Motor Vehicle Law	1998	2001	700 (11,300)	High
	3-C. Strengthening of Vehicle Inspection Program	HUB, BAPEDAL	DLLAJK, L-BLH	• Road Traffic Law • Blue Sky Program • Automobile Exhaust Standard	DLLAJK and L-BLH	—	—	already commenced	—	Low
	3-D. Promotion of Unleaded Gasoline Usage	BAPENAS, BAPEDAL, HUB	BAPEDAL, PERTAMINA	• Blue Sky Program	—	—	—	already commenced	500 (350,000)	Low
	3-E. Acceleration of Turn-over Rate of Aged Vehicles	BAPENAS, BAPEDAL	DLLAJK, L-BLH	• Road Traffic Law	DLLAJK and L-BLH	—	2001	2006	No cost up to 2000	Medium
	3-F. Promotion of Low-pollution Vehicles	BAPEDAL	DLLAJK, L-BLH, BAPEDAL, PELAKSANA Indonesia Bank	• Blue Sky Program • Soft Loan Program	BAPEDAL	—	—	already commenced	—	Low
	3-G. Suppression of Diesel Use in Vehicles	BAPEDAL	PERTAMINA	—	—	Air Pollution Control Law	1998	2006	No cost up to 2001	Medium

Notes: 1) Prioritization is only among the countermeasures proposed here by the JICA Study Team in addition to the on-going projects. (But all these proposed countermeasures should be implemented to reach the 2010 goals.) Therefore, remaining potential countermeasures are not subject to the prioritization here.
2) Average annual cost shows wage including PR cost. ( ) shows equipment/facilities initial investment cost and foreign consultant fee.

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LIST of ABBREVIATIONS

AAQS	Ambient Air Quality Standard
AMDAL	Indonesian Environmental Impact Assessment (or Analyses)
AVR	Automatic Voltage Regulator
BAKOREN	Energy Regulation Agency
BaP	Benzo-a-pyrene
BAPPEDA	Regional Planning Agency, DKI Jakarta
BAPEDAL	Environmental Impact Management Agency
BAPEDALDA	Local Environmental Management Agency
BAPPENAS	National Development Planning Agency
BKPSL	Environmental Research Center Community
BLH	Environmental and Health Department
BLT	Environmental and Technology Bureau, Ministry of Mines and Energy
BMG	Agency of Meteorology and Geophysics
Botabek	Bogor, Tangerang and Bekasi (Jabotabek area excluding DKI Jakarta)
B/T	BAPEDAL Counterpart Team
BTKL	Directorate of Environmental Health
BPPI	Agency for Research and Development, Ministry of Industry and Trade
BPPT	Agency for the Assessment and Application Technology
C	Carbon - Cel: elemental, Cor: organic, Ct: total
CHN	Three Elements (C, H and N) Analysis
CMB	Chemical Mass Balance
CNG	Compressed Natural Gas
CO	Carbon Monoxide
DEPDAGRI-DPD	Local Development Environmental Management and Guidance Office, Ministry of Internal Affairs
DF/R	Draft Final Report
DIC/R	Draft Inception Report
DKI Jakarta	Special Capital District (Daerah Khusus Ibukota) of Jakarta
DLLAJ	Road Traffic Department
DLLAJR	Road Traffic Department in a Local Department
DPD	Ministry of Internal Affairs
DPF	Diesel Particular Filter
DSN	National Standard Conference
EC	Elemental Carbon
EMC	Environmental Management Center of BAPEDAL (PUSARPEDAL)
EMS	Environmental Management System
F/R	Final Report
GAIKINDO	Association of Indonesian Automotive Industries
GNP	Gross National Product
GOI	The Government of Indonesia
GOJ	The Government of Japan
GRDP	Gross Regional Domestic Product
GRT	Gross Tonnage
HC	Hydrocarbons
HSD	High Speed Diesel
HUB	Indonesian Ministry of Communication (Dephub : Departemen Perhubungan)

IC/R	Inception Report
IDO	Industrial Diesel Oil
I/M	Inspection and Maintenance
INKINDO	Local Consultant Association
Jabotabek	Jakarta, Bogor, Tangerang & Bekasi (Jakarta Metropolitan Area)
JEA	Japan Environment Agency
JICA	Japan International Cooperation Agency
JIS	Japan Industrial Standard
JMDPR	Jabotabek Metropolitan Development Plan Review
J/T	JICA Study Team
KAIT	Technical Certification Committee
KPPL	Inst. of Urban Planning & Environment of DKI Jakarta
L-BLH	Local BLH
LPG	Liquefied Petroleum Gas
MFO	Marine Fuel Oil
MOH	Indonesian Ministry of Health
MRT	Mass Rapid Transit
NMHC	Non-methane Hydrocarbons
N.D.	Non Detection
NOx	Nitrogen Oxides
O & M	Operation and maintenance
OC	Organic Carbon
O.D.	Origin and destination of vehicle traffics
OJT	On the job training
Ox	Oxidants
PASMI	Persatuan Assembler Sepeda Motor Indonesia
PEN	Indonesian Ministry of Information
PERIND	Indonesian Ministry of Industry and Trade (Depperindag : Departemen Perindustrian dan Perdagangan)
PERTAMINA	National Mining and Oil Company
PJP	Indonesian 25 years development plan
PM	Particulate Matter
PM10	SPM under 10 microns
ppb	parts per billion
PPEK	Ecology Health Research Center, Ministry of Health
PPSML	Human Resources Development and Environment Institute
P/R	Progress Report
PSL	Environmental Research Center in a University
PU	Ministry of Public Works
Ref.	Reference
RKL	Environmental Management Program
RPL	Environmental Monitoring Program
SOP	Standard Operation Procedures
SOx	Sulfur Oxides
SPM	Suspended Particulate Matter
S/W	Scope of Work
TAM	Indonesian Ministry of Mining and Energy (Deptamben : Departemen Pertambangan dan Energi)
TC	Total Carbon
TEL	Tetra-ethyl Lead
THC	Total Hydrocarbons
TSP	Total Suspended Particulates
UN-ECE	United Nations' Economic Commission for Europe
URBAIR	Urban Air Quality Management Strategy Project by the World Bank

EXECUTIVE SUMMARY

1. INTRODUCTION

1.1 Background

Jakarta, the capital city of the Republic of Indonesia, is one of the fastest growing cities in terms of economic activities in the rapidly prospering region of South-east Asia. Due to the rapid economic growth, most cities including Jakarta have suffered from degradation of urban environment.

Broadly speaking, motorization, urbanization, and industrialization have affected the air quality of Jakarta. A lot of traffic volume, large scale combustion facilities such as thermal power stations, and cement factories are worsening the air quality. Industrial development estates such as Pulogadung, Tangerang, and Bekasi also discharge a large amount of air pollution load.

The Indonesian authorities are fully aware of air pollution and have taken various kinds of countermeasures for environmental management and reduction of pollution load. The Ministry of Environment is in charge of environment planning in Indonesia. The Environmental Impact Management Agency (BAPEDAL) established in 1990, is the executing agency responsible for protection of the environment.

BAPEDAL has started the 'Blue Sky Program' for air quality improvement. Although several air quality management studies in and around the Jakarta metropolitan area (Jabotabek) were conducted by donor countries, proposed countermeasures against air pollution have not been effectively implemented. With this background, capacity building of the agencies concerned such as BAPEDAL is an urgent task for planning and implementation of integrated air pollution control projects.

For the reason mentioned above, the Government of the Republic of Indonesia (GOI) requested the Government of Japan (GOJ) to assist in clarifying the structure of air pollution problems, formulating an implementation schedule for the overall control strategy, and conducting technology transfer and training in Jabotabek.

In response to this request, the Japan International Cooperation Agency (JICA) appointed by GOJ as an executing agency dispatched a mission for preliminary studies in April and December 1994. The Study on the Integrated Air Quality Management for Jabotabek (the

Study) was implemented in accordance with the Scope of Work (S/W) and subsequent Minutes of Meetings (M/M) agreed between BAPEDAL and JICA.

1.2 Objectives

This Study aimed to monitor continuously and by scientifically proven methods applied for the first time in Jabotabek, ambient air quality and actual emission data of stack gases, in order to grasp the present air condition, and to prepare an air pollution control strategy until 2010 and a more concrete action plan until 2000. Another major objective of the Study was technology transfer and training of counterpart members of BAPEDAL and related organizations through the Study.

1.3 Study Area

The Study Area is Jabotabek which extends over DKI Jakarta, Bogor, Tangerang, and Bekasi, as shown in Figure 1.1.

1.4 Work Flow of the Study

A work flow of the Study is shown in Figure 1.2. The Study consists of a number of field and analytical works, and the whole study lasts from December 1994 to June 1997.

The Study was carried out the analytical work using the field work data as the continuous ambient air quality monitoring data, exhaust gas measurement data, and so on.

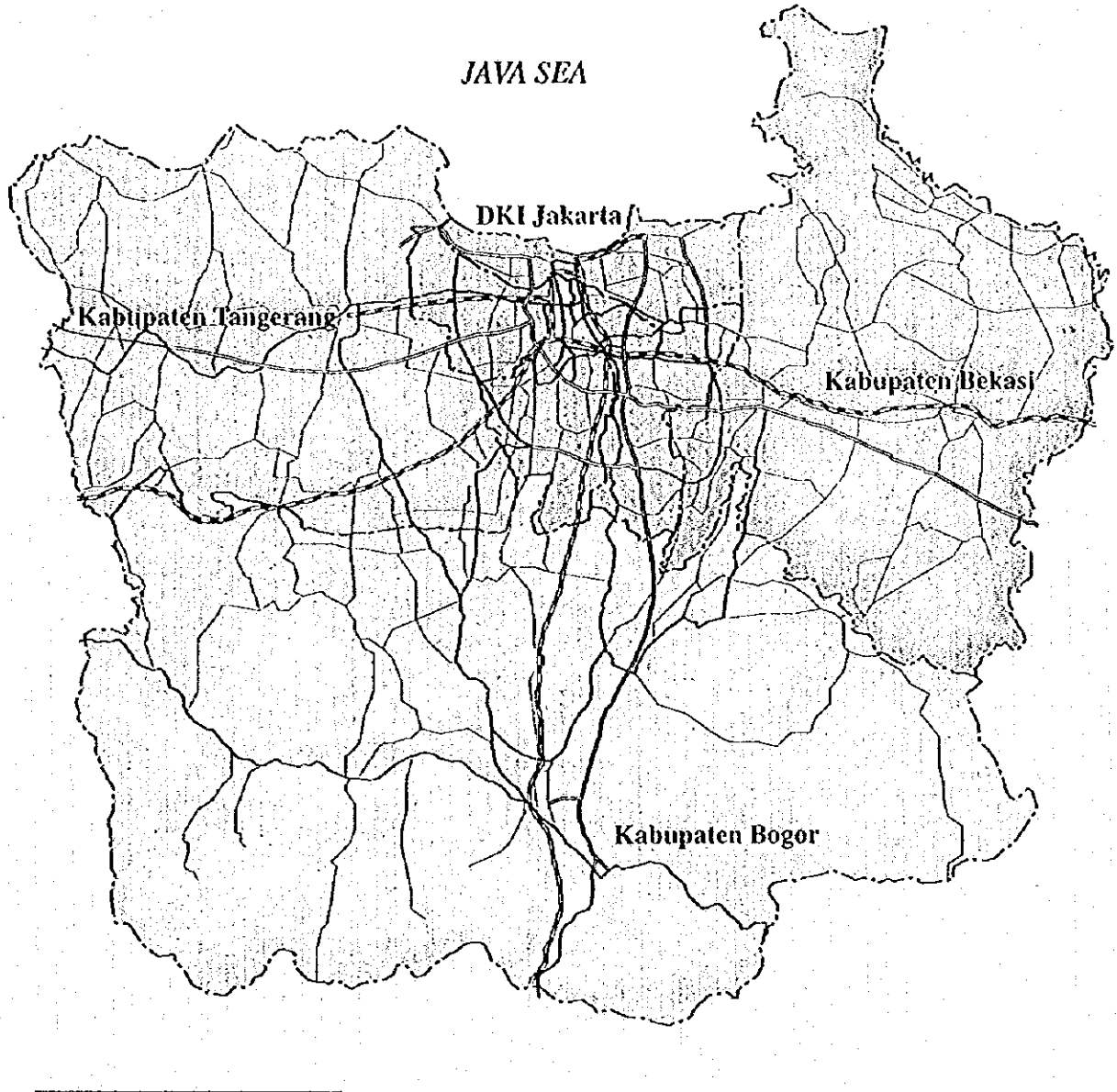
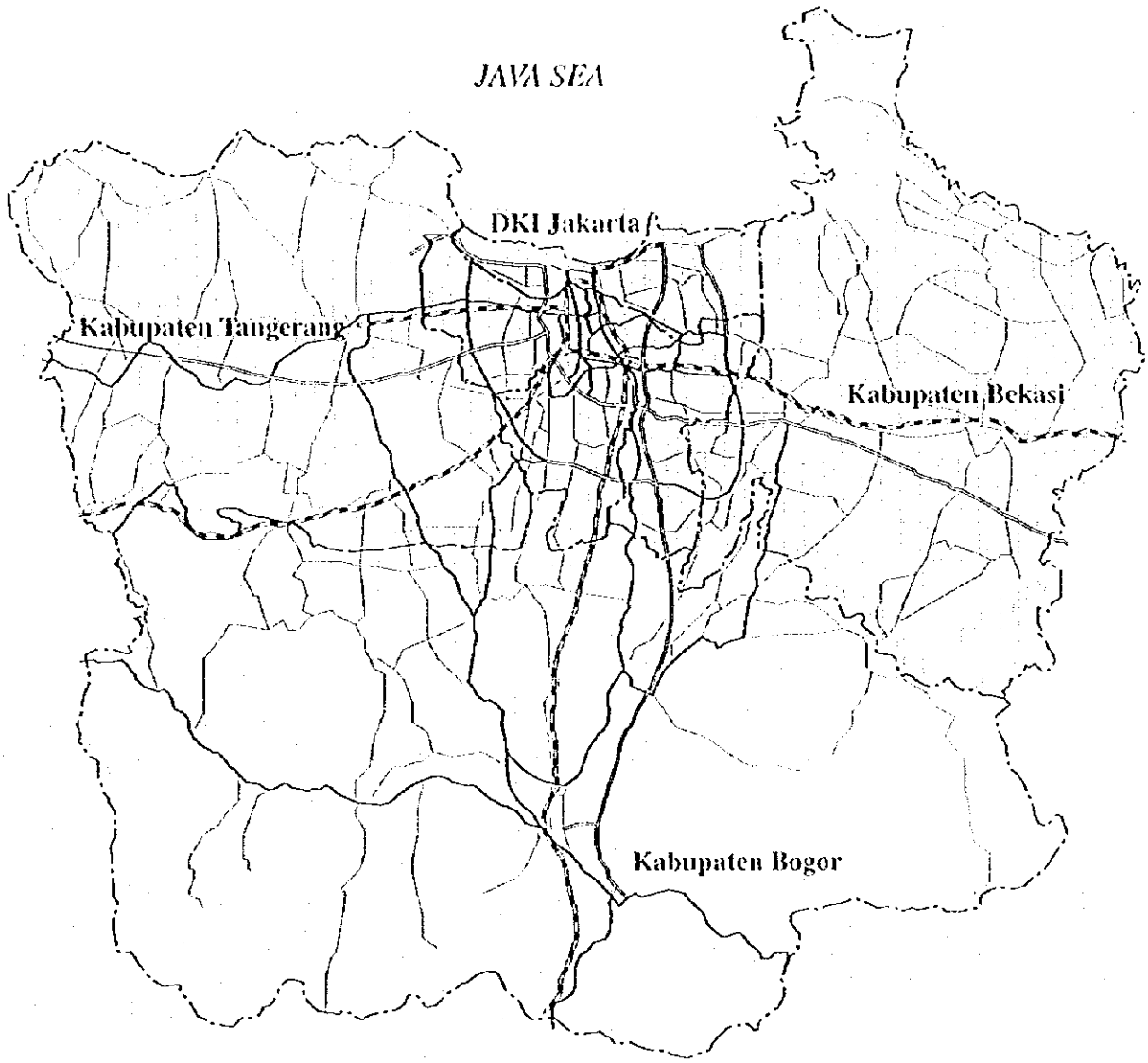
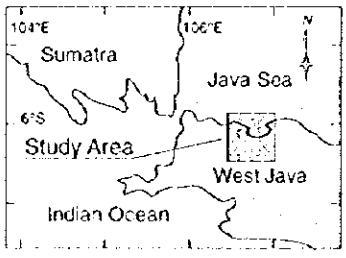


Figure 1.1 The Study Area





LEGEND

- Primary Road
- Secondary Road
- Road
- Railway
- Administrative Boundary

N

SCALE

0 5 10 15 (km)

Figure 1.1 The Study Area

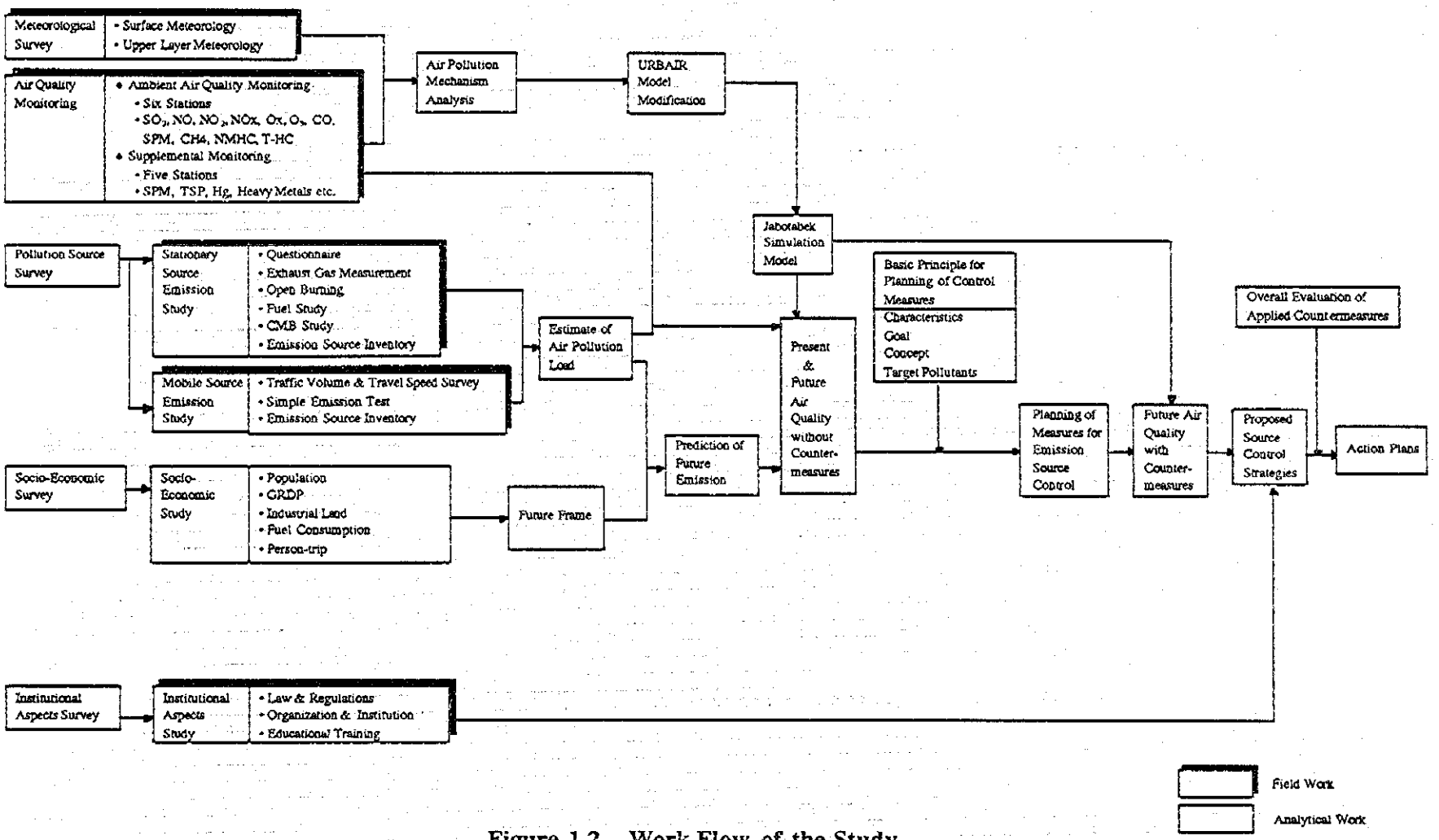


Figure 1.2 Work Flow of the Study

2. METEOROLOGY

Surface meteorological observation was continuously carried out basically at five stations for one year. Meteorological observation at upper layers was carried out four times intermittently.

According to the results of the surface meteorological observation, the annual average wind in the Jabotabek area is very weak. It is often calm (wind speed lower than 0.5 m/s) in night time. The wind speed is very low at night and is only moderate in daytime. The highest annual average wind speed is in the range of 1.5 to 3 m/s and is recorded at 2:00 p.m. at all 5 monitoring stations. The annual average diurnal temperature in Jabotabek ranges between the lowest of 24 to 26°C recorded at 6:00 a.m. and the highest of 32 to 33°C at 1:00 p.m.

According to the results of upper layer observation, the directions of upper layer winds are westerly in December, northwesterly in February, easterly in May, and southeasterly in August. Wind speeds are highest in December and lowest in August. The frequency of lower inversion (lower than 450 m) reaches 68.4% and 63.6% at nights in December and May, respectively. The intensity of the inversion layers is not so strong, because the temperature gradient is lower than 3.0°C/100 m. Seasonal averages of daily maximum 'Lid' (inversion layer) heights are between 700 m in February and 1,300 m in August.

The surface layer in Jabotabek area has a character to diffuse pollutants emitted close to the surface, such as mobile sources, because of the prevalence of wind in daytime. On the contrary, pollutants emitted at a higher level can reach the ground surface by the disturbance in the mixing layer. This is one of the reasons for high concentration of pollutants in daytime.

In the night, because of less windy condition, pollutants emitted near the ground surface accumulate there. However, as activities of the emission sources become slower at night, usually pollutant concentrations will gradually go down. Next morning, if there remains a stable layer, the high concentration will appear again when the activities re-gain. The pollutants emitted at a high level in the night drift in the stable layer, and finally reach the ground after development of a mixing zone in the morning.

3 CURRENT AIR QUALITY

Automatic continuous air quality monitoring was carried out for one year at six stations. Besides these automatic monitoring, supplemental monitoring was carried out at five stations.

The elements continuously monitored are SOx, NOx, Ox, O_3, CO, SPM, and HC. The average concentration of these elements at each monitoring station is shown in Table 3.1.

Table 3.1 Monitoring Results (Average from January to December 1996)

Items	Unit	EMC	Pulo Gadung	Pluit	Thamrin	KPPL	Cibinong	Standard
SO_2	ppb	3.7	4.7	4.7	9.4	4.0	-	20
NO	ppb	3.0	27.3	27.9	109.4	35.0	-	-
NO_2	ppb	7.7	18.6	10.0	29.1	25.5	-	50
NOx	ppb	10.7	45.9	37.9	138.5	60.5	-	-
Ox	ppb	18.0	-	-	-	10.7	-	-
O_3	ppb	-	17.5	10.9	9.2	-	-	-
CO	ppb	440	1,490	1,000	2,790	1,840	-	8,100
SPM	$\mu g/m^3$	53.0	116.1	84.4	81.5	87.8	46.6	*60
CH_4	ppbc	2,145	2,600	2,584	2,568	2,299	-	-
NMHC	ppbc	370	1,722	1,187	1,797	1,212	-	-
T-HC	ppbc	2,515	4,322	3,770	4,366	3,511	-	240

Note : 1) Ox & O_3 were observed from 6:00 to 18:00. CH4, NMHC & THC were observed from 6:00 to 9:00
2) The draft national standard or the standard values of DKI Jakarta(*) were applied.

None value of SO_2, NO_2, and CO exceeds the draft National Ambient Air Quality Standard (AAQS) or Ambient Air Quality Standard of DKI Jakarta. 24-hour average of SPM concentrations is over AAQS occasionally at Pulo Gadung and KPPL stations as shown in Table 3.2. One-year average of SPM at 4 stations of DKI Jakarta exceeds the AAQS of DKI Jakarta of 60$\mu g/m^3$. Total hydrocarbon value exceeds AAQS at all stations as shown in Table 3.3.

Table 3.2 Comparison of SPM Concentration with the Ambient Air Quality Standard of DKI Jakarta

24-HOUR AVERAGE				
			Count	
Location	Pollutant	Standard Value	Over Standard	Total Samples
EMC	SPM	180 μg/m³	0	349
PULO GADUNG			17	331
PLUIT			0	300
THAMRIN			0	320
KPPL			1	348
CIBINONG			0	343

Table 3.3 Comparison of T-HC Concentrations with the Current and the Proposed National Ambient Air Quality Standard

3-HOUR AVERAGE (6:00 to 9:00)				
		Standard Value	Count	
Location	Pollutant	Current/Proposed	Over Standard	Total Samples
EMC	THC	240 ppb/ 240 ppb	213	213
PULO GADUNG			317	317
PLUIT			190	190
THAMRIN			302	302
KPPL			346	346

4 FUEL AND EMISSION STUDIES

4.1 Fuel Study

Fuel consumption rates by factory, household, and automobile were estimated from the statistical data and the results of questionnaire survey. Estimated total annual fuel consumption rates in the Jabotabek area in 1995 are shown in Table 4.1.

4.2 Emission from Stationary Sources

(1) Factories

Based on the results of the questionnaire survey and the flue gas analysis, the fuel consumption rates by industry type and region were estimated.

The total emissions from factories by industry type and by region are shown in Tables 4.2 and 4.3, respectively.

Table 4.1 Estimated Annual Fuel Consumption Rate in Jabotabek in 1995

Source	Fuel	Unit	Estimated Consumption Rate in JABOTABEK
Stationary Sources	Kerosene	kl/year	2,227,140
	High Speed Diesel	kl/year	1,520,070
	Industrial Diesel Oil	kl/year	763,825
	Marine Fuel Oil	kl/year	498,109
	Coal	ton/year	1,647,263
	Natural gas	1,000m³/year	4,741,679
	LPG	ton/year	233,161
Automobile	Premium	kl/year	2,477,500
	Solar	kl/year	1,480,700

Table 4.2 Total Emissions from Factories in Jabotabek (1995)

(Unit : ton/year)

Industry	SOx	NOx	PM
Electricity	15,096	20,088	760
Cement	6,379	5,740	2,009
Other	21,222	11,004	10,812
Total	42,697	36,832	13,581

Table 4.3 Total Emissions from Factories by Region (1995)

(Unit : ton/year)

District	SOx	NOx	PM
DKI Jakarta	20,875	21,499	2,330
Bogor	12,552	9,767	5,484
Tangerang	4,727	3,150	2,829
Bekasi	4,543	2,417	2,937
Jabotabek Total	42,697	36,833	13,580

(2) Households

Based on the population in Jabotabek (Table 4.4) and fuel consumption rate by household, the total emission load from households in 1995 was estimated as shown in Table 4.5.

Table 4.4 Regional Population in 1995

(Unit : 1,000 persons)

District	1995
DKI Jakarta	9,062.5
Bogor	4,764.5
Tangerang	3,595.0
Bekasi	2,738.5
Jabotabek Total	20,160.5

Table 4.5 Regional Air Pollutant Emissions from Households (1995)

(Unit : ton/year)

District	SOx	NOx	PM
Jakarta	1,897	2,230	288
Bogor	997	1,173	152
Tangerang	753	885	114
Bekasi	573	674	87
Jabotabek Total	4,220	4,962	642

4.3 Emission from Mobile Sources

The pollution load from mobile sources was estimated as shown in Table 4.6 and Table 4.7.

Table 4.6 Pollution Load and Running Kilometers of Automobiles in Jabotabek

Vehicle Type	Air Pollution Emission (ton/year)					Running km (10^6km/year)
	CO	HC	NOx	SOx	PM	
Motorcycle	120,002	38,302	971	101	101	10,100
Passenger Car	197,055	26,492	29,832	1,433	2,134	13,040
Taxi	21,295	2,892	3,879	353	425	1,934
Microbus	68,429	8,500	17,699	1,402	2,232	2,899
Bus	12,105	2,682	8,799	1,507	1,156	826
Van	106,330	12,340	19,488	479	1,005	6,183
Small Truck	34,161	3,997	6,693	436	603	2,233
Truck, 2-axle	2,736	1,538	6,304	1,322	1,390	993
Truck, 3-axle	2,180	1,227	5,074	1,109	517	369
Total	564,292	97,971	98,738	8,142	9,563	38,577

Table 4.7 Pollution Load from Ships and Aircraft

(ton/year)

Item	SOx	NOx
Ship	808	1,960
Aircraft	91	1,026

4.4 Analysis of Air Pollution Load

A summary of air pollutant emissions from factories, households, automobiles, ships and aircraft in the Jabotabek area is given in Table 4.8 and the share of sources in total SOx, NOx and PM emission is shown in Figures 4.1, 4.2 and 4.3, respectively. Distributions of emission load of SOx and NOx is shown in Figures 4.4 and 4.5, respectively.

Table 4.8 Estimated Pollution Load by Source in Jabotabek (1995)

(Unit : ton/year)

		SOx	NOx	PM	CO	HC
Stationary Sources	Factories	42,697	36,832	13,581		
	Households	4,220	4,962	642		
	Sub-total	46,917	41,794	14,223		
Mobile Sources	Automobiles	8,142	98,738	9,563	564,292	97,971
	Ships	808	1,960			
	Aircraft	91	1,026			
	Sub-total	9,041	101,724	9,563	564,292	97,971
Total		55,958	143,518	23,786	564,292	97,971

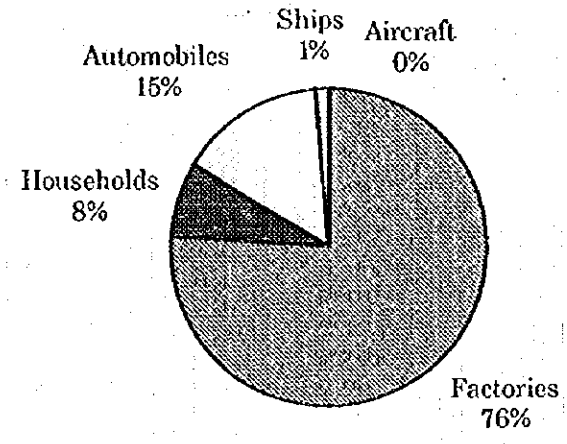


Figure 4.1 Shares of Sources in Total SOx Emission (1995)

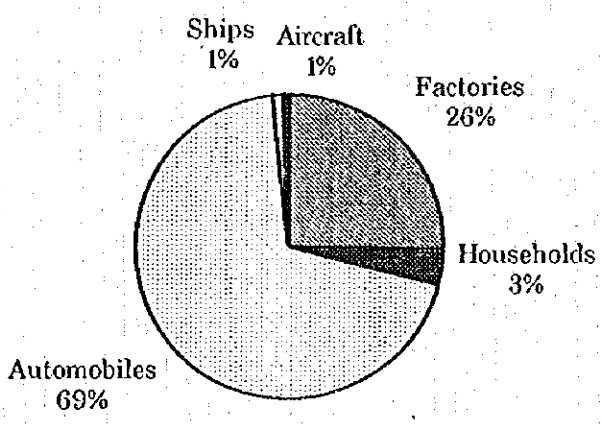


Figure 4.2 Shares of Sources in Total NOx Emission (1995)

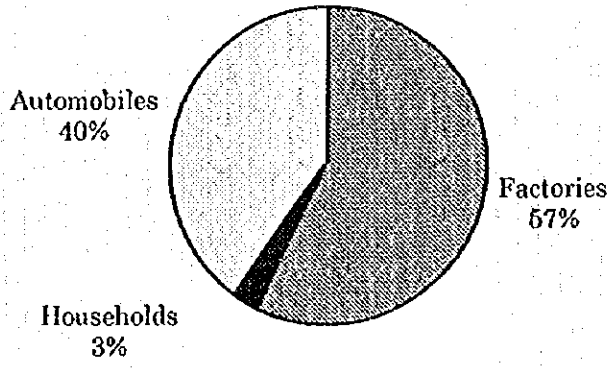


Figure 4.3 Shares of Sources in Total PM Emission (1995)

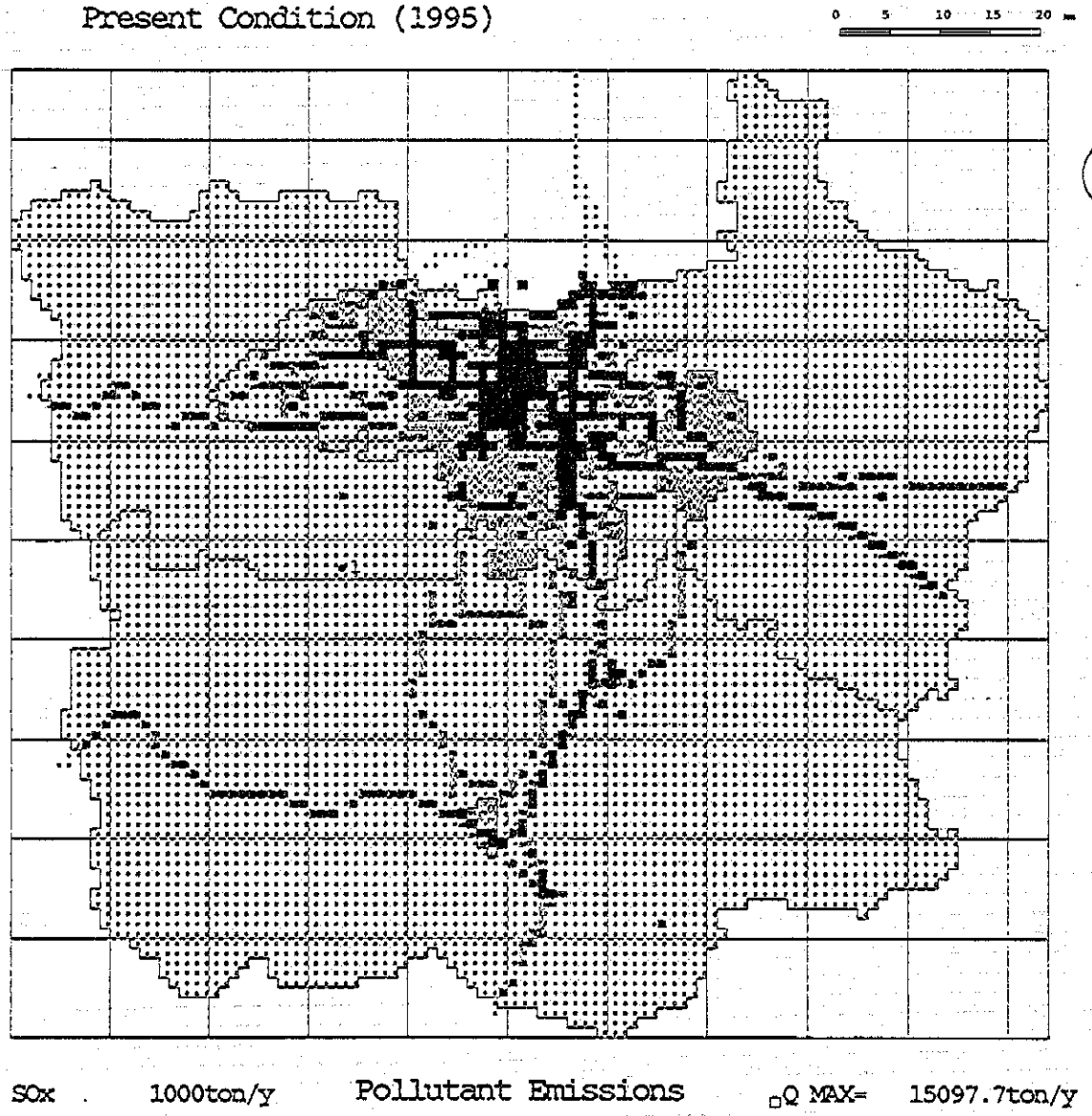


Figure 4.4 Regional Distribution of Total Emission of SO_x

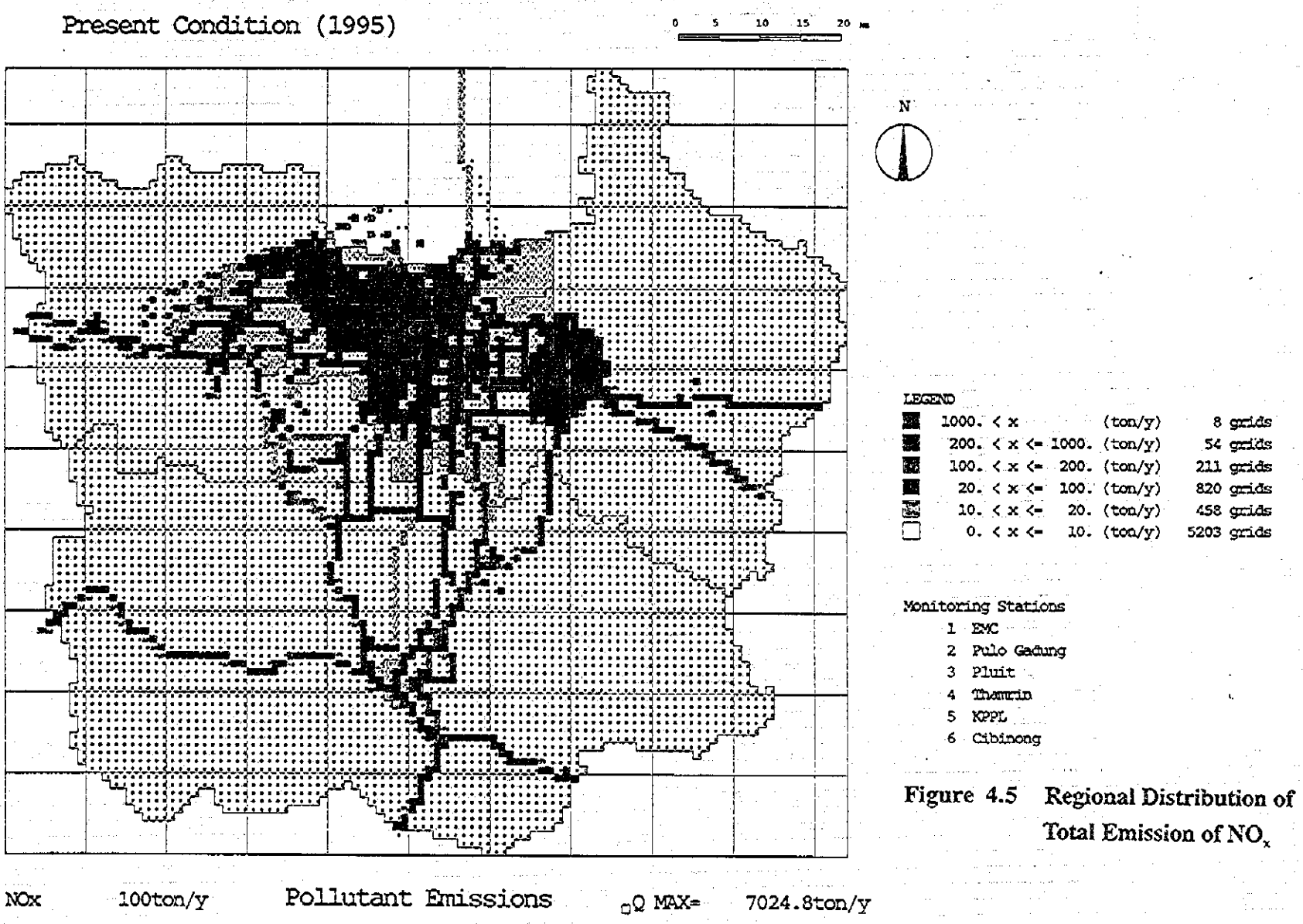


Figure 4.5 Regional Distribution of Total Emission of NO_x

5 INSTITUTIONAL AND LEGAL ASPECTS

(1) Administrative Institutions

1) National Government Agencies

BAPEDAL is the environment supervisory agency under the direct control of the President. Besides, there are independent agencies under different ministries, which deal with environmental matters directly linked with activities under the jurisdiction of the ministries concerned. In addition, several ministries have a specific personnel to cope with environmental matters.

2) Local Government

In the Study Area, several local governmental agencies are working for air pollution control. Institute of Urban Planning and Environment of DKI Jakarta is one example.

3) Industrial Sector

Environmental control at the industry level is not yet fully developed. It mostly lacks monitoring activities, and management staffs. Environmental managers with substantial qualification have to be assigned to each factory.

(2) Legal Aspects

The most important law concerning air pollution control is "Basic Provisions for the Management of the Living Environment Act". It is now under revision for strengthening control of pollution caused by factories.

An assessment system was introduced in accordance with the government ordinance on environmental impact assessment in 1985. The environmental impact assessment is to be carried out by qualified professionals registered with BAPEDAL.

The existing National Ambient Air Quality Standards are now under revision. So the proposed one is shown in Table 5.1, compared with the Ambient Air Quality Standards of DKI Jakarta. Both standards are used for evaluation of air quality in this Study.

Table 5.1 National (Draft) and DKI Jakarta Ambient Air Quality Standards

Parameter	Time of measurement	Standards	
		National - Draft	DKI Jakarta
Sulfur dioxide	1 hour	900 μ g/m^3 (0.34 ppm)	900 μ g/m^3
	24 hours	300 μ g/m^3 (0.11 ppm)	300 μ g/m^3
	1 year	60 μ g/m^3 (0.02 ppm)	60 μ g/m^3
Carbon monoxide	1 hour	30,000 μ g/m^3 (26 ppm)	26,000 μ g/m^3
	8 hours	10,000 μ g/m^3 (9 ppm)	9,000 μ g/m^3
	1 year	-	9,000 μ g/m^3
Nitrogen dioxide	1 hour	400 μ g/m^3 (0.21 ppm)	400 μ g/m^3
	24 hours	150 μ g/m^3 (0.08 ppm)	150 μ g/m^3
	1 year	100 μ g/m^3 (0.05 ppm)	100 μ g/m^3
Oxidant as O_3	1 hour	160 μ g/m^3 (0.08 ppm)	200 μ g/m^3
	24 hours	-	50 μ g/m^3
	1 year	-	30 μ g/m^3
Total Suspended Particulates (TSP)	24 hours	230 μ g/m^3	230 μ g/m^3
	1 year	90 μ g/m^3	90 μ g/m^3
Suspended Particulate Matters (SPM)	24 hours	-	180 μ g/m^3
	1 year	-	60 μ g/m^3
Lead	24 hours	2.0 μ g/m^3	6 μ g/m^3
	1 year	-	1 μ g/m^3
Hydrocarbon	3 hours	160 μ g/m^3 (0.24 ppm)	150 μ g/m^3

Note : Values are based on the atmospheric conditions of temperature: 25 °C and pressure 1 atmosphere.

The decree of State Minister "The Emission Standards for Stationary Emission Sources" regulates emission from four industries (iron & steel, pulp & paper, cement, and coal thermal power plants) and other industries. This standard is effective in two target years of 1995 and 2000 as shown in Table 5.2.

Table 5.2 Maximum Limit of Emissions from Selected Stationary Sources (in parentheses : effective from 2000)

(Unit : mg/m^3)

Sources		TSP	SO_2	NO_2
Four Prime Industries	Electric Arc Furnace	600 (150)	- -	- -
	Power Boiler (ex. Power Ind.)	400 (230)	1,200 (800)	1,400 (1,000)
	Power Ind. Boiler (Coal)	300 (150)	1,500 (750)	1,700 (850)
	Cement Kilns	150 (80)	1,500 (800)	1,800 (1,000)
Other Industries		400 (350)	1,500 (800)	1,700 (1,000)

Notes : 1) Nitrogen Oxide is expressed as NO_2.
2) Gas volume is on a dry basis in a standard condition of temperature: 25 °C and pressure 1 atmosphere.
3) Values shall be met in 95% of the time during normal operation computed over a period of three months, except 'other industries'.
4) Oxygen correction is different from each facility.

Source: State Minister Decree on Environment of the Republic of Indonesia (Ref. 110)

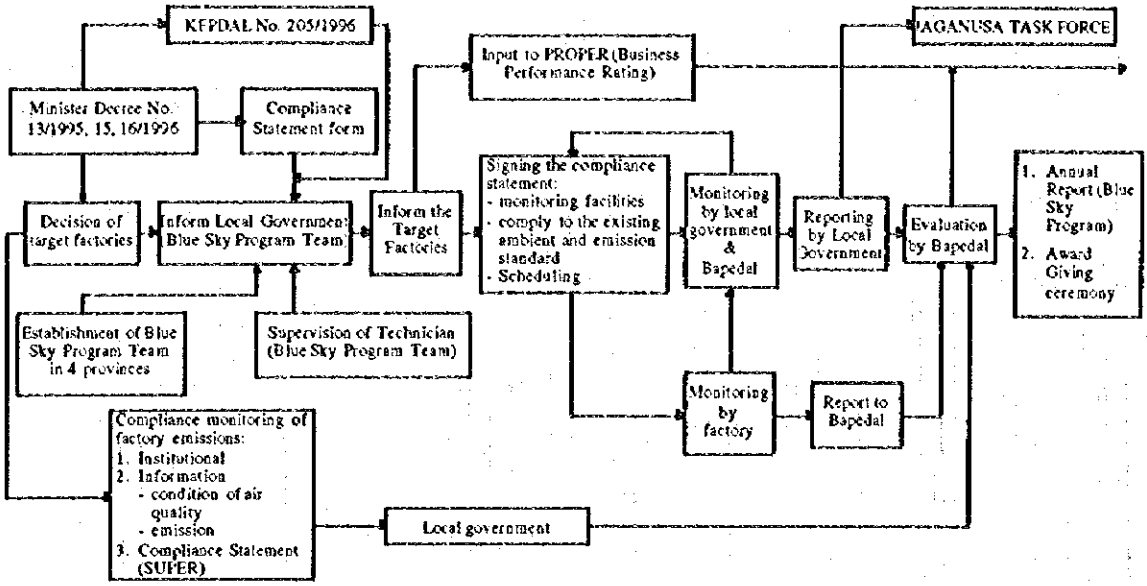
Standards for gas emission by vehicles during idling were established in 1993 for commercial vehicles. BAPEDAL is considering to adopt emission standards for newly produced vehicles from the United Nations' ECE Committee standard - 8301.

(3) Blue Sky Program and Ambient Air Monitoring System

1) Blue Sky Program

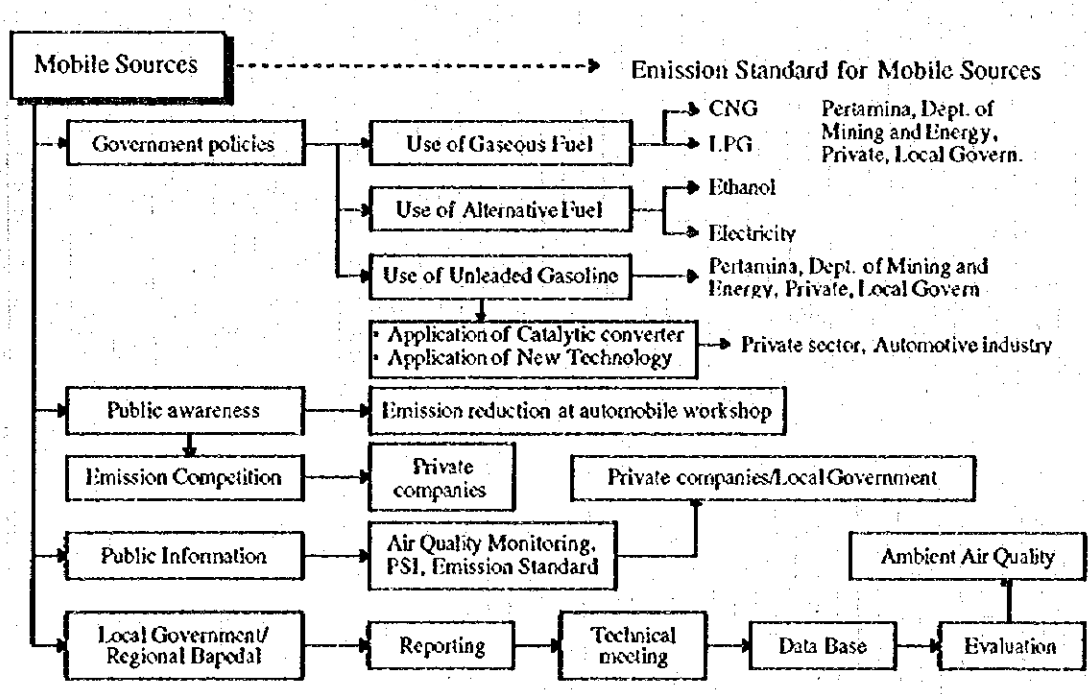
BAPEDAL responded to the increasing air pollution problems by introducing the air pollution control program, Blue Sky Program, in July 1992. The Blue Sky Program aims to improve air quality and to meet the designated air quality standards. At first, this program was implemented in four province, Jakarta, West Jawa, Central Jawa, and East Jawa. This will be expanded shortly to other provinces.

The Blue Sky Program consists of stationary and mobile emission source control as shown in Figures 5.1 and 5.2.



Source : The Blue Sky Program, BAPEDAL

Figure 5.1 Stationary Emission Source Control



Source : The Blue Sky Program, BAPEDAL

Figure 5.2 Mobile Emission Source Control

2) Ambient Air Monitoring System

Ambient air quality monitoring is carried out by EMC, KPPL, MOH, and BMG at the following monitoring stations :

EMC : 1 station (continuous and automated monitoring)
KPPL : 12 stations and 6 stations (continuous and automated monitoring)
MOH : 4 stations
BMG : 7 stations

(4) Training System

There are 65 Environmental Research Centers (PSL) under various universities which train environmental impact assessment skills. Examination to qualify professionals in environmental impact assessment is conducted several times a year.

The Environmental Management Center (EMC) is the BAPEDAL's supporting facility working for environmental monitoring, environmental information management and environmental training. It also acts as a reference laboratory.

6. ANALYSIS OF AIR POLLUTION MECHANISM

6.1 Dispersion Simulation

Study Team developed the Dispersion Simulation Model for Jabotabek area using collected source information, environmental concentrations and meteorological data.

Dispersion simulation represents the phenomena with computer that the pollutants emitted from the source such as factories, motor vehicles etc. are diffused by the wind. With more accurate source information data, meteorological data and measured actual concentrations, the accuracy of the simulation model become higher.

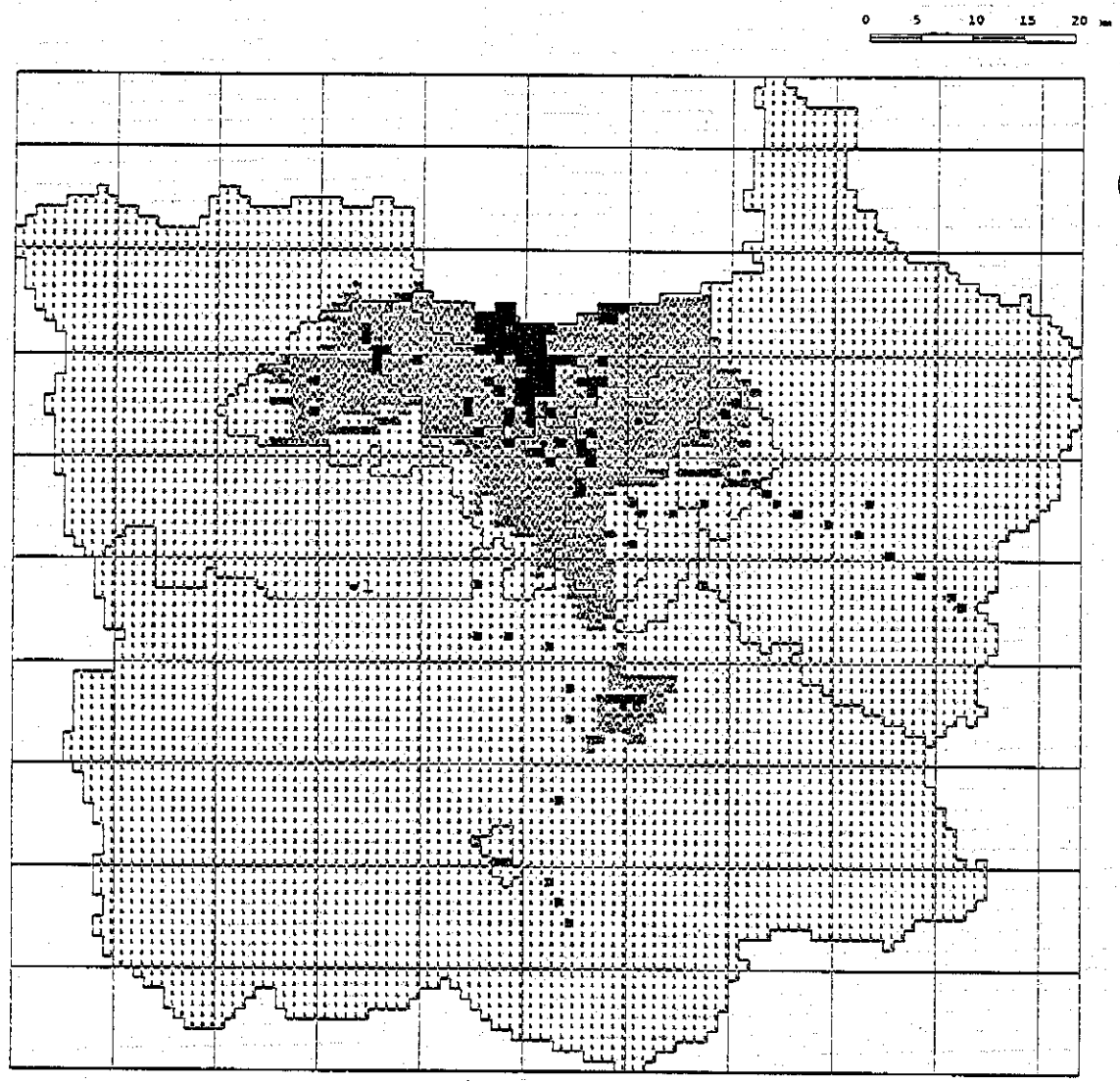
This simulation model clarify the following features;

a) This simulation model can be used for the calculation of present and future concentration in whole Jabotabek area.
b) The result of calculation for present concentration shows that the concentration of one grid exceeds the proposed National AAQS for SO_2, and also 3 grids exceed for NO_2, and CO concentration satisfy the standard at all calculated grids.
c) For SPM, the influence of unknown sources are relatively high, so the model can not be used for the prediction of SPM concentration.

The simulation for the Jabotabek district was introduced in this Study. BAPEDAL is expected to accumulate higher quality source inventory and precise meteorological data representing the district.

The simulation assumed 1995 as the present case and 2010 as a future case. Calculation was made for 6,682 grids of 1 km by 1 km mesh of the total target area of 105 km × 100 km. The concentration maps of SO_2, NO_2 and CO in 1995 are shown in Figures 6.1 to 6.3. SO_2 concentrations are relatively high in the central and northern parts of DKI Jakarta, but most of them are below the standards. NO_2 concentrations are relatively high in DKI Jakarta and are spreading towards Bekasi and Tangerang. CO concentrations are much lower than the standard.

Present Condition (1995)



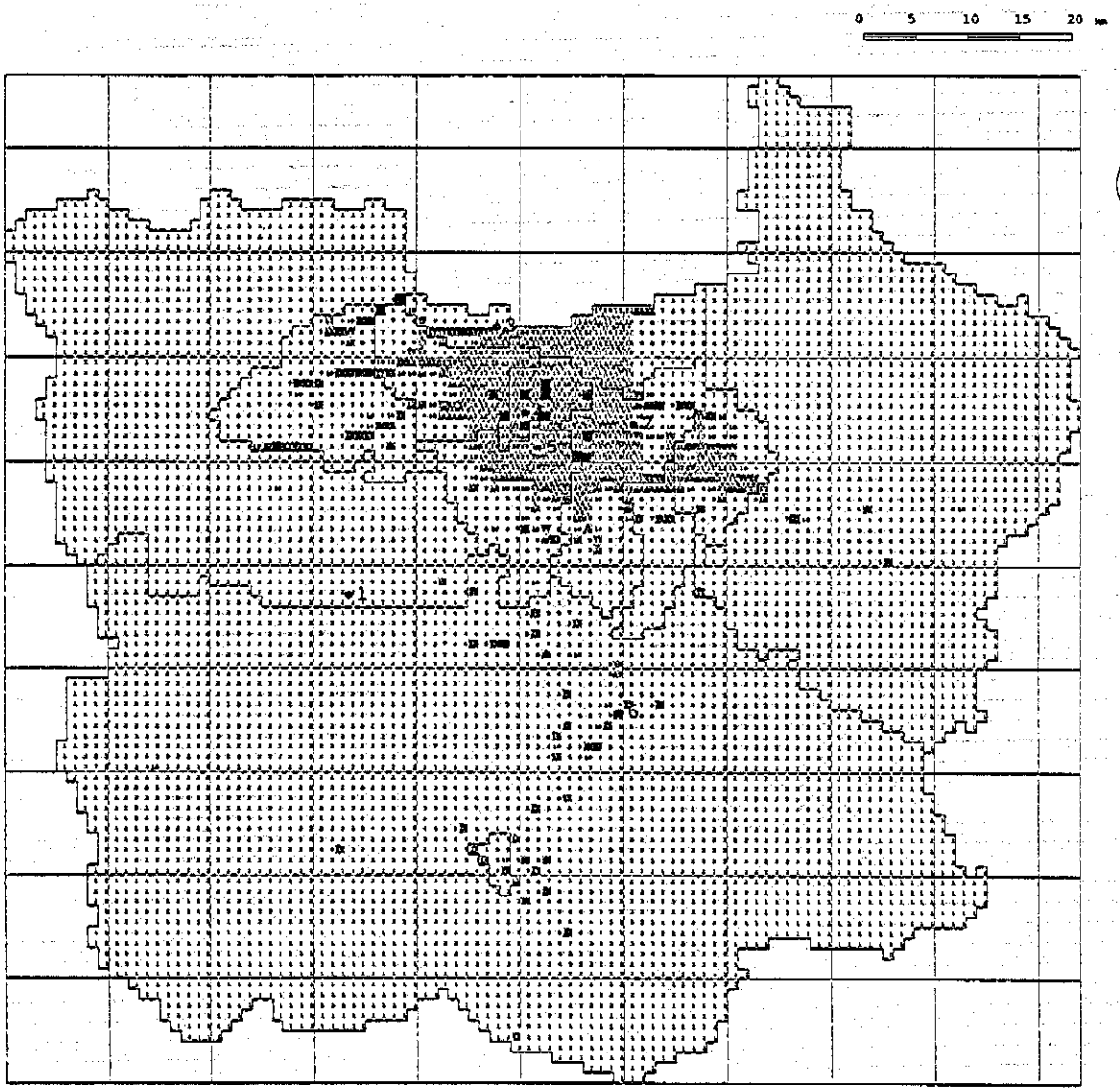
SO2 ppb Annual Average

□C MAX= 20.4ppb

Background Concentration: 0.ppb

Figure 6.1 Concentration Map of SO_2 from All Sources in 1995

Present Condition (1995)



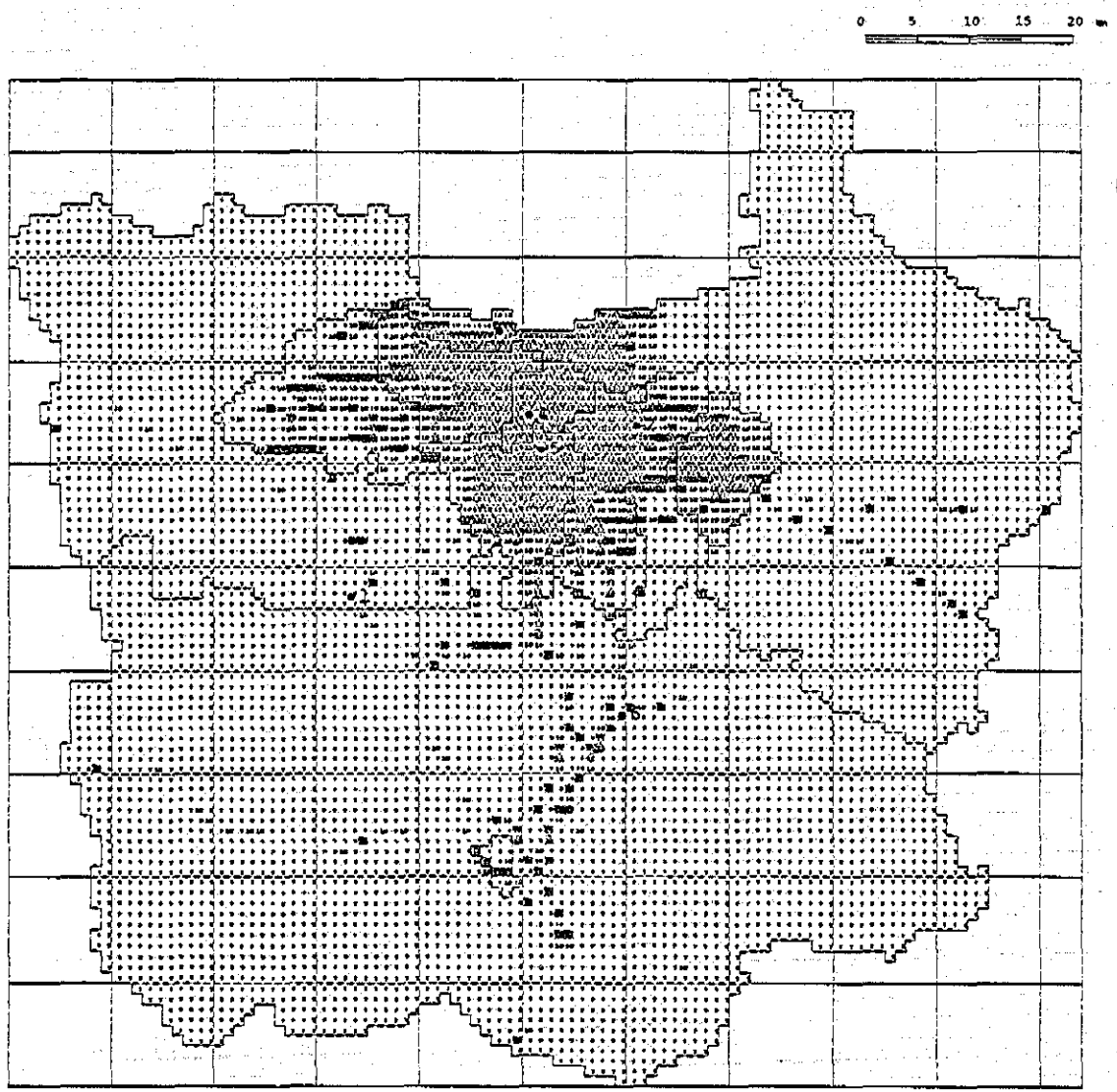
NO2 ppb Annual Average

C MAX= 80.9ppb

Background Concentration: 0.ppb

Figure 6.2 Concentration Map of NO_2 from All Sources in 1995

Present Condition (1995)



CO 100ppb Annual Average

□C MAX= 3077.3ppb

Background Concentration: 860.ppb

Figure 6.3 Concentration Map of CO from All Sources in 1995