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

VOLUME 1

MAIN REPORT

JUNE 1997

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

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

VOLUME I

MAIN REPORT

JUNE 1997

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

LIST OF REPORTS

(This Volume is indicated by [shaded box])

Currency Equivalents

US$ 1.00	=	Rp. 2,321
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

CONTENTS

CHAPTER 4 FUEL AND EMISSION STUDIES

CHAPTER 5 INSTITUTIONAL AND LEGAL ASPECTS

CHAPTER 6 ANALYSIS OF AIR POLLUTION MECHANISM

List of Tables

List of Figures

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
USAID	U. S. Agency for International Development
UV	Ultra Violet

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

Jakarta, the capital city of the Republic of Indonesia, is located in the northwest of Java Island, and its northern part faces the Java Sea.

Motorization, urbanization and industrialization have had detrimental effects on the air quality in Jakarta. Although motorization seems the main cause, large scale stationary sources (combustion or dust emission facilities) such as thermal power stations, large cement factories, and the development of industries in areas such as Pulogadung, Tangerang, and Bekasi are considered to worsen the air quality.

The Ministry of Health and the Institute of Urban Planning & Environment of DKI Jakarta (KPPL) have been monitoring air quality regularly since 1978. The Agency of Meteorology and Geophysics (BMG) started monitoring air quality in 1987. In addition, continuous automated monitoring of some stations has been carried out by KPPL and the Environmental Management Center (EMC) of the Environmental Impact Management Agency (BAPEDAL) since 1981 and 1993 respectively. The Ministry of Environment is in charge of planning of the environment-related policies in Indonesia, and BAPEDAL was established in June 1990 as the executing agency responsible for protecting the environment.

BAPEDAL planned and implemented the Blue Sky Program for the purpose of improving air quality. So far, several air quality management studies have been conducted in Jakarta or Jakarta metropolitan area (Jabotabek) by donor countries. These donors are the World Bank, Australia, Canada, and many other countries. They have already prepared and proposed so many reports and program by sending many experts for long-stay studies.

Countermeasures for air pollution proposed in a number of studies have not yet been effectively implemented. The planning and implementation of integrated and concrete air pollution control projects, concentrating on building up and reinforcing implementation organizations and systems, are expected. For the reason stated above, the Government of the Republic of Indonesia (GOI) has requested the Government of Japan (GOJ) to assist in clarifying the structure of air pollution problems by investigating pollution sources, planning an implementation schedule for the overall control strategy, and conducting technology transfer and training in Jabotabek.

The Japan International Cooperation Agency (JICA) appointed by GOJ as an executing agency, conducted the preliminary studies in April and December 1994, in response to this request. 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 agreed upon between BAPEDAL, the executing agency appointed by GOI, and JICA. Subsequently, JICA set up a Study Team (the Team) and an Advisory Committee for the conduct of the Study. The Study began in December 1994 with the first visit of the Team to Jakarta. The Team then carried out field works in the Study Area for five times from November 1994 to June 1996.

1.2 Outline of the Study

1.2.1 Objectives of the Study

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 in consideration of socio-economic conditions. The Study also included the formulation of a more concrete action plan until 2000 by conducting investigation and analyses on the present status of the socio-economy, nature and meteorology, air quality, and air pollution sources.

Another major objective of the Study was technology transfer and training of counterpart members of BAPEDAL and related organizations through the Study.

1.2.2 Study Area

The Study Area extends over DKI Jakarta, Bogor, Tangerang, and Bekasi, altogether known as Jabotabek, as shown in Figure 1.2.1. Within this area, the Study focused on the region where air quality management is essential and/or significant pollution sources are located.

1.2.3 Work Flow and Time Schedule of the Study

First of all, meteorological survey, air quality monitoring and pollution source survey were carried out. Then a simulation model of the present condition was prepared using URBAIR Model. Besides, the future frame work was assumed using the data from socio-economic survey and the future emission from pollution sources was predicted after estimating the air pollution load and assuming the future framework. Then the present and future air quality of Jabotabek district was simulated using the Jabotabek simulation model. In consideration of the simulation results, countermeasures for the air quality were proposed.

The Study consisted mainly of field work and analytical work mentioned above and shown in the work flow diagram in Figure 1.2.2. The time schedule is shown in Table 1.2.1 by respective study items.

The Study is carried out the analytical work using the field work data as the continuous ambient air quality monitoring data, exhaust gas measurement data, etc.

1.2.4 Technology Transfer

Transfer of technology on measurements of meteorology, ambient air quality and pollution sources to counterparts from EMC, KPPL, BMG and other relevant organizations was carried out through the field work. Technology of preparation of stationary and mobile source inventory was also transferred to the counterparts from BAPEDAL, using the stationary and mobile source study guidelines. In addition, technology of simulation of the present and future air quality was transferred to the counterparts from BAPEDAL and EMC using the simulation model.

1.3 Organization for the Study

1.3.1 Japanese Organization

The organization for the Study on the Japanese side consisted of the Advisory Committee and the Team. The Advisory Committee provided occasional guidance to the Team. The lists of members of the Advisory Committee and the Team are shown in Tables 1.3.1 and 1.3.2, respectively.

1.3.2 Indonesian Organization

On the Indonesian side, BAPEDAL organized the Steering Committee and the Counterpart Team. The members of this organization were from the various governmental agencies and others related to the Study. The lists of members of BAPEDAL Steering Committee and Counterpart Team are shown in Tables 1.3.3 and 1.3.4, respectively.

1.4 Study Reports

In the course of the Study, an Inception Report, Progress Reports, and an Interim Report were prepared. This Final Report is composed of four 4 volumes : Executive Summary, Main Report, Supporting Report, and Data Book.

In the Main Report, Chapters 2 to 5 cover the data monitored, measured, and analyzed in the Study. Chapter 6 and 7 show the simulation of air quality in 1995 and 2010 using Jabotabek Simulation Model. Chapter 8 shows the basic principles for the air pollution control strategy and action plan. And Chapter 9 and 10 present the source control strategy and action plans, respectively.

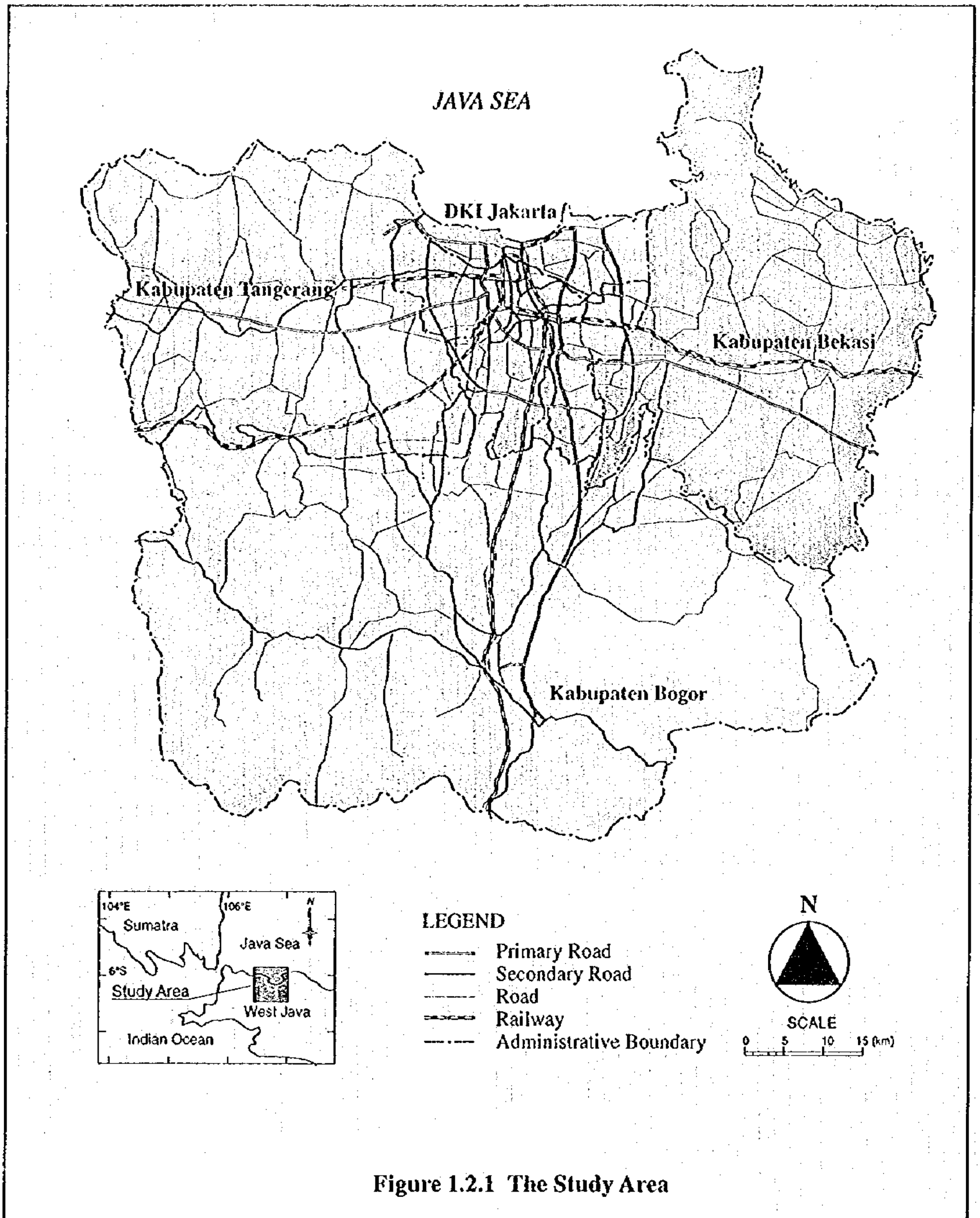


Figure 1.2.1 The Study Area

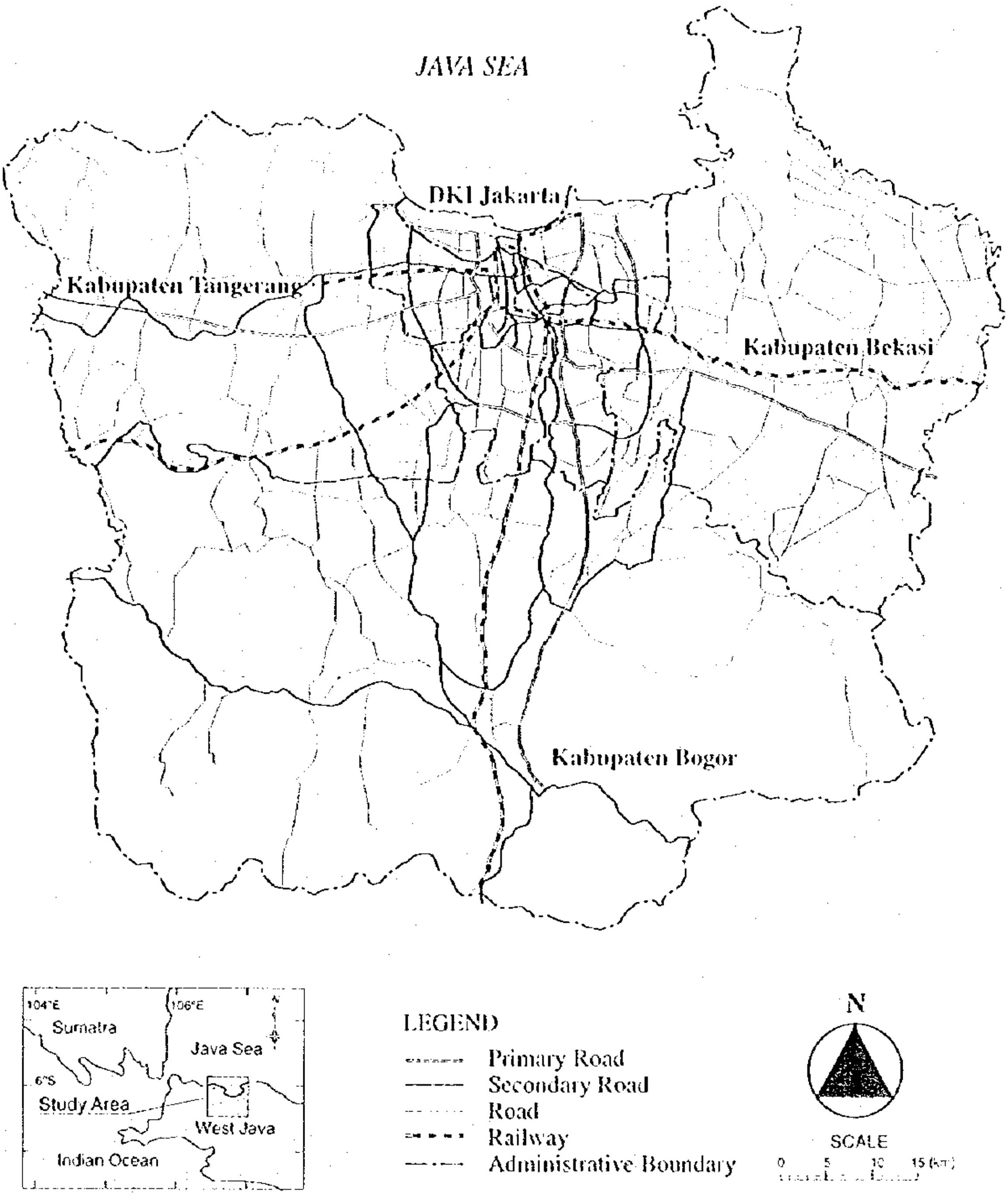


Figure 1.2.1 The Study Area

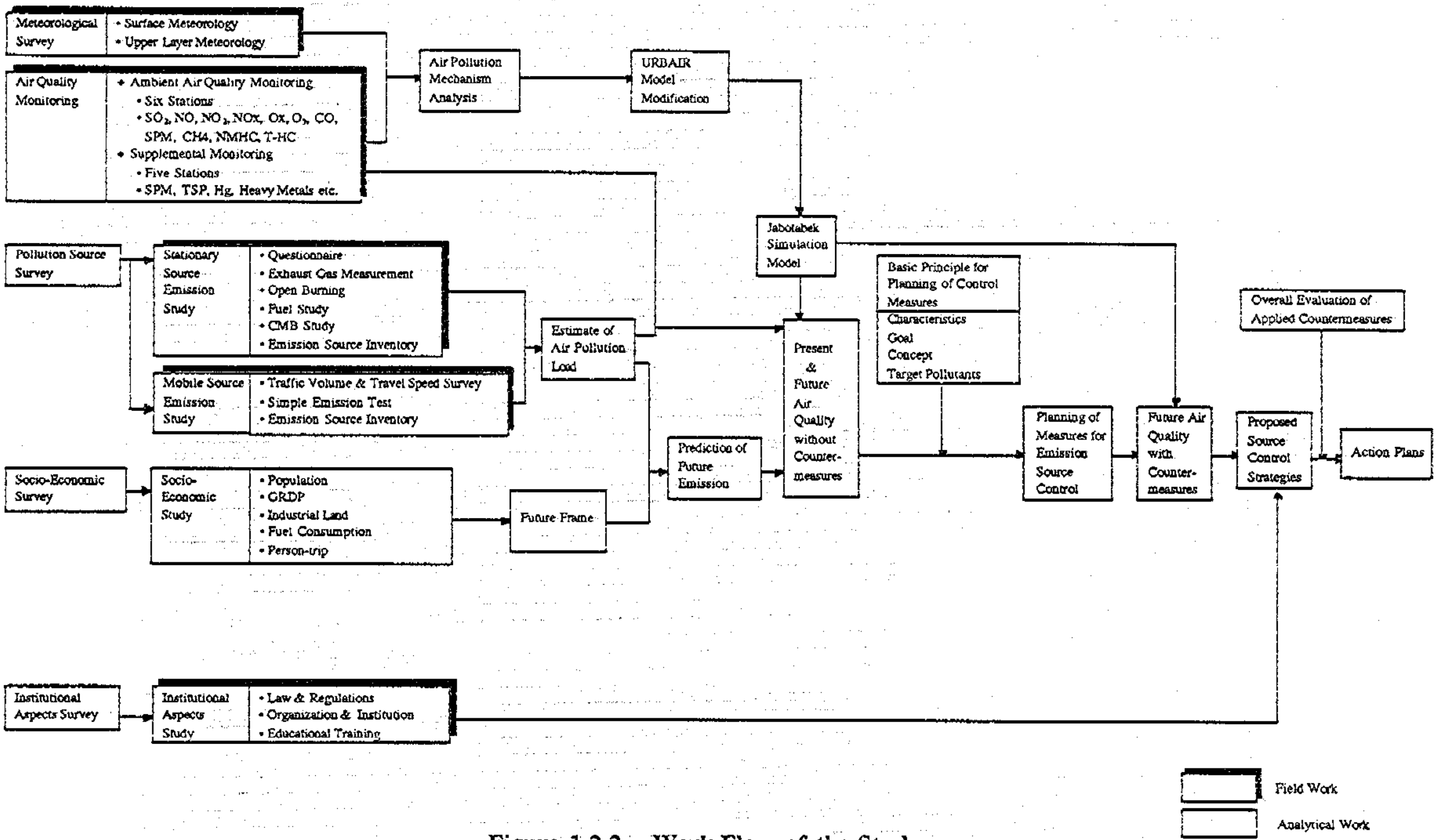
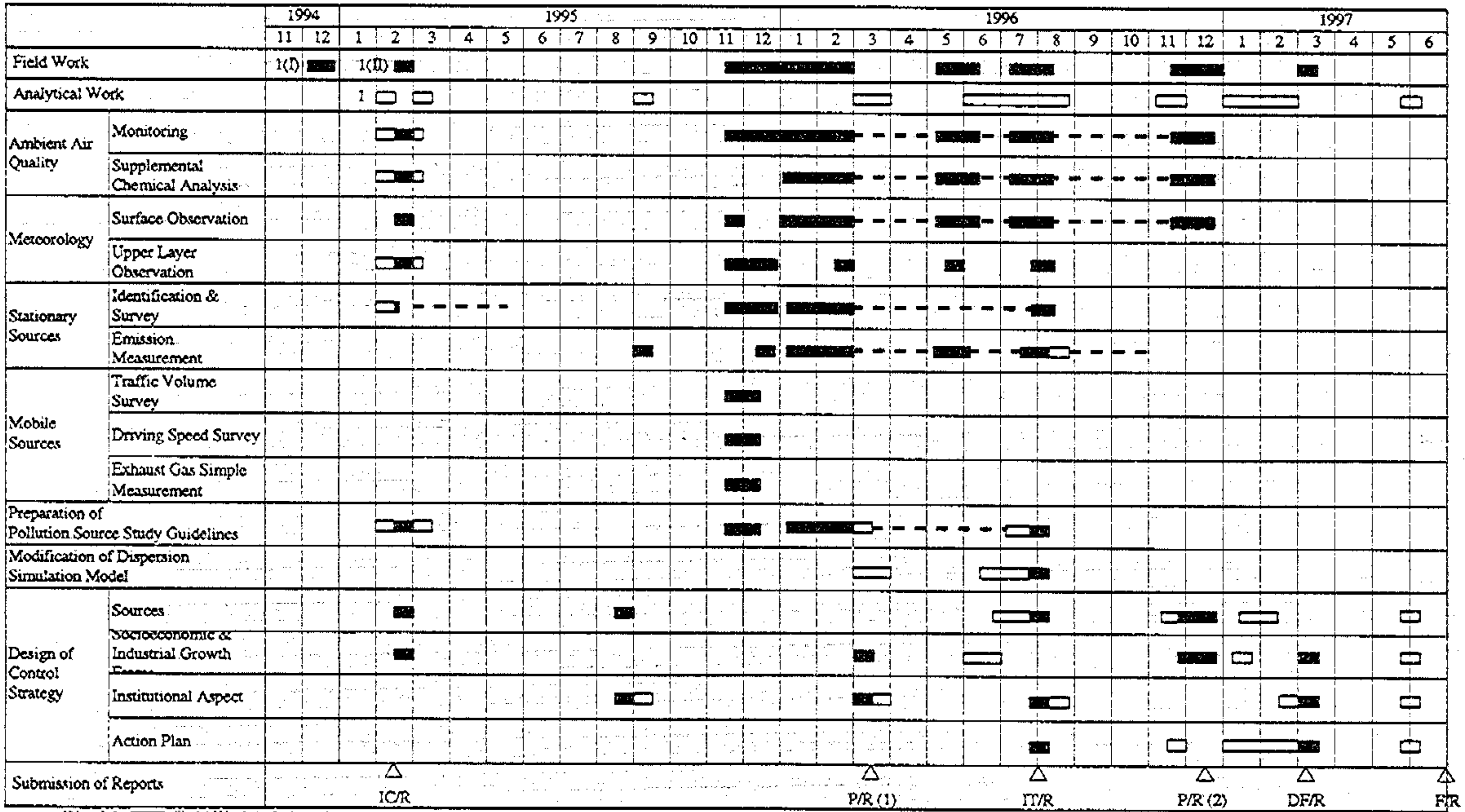


Figure 1.2.2 Work Flow of the Study

Table 1.2.1 Study Time Schedule



[Note] 1. ▭ : Field Work in Indonesia
2. ■ : Analytical Work in Japan
3. - -: Field Work without JICA Counterpart attendance
4. Analytical Work : Detailed Schedule is omitted.

Table 1.3.1 List of JICA Advisory Committee Members

Name	Field in Charge	Position
Hidetsuru Matsushita	Chairman and Overall Supervision	Professor, Graduate School of Nutritional and Environmental Science, University of Shizuoka
Shigemoto Kajihara	Air Pollution Institutional Aspect	Deputy Director, Planning Division of Air Quality Bureau, Environment Agency
Yoshikazu Suzuki	Emission Source Control	Section Chief, Air Conservation Department, Hyogo Prefecture
Nobuhiro Koyama	Traffic and Urban Planning	Senior Development Specialist, JICA

Table 1.3.2 List of JICA Study Team Members

Name	Field in Charge
Shonosuke Ezoe	Supervision/Overall Control Strategy
Masaaki Noguchi	Under-supervision/ActionPlan/ Cost Evaluation
Yoichiro Okayama	Air Quality Monitoring
Ikuo Inoue	Chemical Analysis
Norihiko Kawanaka	Meteorological and Air Monitoring
Yoichi Endo	Emission Measurement
Makoto Miyakawa	Stationary Source Analysis
Akeo Fukayama	Mobile Source Analysis
Masanao Nishimura	Source Control Plan
Kazuyuki Otsuka	Traffic and Urban Planning
Akira Yasuraoka	Air Pollution Mechanism/Simulation Model
Hiroshi Hasegawa	Economic and Financial Analysis
Yoshio Yamanaka	Institutional Aspects
Tomoo Aoki	Liaison Support

Table 1.3.3 List of BAPEDAL Steering Committee Members

Name & Position in the Committee	Position
Ir. Margana Koesoemadinata - Chairman	Director of Air Pollution Control, BAPEDAL
Ir.T. Sachrul Ismail - Vice Chairman	Head of Environmental Management Center, BAPEDAL
Sidik Poernomo, MPA	Director for Program Development, BAPEDAL
Dra Rosalind R. S, MSi - Secretary	Staff of BAPEDAL
Dr. R.T.M.Sutamihardja	Deputy Assistant 1, Ministry of Environment
Ir. H.Budihardjo Soekmadi, MSi	Head, Regional Development Planning Agency, DKI Jakarta (BAPEDA)
Ir. Kosasih W, MSc	Head, Bureau of Environmental Studies (BLH), DKI Jakarta
Ir. H. M. Ali Rozi	Head, Office of Urban & Environmental Studies (KPPL), DKI Jakarta
Drs. Hery Harjanto, MSc	Head, Analysis Section, Meteorological & Geophysical Agency (BMG)
Ir. Sjarief Sadikin D.	Head, Artificial Environment Section, TK 1, West Java Province
Dra. A. Tri Tugaswati, Dipl. EST	Health Ecology Research Center, Dept.of Health
Ir. Tjokorde Gde Agung SP	Directorate General of Land Transport, Dept. of Communication
Ir. Yusran M. Munaf	Director, R & D, Industrial Res & Pollution Control, Dept. of Industry
Ir. Harry Santosa	Indonesian Automotive Industry Association

Table 1.3.4 List of BAPEDAL Counterpart Team Members

Counterpart Activity	Name	Organization
Management / Overall Control Strategy	Margana Koesoemadinata	BAPEDAL
Under supervision	Hary Wahyudi	BAPEDAL
Air Quality Monitoring	Hary Wahyudi / Hesrom Rafdjon Rax / Yusuf Sumiratno / Tuti Mulyani Sukar	BAPEDAL KPPL BMG Dept. Health
Meteorological Observation	Rina Aprishanty / Sigit Achmad Sasmito / Imam Prawoto / Hartono / Yoga Sambodo / Edy Kelana / Syamsul / Edison / Ali Usman Rafdjon Rax / Yusuf	BAPEDAL BMG KPPL
Emission Measurement	Djurit / Suprihandari Rafdjon Rax / Yusuf Eliza / Ghazali Adlin / Mustafa	BAPEDAL KPPL Dept. Industry Dept. Transpt.
Under supervision	Ridwan D Tamin	BAPEDAL
Emission Source Analysis	Achmad Gunawan / Anwar Hadi / Atu Toto Wicaksono Mangasa Junani / Liliansari	BAPEDAL Dept. Transpt. BMG KPPL
Action Plan / Cost Evaluation	Edy Purwanto Liliansari	BAPEDAL KPPL
Source Control Plan	M Ilham Malik / Atu / Aristin Junani Toto Wicaksono	BAPEDAL KPPL Dept. Transpt.
Traffic and Urban Planning	Edy Purwanto / Fitri Harwati Nugroho Indriyo Purwoto	BAPEDAL Dept. Transpt. KPPL
Air Pollution Mechanisms / Simulation Model	Fitri / Saiful / Wisnu / Saptanti Rafdjon Rax Imam Prawoto	BAPEDAL KPPL BMG
Economic and Financial Analysis	Helneliza Kosasih W Purwoto	BAPEDAL BLH KPPL
Institutional Aspects	Umar Suyudi Aurora Junani	BAPEDAL BAPPEDA KPPL

CHAPTER 2 METEOROLOGY

2.1 Outline

New equipment for measurement was installed in the stations at KPPL and Thamrin during November - December 1995, and existing equipment was overhauled at the monitoring stations of EMC, Pulogadung, and Pluit.

Surface meteorological observation started in January and ended in December 1996. Upper layer observations were carried out on December 12, 1995 for the first time, from February 3 to 9, 1996 for the second time, from May 22 to 28, 1996 for the third time, and from August 1 to August 7, 1996 for the fourth time.

2.2 Surface Meteorological Observation

Technical know-how transfer was made to counterpart personnel from EMC and KPPL. This involved mainly theories of measurement and methods of operation of monitoring equipment. A manual on basic operation and proofreading methods was prepared for technical know-how transfer, since time was too limited to transfer directly the operational methodologies for many kinds of monitoring equipment. Monitoring items and instruments at various monitoring stations are shown in Table 2.2.1.

Table 2.2.1 Monitoring Items and Instruments at Various Monitoring Stations

Items	Instruments	EMC	Pulo Gadung	Pluit	Thamrin	KPPL
Wind Direction	Wind Vane & Anemometer	●	●	●	●	●
Wind Velocity	Wind Vane & Anemometer	●	●	●	●	●
Temperature	Electrical Resistance Thermometer	●	●	●		
Humidity	Hair Hygrometer	●	●	●		
Solar Radiation	Pyranometer	●				
Net Radiation	Net Pyradiometer	●				

2.3 Upper Layer Meteorological Observation

Technical know-how of methods concerned was transferred to counterpart personnel from BMG and EMC, during the four observations. This technology transfer was carried out through guidance on objectives, methods and equipment for upper layer meteorological measurements, and by rehearsal and actual operation of the observation equipment.

Meteorological observations were carried out for four times, and the observation items were wind speed, wind direction, and temperature at each standard height level.

2.4 Results of Observations

(1) Data

All field data are arranged in Part 1 of the Data Book attached to this Main Report. Part 1 (Meteorology) of the Supporting Report, also contains the compiled data from the field data.

(2) Surface Meteorology

As shown in Figure 2.4.1, 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.

Adjusted Pasquill's stability of surface atmosphere is given in Figure 2.4.2 as an average frequency at each monitoring stations. The net radiation data at EMC ware used to estimate the stability in other stations. The highest stability is G (the extremely stable condition), followed by dD and nD (neutral condition, day and night).

(3) Upper Layer Meteorology

Figure 2.4.3 shows the annual average wind rose diagram of the upper layer. 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.

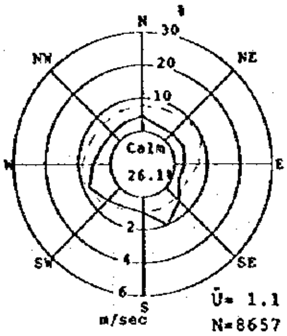
2.5 Evaluation

The surface layer in Jabotabek 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.

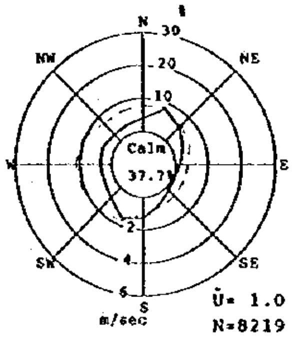
In the night, because of less windy condition, pollutants emitted near the ground surface accumulate there. However, as activities of the emission sources become slower at night, usually pollutant concentrations will gradually go down. Next morning, if there remains a stable layer, the high concentration 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.

In Jabotabek, wind pass is smooth because of the flat and open land area and because it faces the sea. Consequently, the intensive inversion layer develops not so often in the region. However, the data show that sometime the lid height is not so high, such as in February.

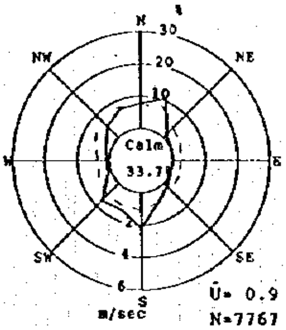
EMC



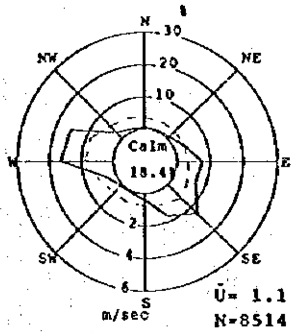
PULO GADUNG



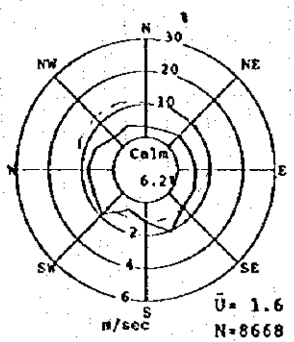
PLUIT



THAMRIN



KPPL



——— Frequency of Wind Direction
- - - Average of Wind Speed
Calm: <= 0.4 m/sec
U=: Ave. of wind speed (m/sec)
N=: Number of sample

Figure 2.4.1 Wind Rose Diagram in 1996 (Jan. to Dec.)

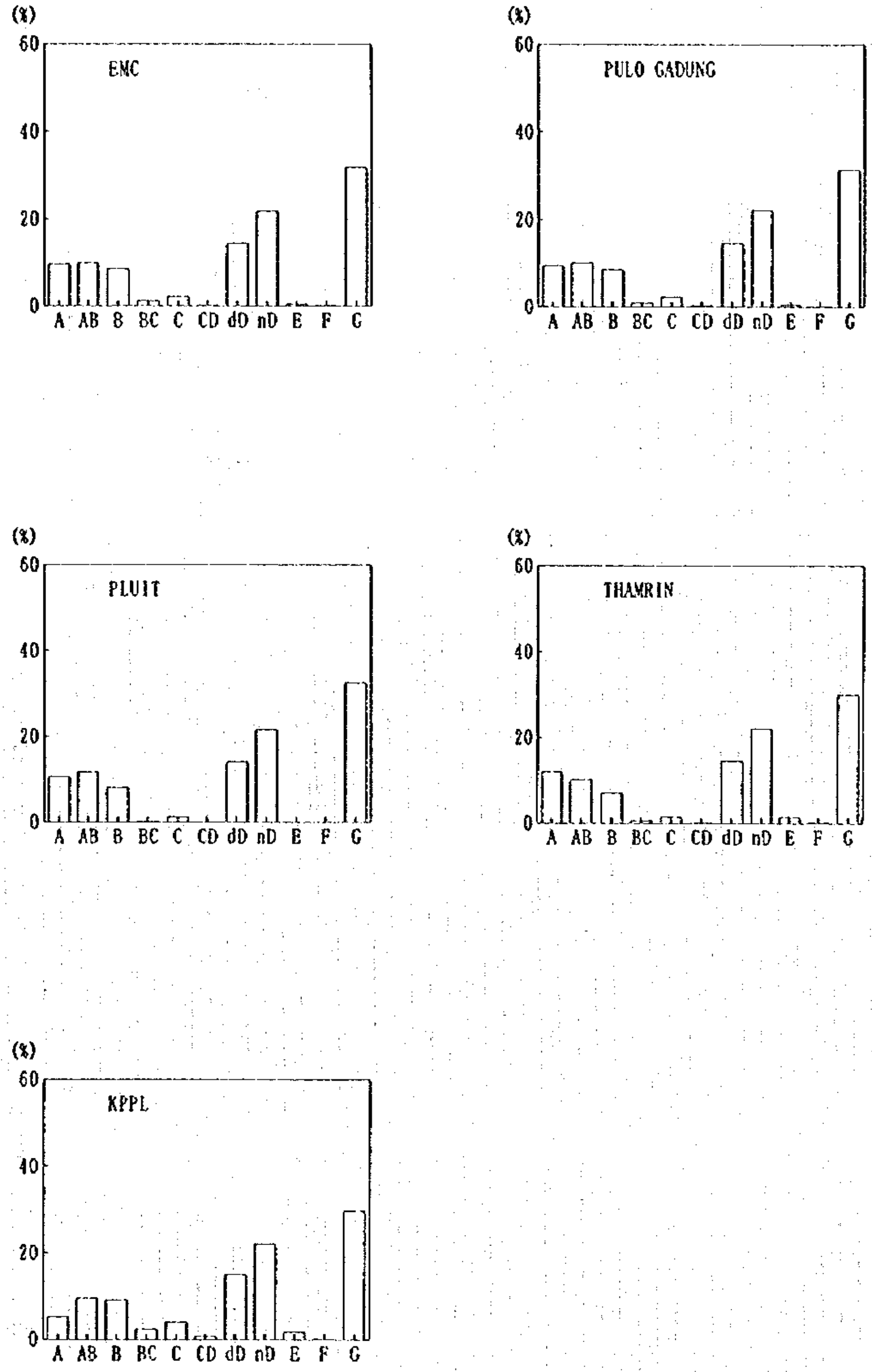


Figure 2.4.2 Stability Frequency in 1996 (Jan. to Dec.)

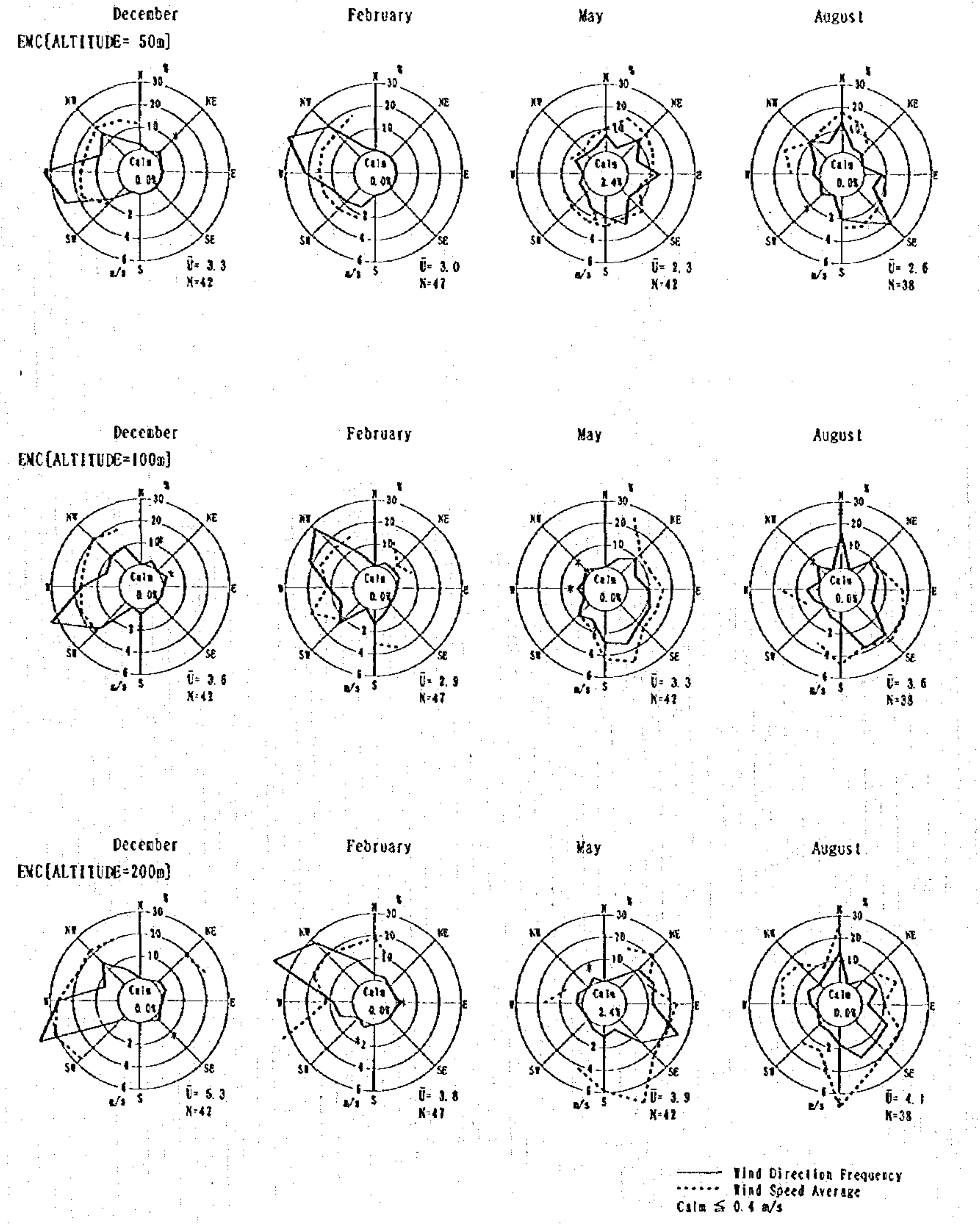


Figure 2.4.3 Wind Rose Diagram of Upper Layer in 1995 Dec. to 1996 Aug. (1/2)

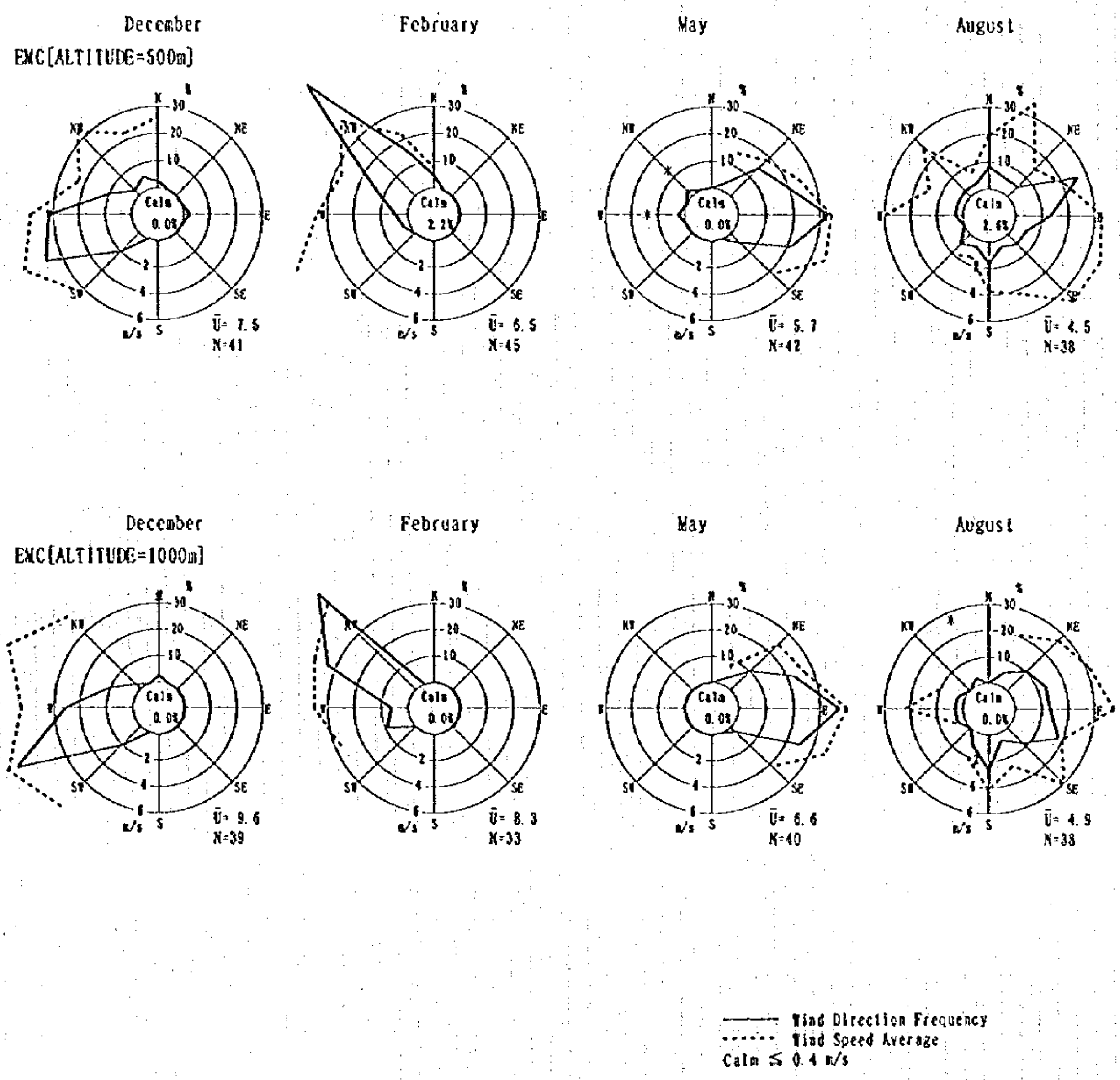


Figure 2.4.3 Wind Rose Diagram of Upper Layer in 1995 Dec. to 1996 Aug. (2/2)

CHAPTER 3 CURRENT AIR QUALITY

3.1 Outline

Initial air quality monitoring and supplemental monitoring were carried out as follows:

(1) Air Quality Monitoring

New monitoring equipment was installed at the KPPL, Thamrin and Cibinong stations, and the existing monitoring equipment at EMC, Pulo Gadung, and Pluit was overhauled during November - December 1995. Monitoring activities started in January 1996 with equipment maintenance, data collection, and technology transfer. It was carried out for one year.

(2) Supplemental Monitoring

To supplement the automated continuous monitoring at the fixed stations and obtain the input data for CMB analysis, supplemental monitoring was carried out at Pulo Gadung, Pluit, Thamrin, KPPL, and EMC.

3.2 Air Quality Monitoring

(1) Air Quality Monitoring Stations

The name and location of each monitoring station is shown in Table 3.2.1 and Figure 3.2.1.

Table 3.2.1 Name and Location of Monitoring Stations

Name	Location
EMC	Serpong, southwest of Jakarta city. No specific emission source nearby. Typical monitoring point for hinterland.
Pulo Gadung	Industrial park, east of Jakarta city.
Pluit	North of Jakarta city surrounded by a residential area.
Thamrin	Central part of Jakarta city along Jl. Thamrin near the rotary.
KPPL	Central part of Jakarta city, about 30 m from Jl. Casablanca surrounded by residences, buildings and graveyards.
Cibinong	South of Jakarta city near large cement factories.

(2) Monitoring items and measurement methods

The monitoring items and measurement methods are shown in Table 3.2.2.

Table 3.2.2 Monitoring Items and Measurement Methods

Items	Measurement Method	EMC	Pulo Gadung	Pluit	Thamrin	KPPL	Cibinong
SO_2	Solution-conductivity method	●				●	
	Continuous UV fluorescent method		●	●	●		
NOx	Absorptiometry using absorber solution	●				●	
	Continuous chemiluminescent method		●	●	●		
Ox	Absorptiometry by neutral KI absorption method	●				●	
O_3	Continuous UV absorptiometry method		●	●	●		
CO	Non-dispersion infrared absorption method	●	●	●	●	●	
SPM	β ray absorption method	●	●	●	●	●	●
HC	Gas chromatograph (using FID) method	●	●	●	●	●	

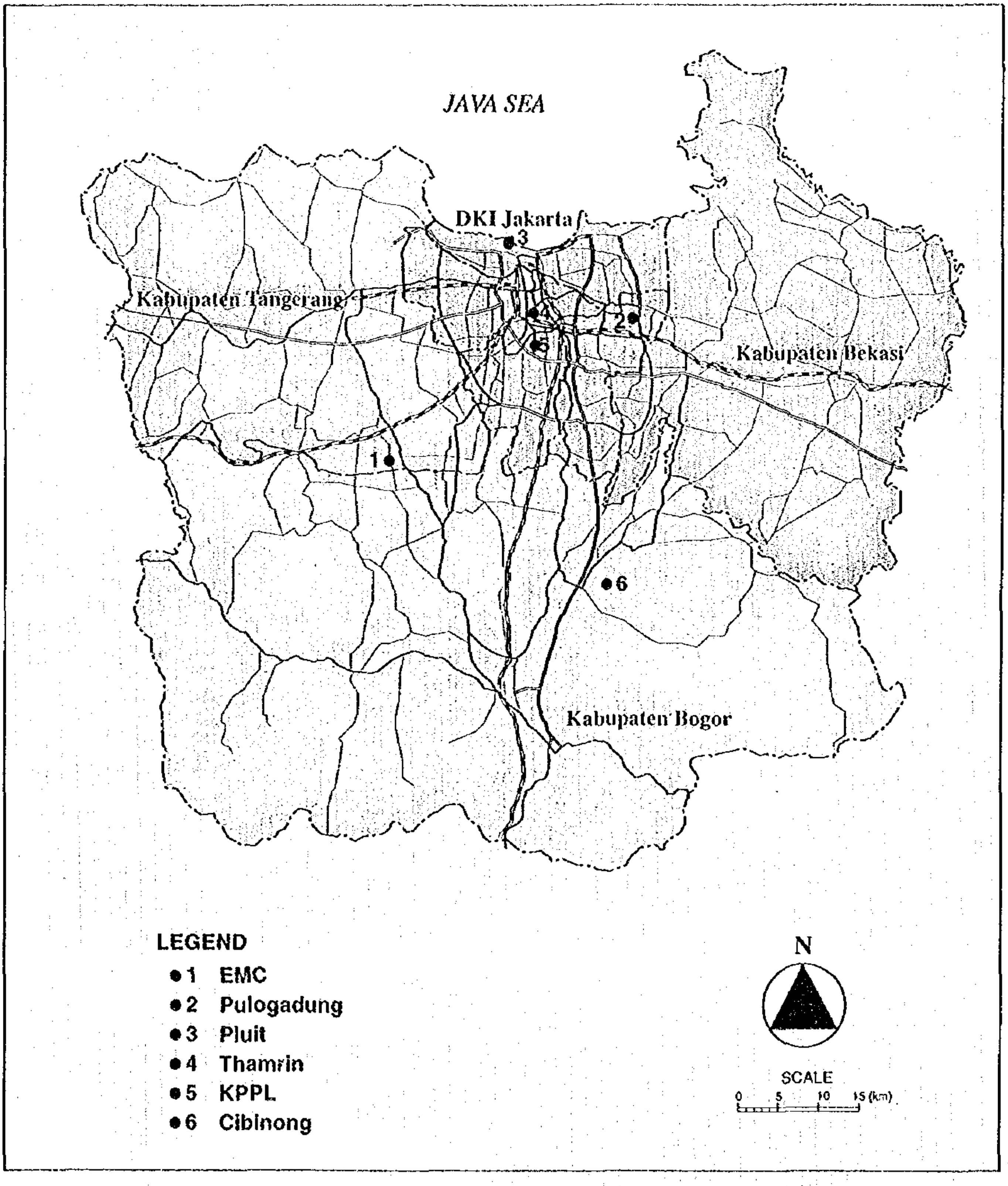


Figure 3.2.1 Air Quality Monitoring Stations in the Study

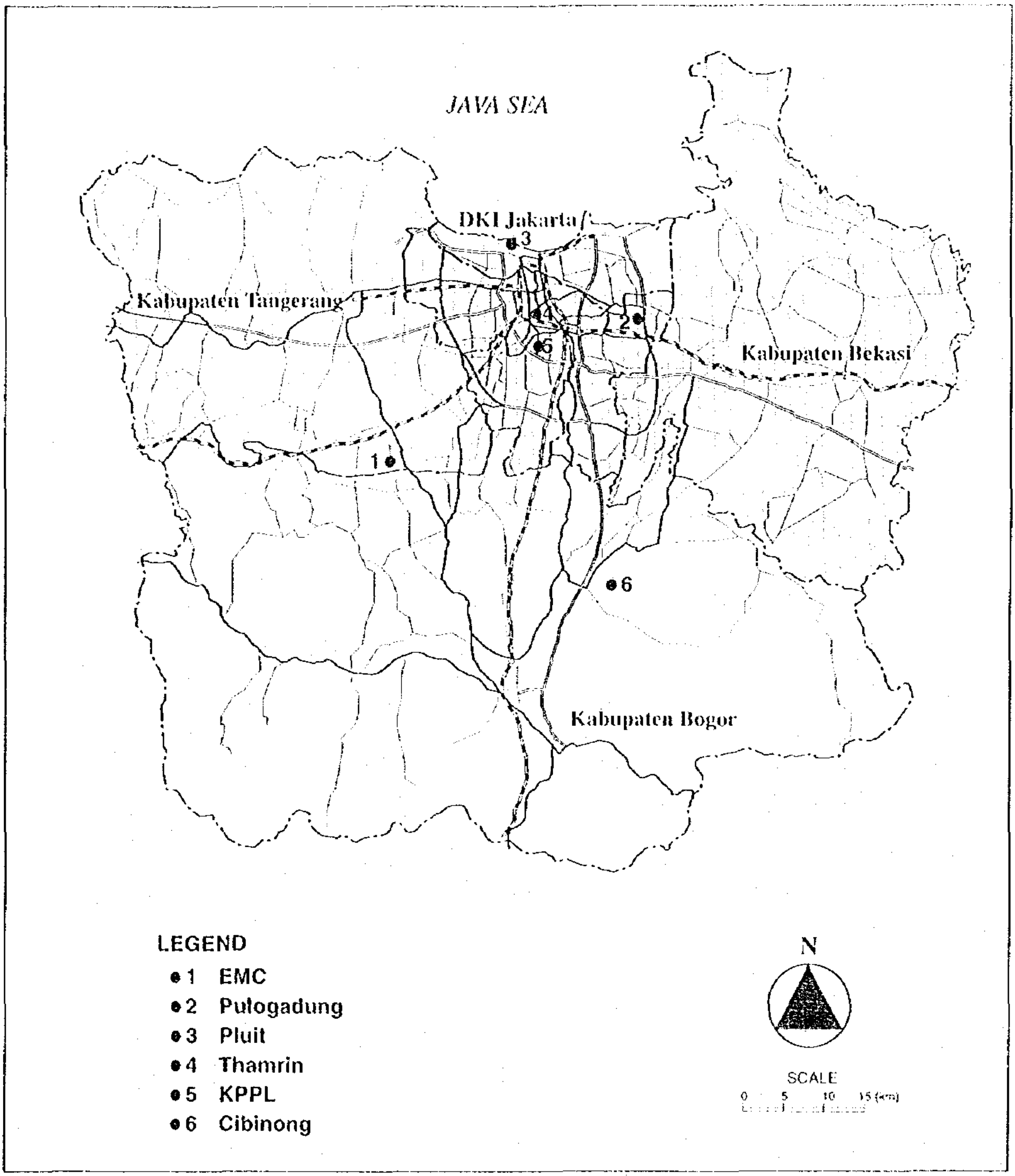


Figure 3.2.1 Air Quality Monitoring Stations in the Study

3.3 Results of Monitoring

3.3.1 Comparison with Ambient Air Quality Standards

Monitoring data were collected during the period from January to December 1996. Average concentration in each monitoring station in the period of observation is shown in Table 3.3.1.

Table 3.3.1 Monitoring Results (Average from January to December 1996)

Items	Unit	EMC	Pulo Gadung	Pluit	Thamrin	KPPL	Cibinong
SO_2	ppb	3.7	4.7	4.7	9.4	4.0	-
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	-
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	-
SPM	$\mu g/m^3$	53.0	116.1	84.4	81.5	87.8	46.6
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	-

Notes: CH4, NMHC & T-HC, from 6:00 to 9:00

(1) One-Year Average

As shown in Table 3.3.1, SO_2 concentrations at 5 monitoring stations are all lower than the valve of 20 ppb specified in the proposed National Ambient Air Quality Standards (AAQS). NO_2 is also lower than 50 ppb specified in the proposed National AAQS at all stations. And CO is far below 8,000 ppb specified in the current AAQS of DKI Jakarta (there is no national AAQS for one-year average).

There is also no one-year average of Oxidant or O_3 standard in the proposed National AAQS. AAQS of DKI Jakarta prescribe a level of 15 ppb for Oxidant O_3 which is not satisfied by the data (Table 3.3.1) of EMC and Pulo Gadung stations. However, Oxidant concentration at EMC includes the other photochemical Oxidants besides O_3.

There is no SPM standard in the proposed National AAQS. DKI AAQS is 60 $\mu g/m^3$

for one-year average. Except EMC and Cibinong stations, the SPM valves in Table 3.3.1 exceed the DKI standard.

(2) Shorter Time Average

As shown in Table 3.3.2 all values of SO_2 24-hour average concentration at each monitoring station satisfy the current and the proposed AAQS. NO_2 concentrations exceed the current standard 24 days out of 313 days at Thamrin station and 5 days out of 345 days at KPPL station. NO_2 concentrations exceed the proposed standard 15 days at Thamrin.

Table 3.3.3 shows the comparison of SPM concentrations with AAQS of DKI Jakarta. SPM concentrations exceed the standard 24-hour average 17 days out of 331 days at the Pulo Gadung station and only one day out of 348 days at the KPPL station.

Tables 3.3.4 and 3.3.5 show the comparison of CO and Total Hydrocarbon (THC) concentrations respectively with AAQS., The concentrations of CO at all the stations satisfy 8-hour averages of the current and the proposed AAQS. The concentrations of THC at all the monitoring stations exceed 3-hour average of the current and the proposed AAQS. According to these results, THC concentrations are the biggest problem in the Jabotabek area.

Table 3.3.2 Comparison of SO_2 and NO_2 Concentrations with the Current and the Proposed National Ambient Air Quality Standards

24 HOUR AVERAGE						
		Standard Value		Count		
				Over Standard		Total
Location	Pollutant	Current	Proposed	Current	Proposed	Samples
EMC	SO_2	100 ppb	110 ppb	0	0	196
PULO GADUNG				0	0	332
PLUIT				0	0	247
THAMRIN				0	0	258
KPPL				0	0	232
EMC	NO_2	50 ppb	80 ppb	0	0	352
PULO GADUNG				0	0	339
PLUIT				0	0	293
THAMRIN				24	15	313
KPPL				5	0	345

Table 3.3.3 Comparison of SPM Concentrations 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 3.3.4 Comparison of CO Concentrations with the Current and the Proposed National Ambient Air Quality Standard

8-HOUR AVERAGE (0:00 TO 8:00, 8:00 TO 16:00, 16:00 TO 0:00)				
		Standard Value	Count	
Location	Pollutant	Current/Proposed	Over Standard	Total Samples
EMC	CO	20,000 ppb / 9,000 ppb	0	8,353
PULO GADUNG			0	8,026
PLUIT			0	6,663
THAMRIN			0	8,207
KPPL			0	8,525

Table 3.3.5 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

(3) Hourly Values

Table 3.3.6 shows the comparisons of SO_2 and NO_2 with the proposed AAQS. All of SO_2 hourly values satisfy the proposed AAQS. NO_2 concentrations exceed the hourly standard value 18 hours out of 7,637 hours at Thamrin station, and only one hour out of 7,329 hours and 8,377 hours at Pluit and KPPL stations.

Table 3.3.7 shows the comparisons of O_3 (O_x) with the current and the proposed AAQS. O_3 concentrations exceed the standard values at least one hours at Pulo Gadung, Pluit, and Thamrin. O_x concentrations exceed the current standard 96 hours and exceed the proposed standard 228 hours out of 8,000 hours at EMC station, and O_x concentrations exceed the standards 2 hours and 12 hours at KPPL station.

Table 3.3.8 show the comparison of CO with the proposed AAQS, and the concentrations of CO at all of the stations satisfy the hourly standard.

Table 3.3.6 Comparison of SO_2 & NO_2 Concentrations with the Proposed National Ambient Air Quality Standards

HOURLY VALUES				
			Count	
Location	Pollutant	Standard Value	Over Standard	Total Samples
EMC	SO_2	340 ppb	0	5,113
PULO GADUNG			0	8,039
PLUIT			0	6,169
THAMRIN			0	6,213
KPPL			0	6,298
EMC	NO_2	210 ppb	0	8,470
PULO GADUNG			0	8,192
PLUIT			1	7,329
THAMRIN			18	7,637
KPPL			1	8,377

Table 3.3.7 Comparison of O_3 Concentrations with the Current and the Proposed National Ambient Air Quality Standards

HOURLY VALUES						
				Count		
		Standard Values		Over Standard		Total
Location	Pollutant	Current	Proposed	Current	Proposed	Samples
EMC	O_x	100 ppb	80 ppb	96	228	8,000
PULO GADUNG	O_3			10	18	3,710
PLUIT	O_3			5	17	7,318
THAMRIN	O_3			1	8	7,608
KPPL	O_x			2	12	8,002

Table 3.3.8 Comparison of CO Concentrations with the Proposed National Ambient Air Quality Standards

HOURLY VALUES				
			Count	
Location	Pollutant	Standard Value	Over Standard	Total Samples
EMC	CO	26,000 ppb	0	8,353
PULO GADUNG			0	8,026
PLUIT			0	6,663
THAMRIN			0	8,207
KPPL			0	8,525

3.3.2 Comparison of Ambient Air Concentration with Other Megacities

Table 3.3.9 shows the comparison of the annual average ambient air concentrations in Jabotabek with other megacities of Asia.

SO_2 and NO_2 concentrations in Jakarta, Bangkok, Kuala Lumpur, Tokyo, and Calcutta are almost in the equal level, and SO_2 concentrations in Beijing are relatively high.

SPM concentrations in ambient air in Jakarta, except EMC, is more than 1.5 times higher than those in Kuala Lumpur of Malaysia in one-year average. TSP concentrations in Jakarta, Kuala Lumpur, and Bangkok are almost in the equal range, and lower than those in Beijing, Lahore, and Calcutta.

Table 3.3.9 Comparison of Ambient Air Quality between Megacities

City	Monitoring Station	SO_2 (ppb)	SPM ($\mu g/m^3$)	TSP ($\mu g/m^3$)	NO_2 (ppb)
Jakarta*1	EMC	3.7	53.0	-	7.7
	Pulo Gadung	4.7	116.1	-	18.6
	Pluit	4.7	84.4	-	10.0
	Thamrin	9.4	81.5	-	29.1
	KPPL	4.0	87.8	-	25.5
Bangkok*2	SR1	5	-	-	-
Kuala Lumpur*3	Kuala Lumpur	5	58	-	21
	Shah Alam	2	50	-	17
	Petaling Jaya	22	58	-	26
Tokyo*4	Chiyoda	11	57	-	50
	Shinjuku	7	52	-	37
	Ohta	8	40	-	38
	Oume	5	30	-	17
Jakarta*5	Industrial	-	-	185	-
Beijing*5	Commercial	37	-	413	-
Shanghai*5	Commercial	24	-	253	-
Lahore*5	Suburban	-	-	496	-
Bangkok*5	Industrial	-	-	244	-
Kuala Lumpur*5	Industrial	-	-	144	-
Jakarta*6	n.a.	-	-	271	-
Beijing*6	n.a.	40	-	370	-
Bangkok*6	n.a.	5	-	105	-
Kuala Lumpur*6	n.a.	8.4	-	119	-
Calcutta*6	n.a.	19	-	393	-
Bangkok*7	Average	-	-	330	-

Notes :
*1 : Average from January to November, 1996
*2 : Annual mean of 1989, "Urban Air Pollution in Megacities of the World" (Ref.233)
*3 : Annual mean of 1995 (SO2 at Shah Alam : annual mean of 1994), "Malaysia Environmental Quality Report 1995 (Ref. 234)
*4 : Average from April 1995 to March, 1996, "Measurement Report of Ambient Air Monitoring Stations" (Ref.235)
*5 : Average from 1987 to 1990 "World Development Report 1992 (World Bank)"
The data regarded as TSP in our category from the context
*6 : Average from 1987 to 1990 "World Development Indicators 1997 (World Bank)"
The data regarded as TSP in our category from the context
*7 : Average in 1993 and average of 15 places "Action Plan for Controlling of Air Pollution and Noise from Vehicles I Thailand - March 1996 (Pollution Control Depart., M. of Science, T. & Environment)"
The data regarded as TSP in our category from the context

3.3.3 Changing Property of Concentrations

Except ozone and oxidant, almost all monitoring items are influenced by mobile exhaust gas. They have a sharp peak concentration in the morning which coincides with traffic congestion. In the evening and at night they also have peak concentrations, but these peaks are low and broad (Figures 3.3.1 to 3.3.6).

Ozone and oxidant concentrations in Jakarta are low in nighttime, and become high around noon, but at EMC peak concentration occurs 1 or 2 hours later than in the Jakarta area (Figure 3.3.6).

3.3.4 Requirement of Maintenance Activities for the Measurement Equipment

Although no problem related to the measurement equipment themselves occurred on measurement equipment during the Study, most of problems were caused by conditions of temperature, humidity, and especially power source. Other cause of the problem was closely related to maintenance of the equipment by staff who tend to operate the measurement equipment without enough understandings measurement methodology and equipment mechanism.

It is possible to use the measurement equipment in good condition and to obtain high quality data for a long time in Indonesia by maintenance of the equipment with well understanding mechanisms, structures, and futures of the equipment.

It is very important to avoid lack of measurement beforehand by teaching concerned staff such as EMC, KPPL on proper maintenance of the equipment. Accordingly, training and education to learn techniques on the maintenance activities should be conducted.

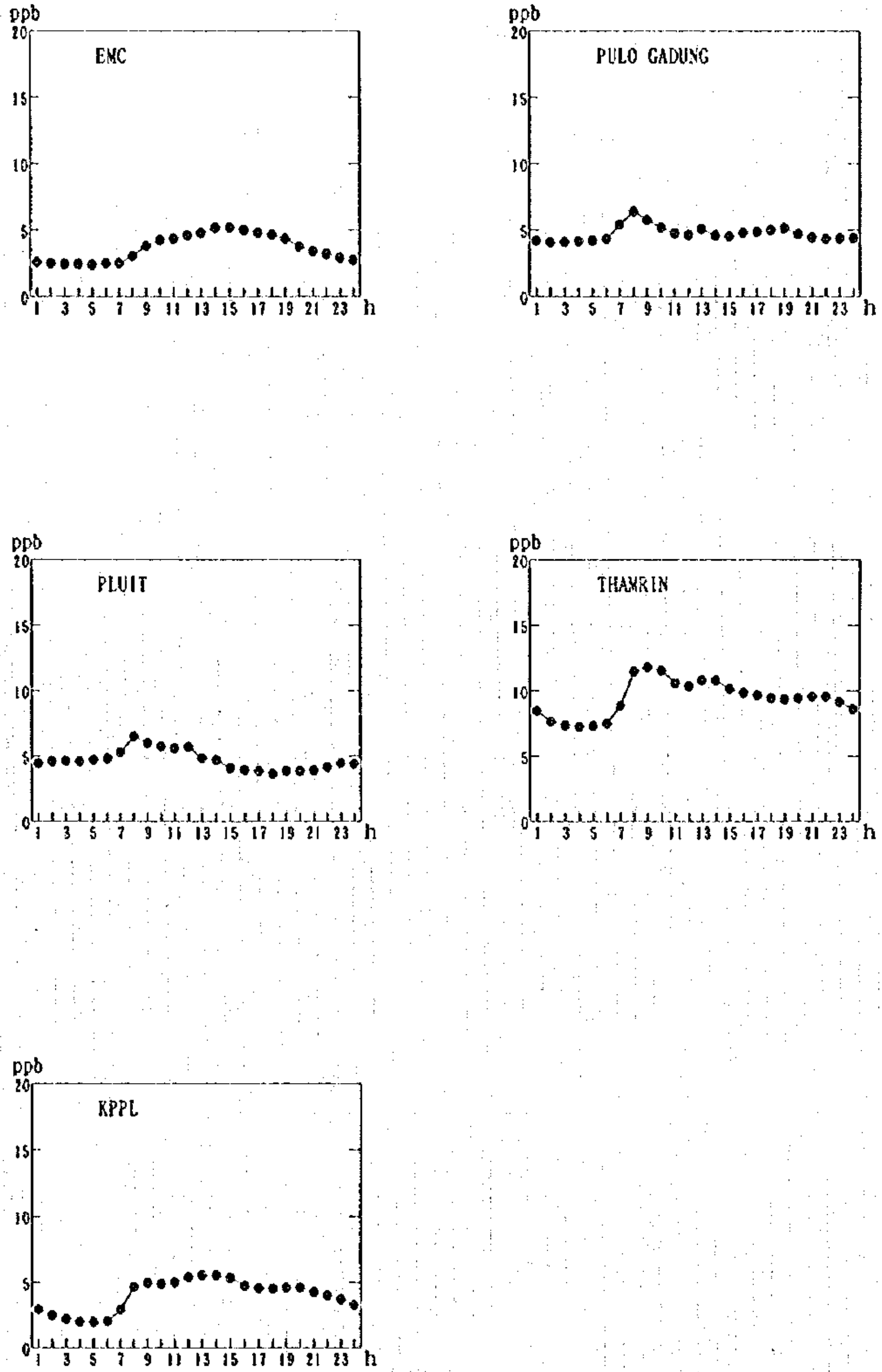


Figure 3.3.1 Diurnal Change of SO_2 in 1996 (Jan. to Dec.)

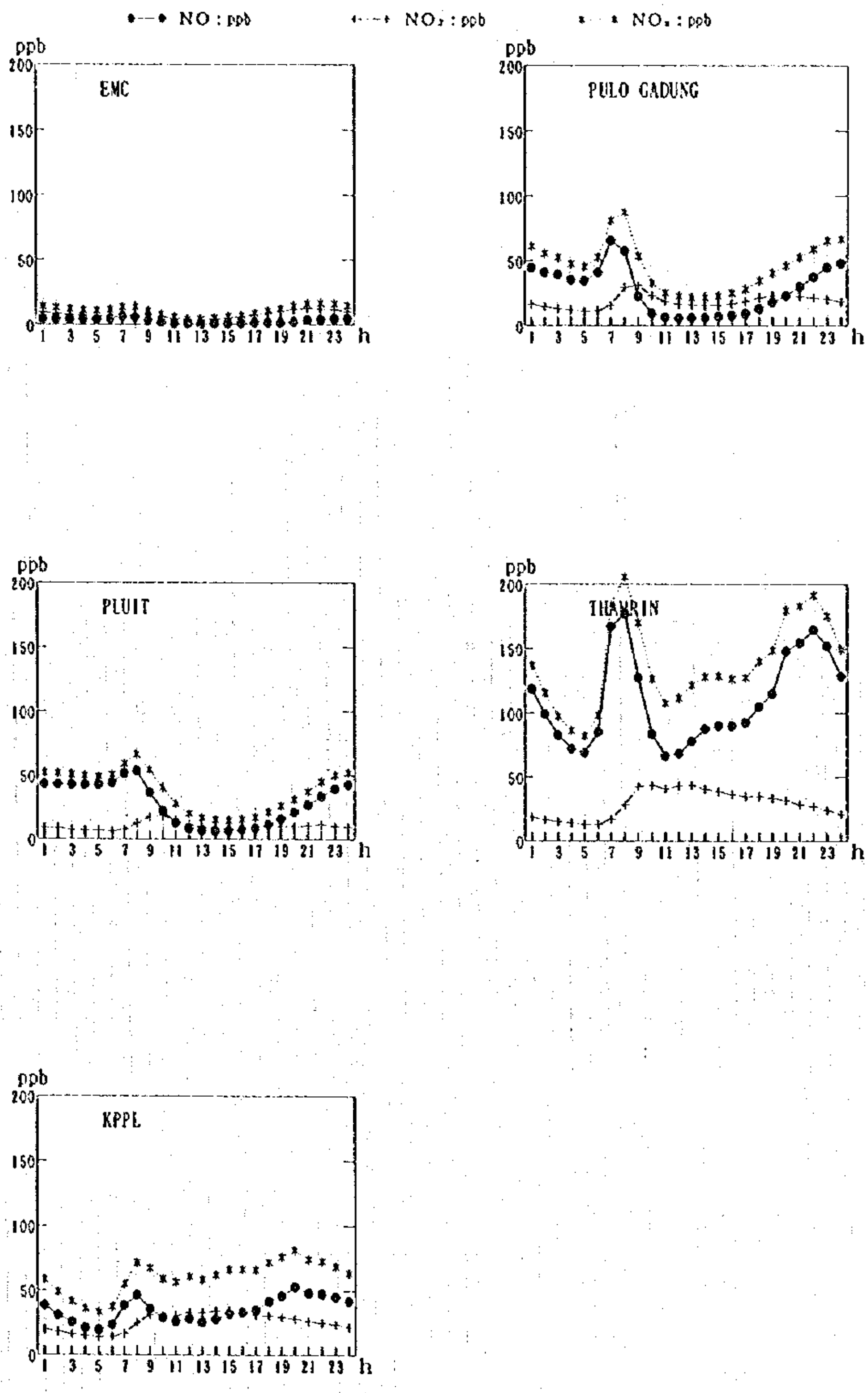


Figure 3.3.2 Diurnal Change of NOx in 1996 (Jan. to Dec.)

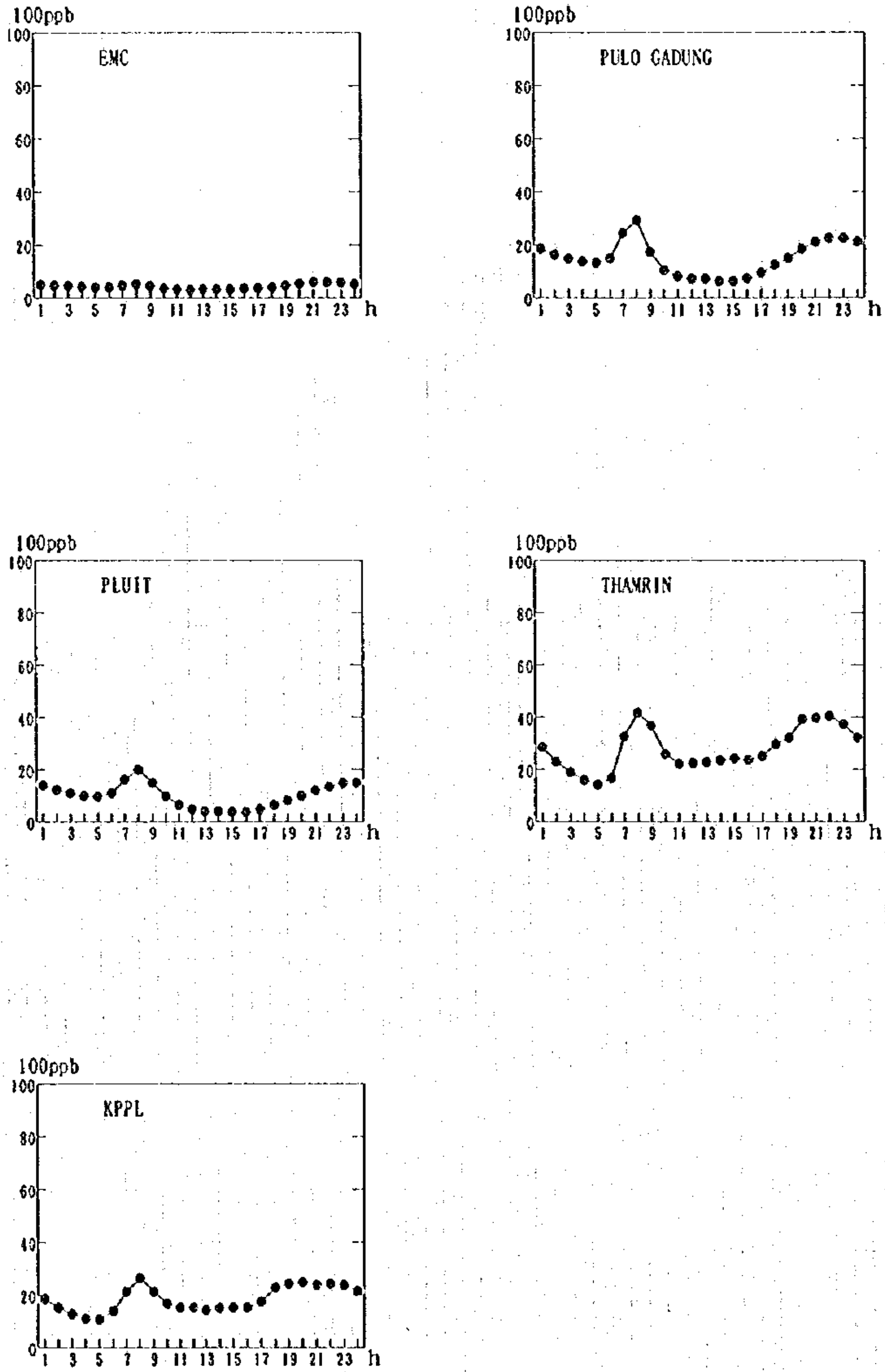


Figure 3.3.3 Diurnal Change of CO in 1996 (Jan. to Dec.)

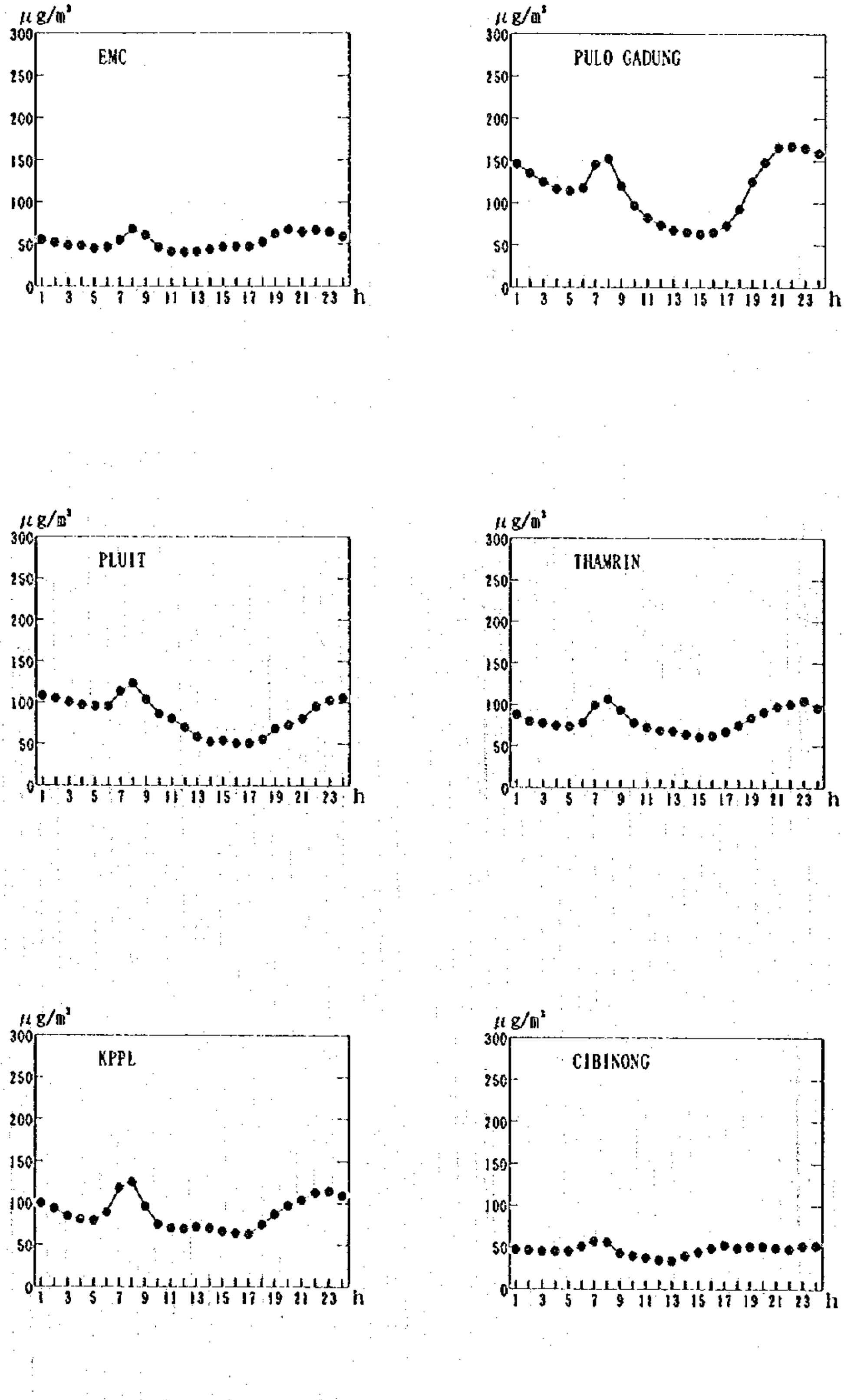


Figure 3.3.4 Diurnal Change of SPM in 1996 (Jan. to Dec.)

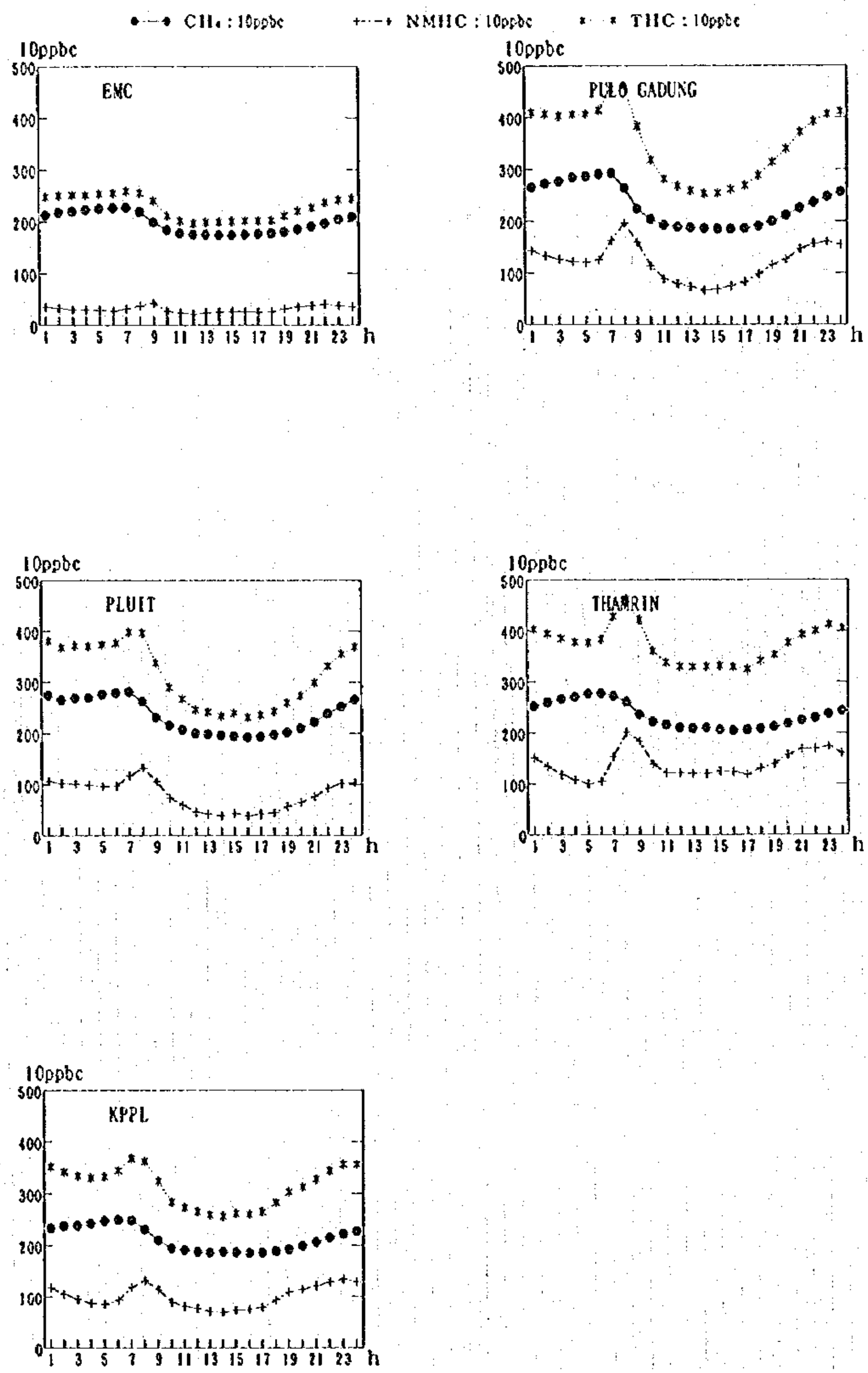


Figure 3.3.5 Diurnal Change of HCs in 1996 (Jan. to Dec.)

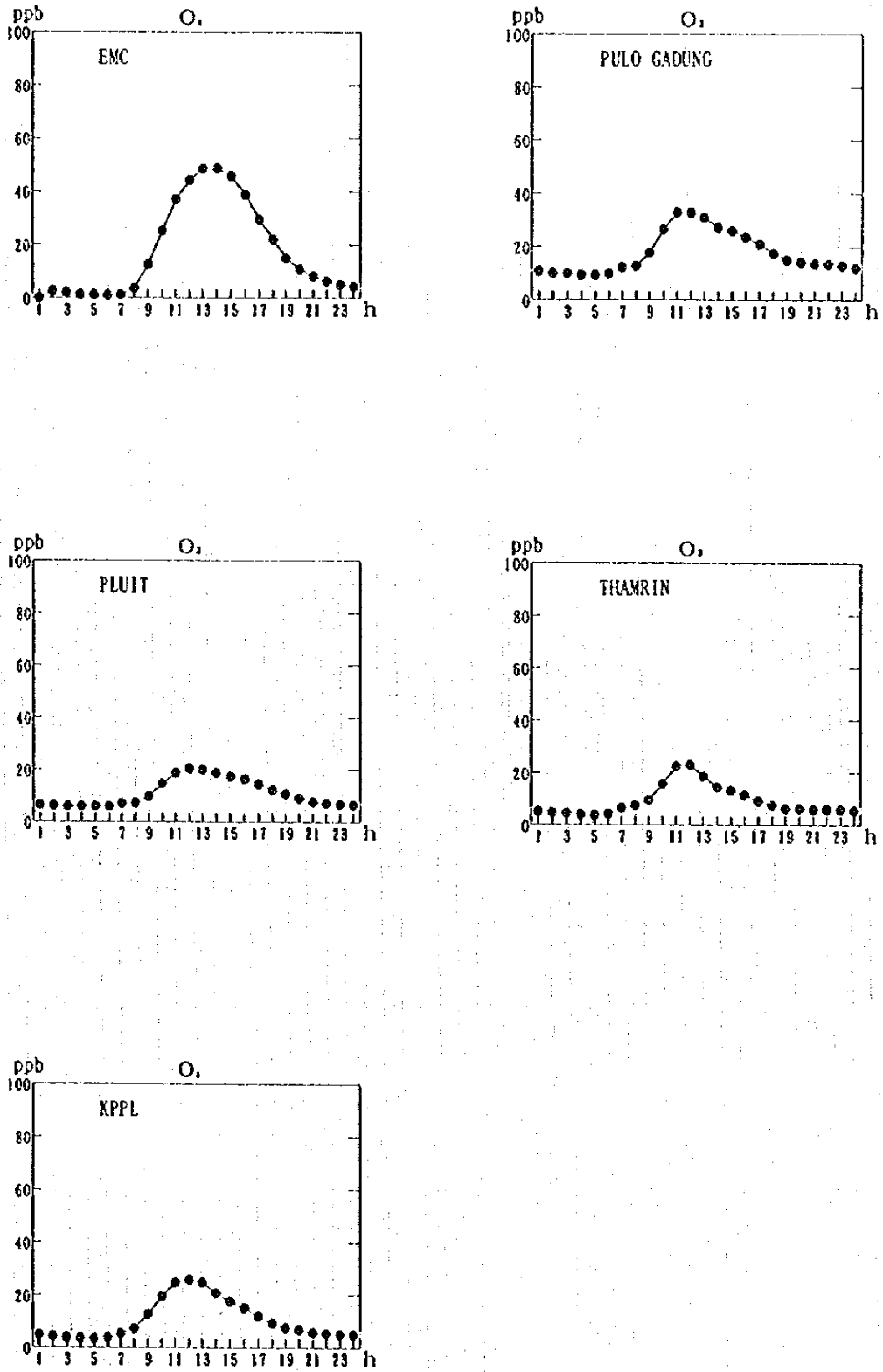


Figure 3.3.6 Diurnal Change of O_3 and Ox Year 1996 (Jan. to Dec.)

3.4 Supplemental Monitoring

3.4.1 Monitoring Results of Selected Items

Supplemental monitoring was carried out on the items indicated in Table 3.4.1.

Table 3.4.1 Supplemental Monitoring Items and Sampling Points

Items	Sampling and Analytical Method	EMC	Pulo Gadung	Pluit	JICA Office	KPPL
SPM	High-volume Sampler - HV Sampler (24 hours operation in one month) & Weighing	● (10)			● (11)	
TSP	High-volume Sampler & Weighing		● (11)	● (9)		● (10)
Hg	Au-amalgam Sampler & Atomic Absorption				● (10)	
Heavy Metals	High-volume Sampler & Neutron Activation Analysis of Ca,Sn,Na,Mn, Ni,Cr,Zn,Fe,Pb,V,K and others	● (10)	● (12)	● (10)	● (11)	● (11)
Particulate Size Distribution	Andersen Sampler (30 days operation in one month) & Weighing	● (7)			● (8)	
Benzo(a)pyrene	High-volume Sampler & High Performance Liquid Chromatography				● (10)	
Nonmetallic Ions	High-volume Sampler & Ion Chromatography, NH_4^+,NO_3^-,SO_4^{2-}	● (10)	● (12)	● (10)	● (11)	● (11)
Carbons	High-volume Sampler & Thermal Manganese Oxidation Method for Elemental and Organic Carbon	● (10)	● (12)	● (10)	● (11)	● (11)

Note: In parenthesis; Number of monitoring during a year.

(1) TSP (Total Suspended Particle) and SPM (Suspended Particulate Matter)

Monitoring results in 1996 are shown in Table 3.4.2 and Figure 3.4.1. TSP concentrations were measured at KPPL, Pulo Gadung and Pluit, and SPM concentrations at EMC and JICA Office. Only in January, TSP concentrations were measured at JICA Office. SPM concentrations were below the DKI Jakarta standard, but TSP ones exceeded the draft national standard in 6 times. Monthly changes show that concentrations are higher in the dry season than in the rainy season. Definition of TSP and SPM are shown in Appendix 2.3.

Table 3.4.2 TSP and SPM Concentrations

(Unit : mg/m^3)

Month	SPM		TSP		
	EMC	JICA	KPPL	Pulo Gadung	Pluit
January	0.064	0.083	0.17	0.13	0.12
February	0.038	0.045	0.13	0.14	***
March	-	0.053	0.21	0.17	0.067
April	-	-	0.13	0.19	0.17
May	0.015	0.065	0.18	0.22	0.11
June	0.055	0.029	0.32	0.26	0.19
July	0.039	0.108	0.28	0.19	0.19
August	0.034	0.063	0.14	0.15	0.22
September	0.047	0.156	0.19	0.32	0.23
October	0.047	0.153	-	0.33	0.30
November	0.017	0.056	0.08	0.17	-
December	0.009	0.064	-	-	-

Note : SPM is measured at EMC and JICA Office (except January), while TSP is measured at KPPL, Pulo Gadung and Pluit.

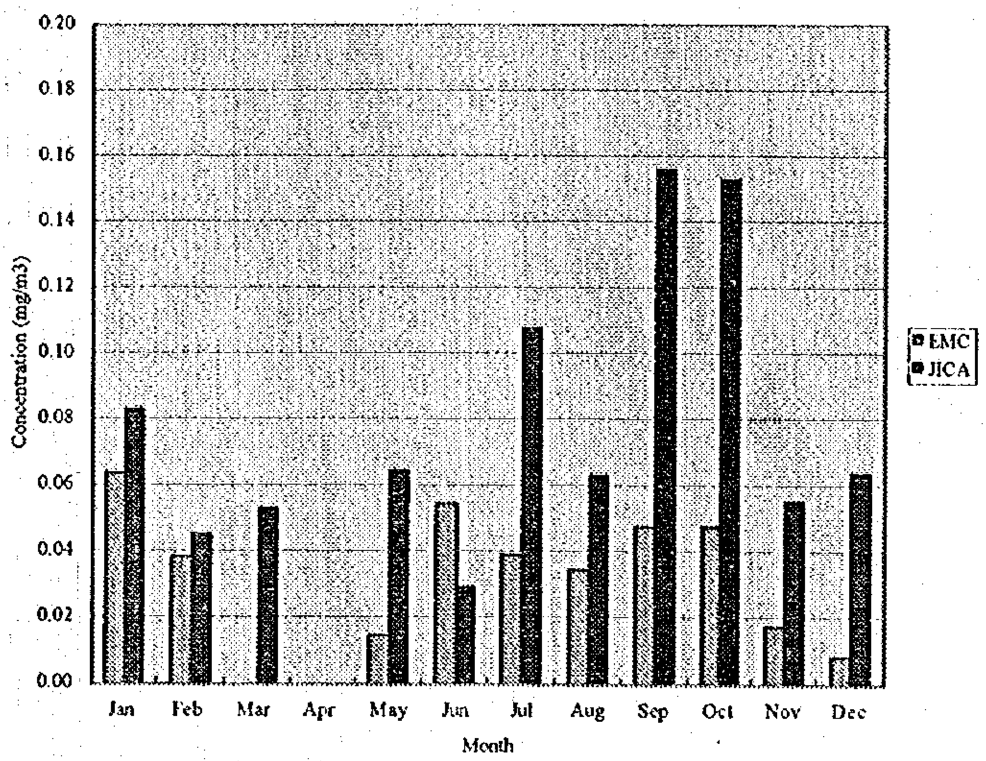


Figure 3.4.1(1) Monthly Changes of SPM

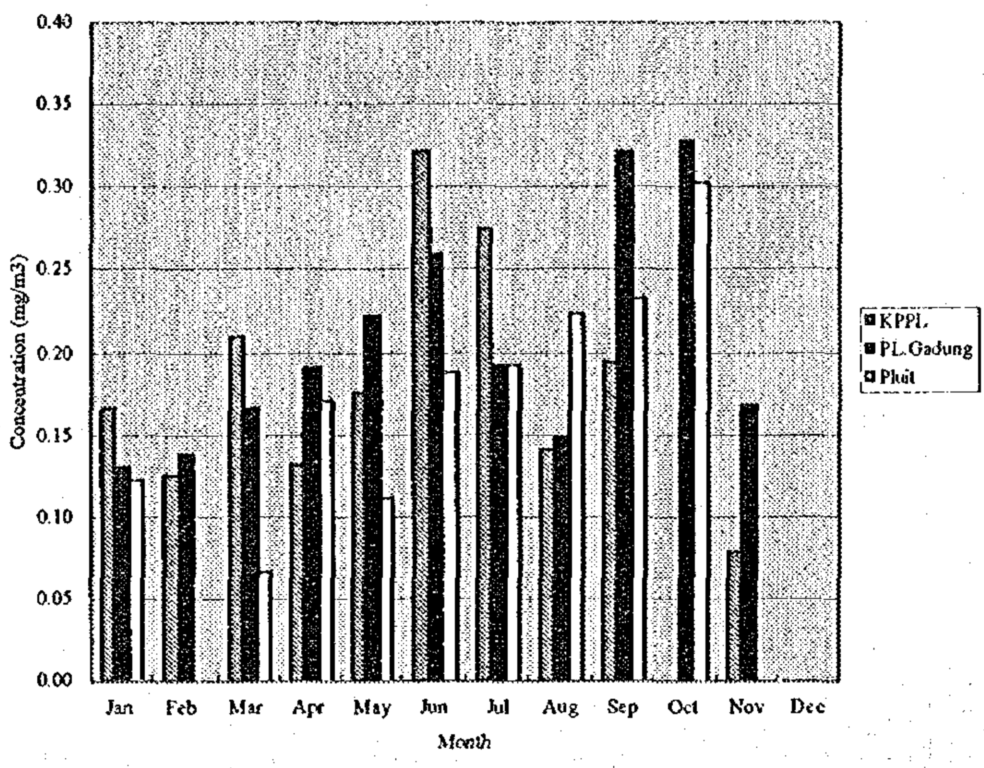


Figure 3.4.1(2) Monthly Changes of TSP

(2) Mercury (Hg)

Hg concentrations range from 6.7 to 33 ng/m^3, and maximum concentration was measured in April (Table 3.4.3 and Figure 3.4.2). The concentrations in April, July and August exceed WHO Environmental Health Criteria, 15 ng/m^3. Even the measured lower range of concentration is higher than the background values in Japanese country sides of Hg (2 or 3 ng/ m^3) in ambient air in Japanese country sides (Ref. 236).

Table 3.4.3 Hg Concentrations

(Unit : ng/m^3)

January	February	March	April	May	June
7.4	11	14	33	11	15

July	August	September	October	November	December
20	17	-	-	9.0	6.7

(Unit : ng/m³)

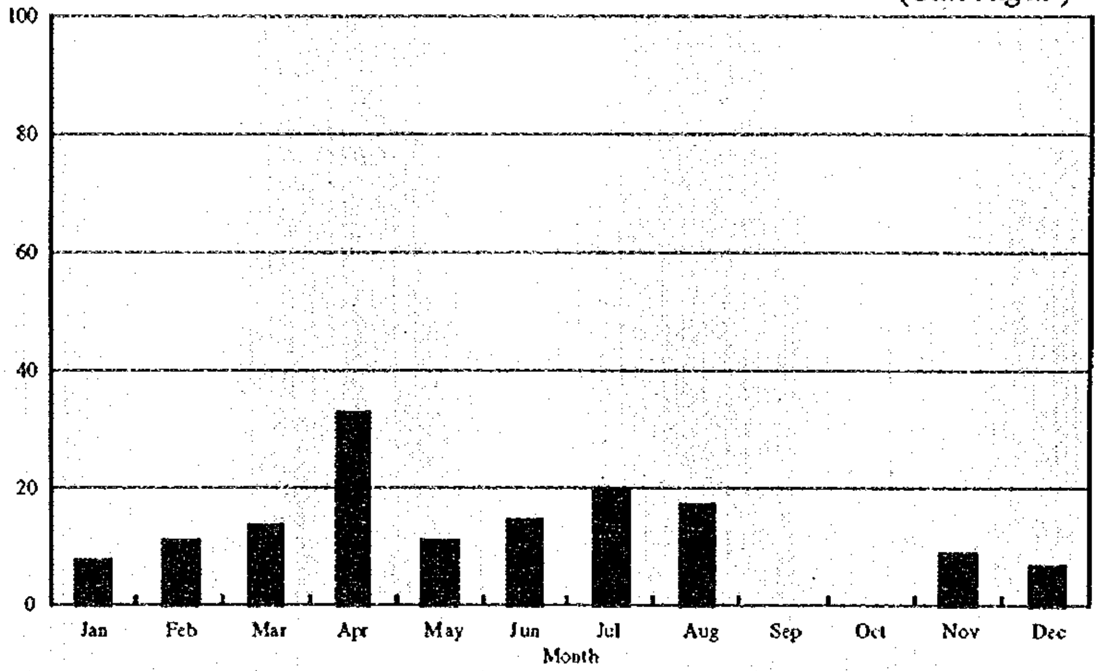


Figure 3.4.2 Monthly Change of Hg Concentration at JICA Office

(3) Benzo(a)pyrene (BaP)

Benzo(a)pyrene concentrations in 1996 ranged from 0.26 to 5.6 ng/m³, and maximum concentration was observed in September and minimum concentration in May. Annual average value was 1.91 ng/m³. Three months average BaP concentration in Bangkok (Thailand) and Tokyo (Japan) were reported to be 2.05 ng/m³ and 2.74 ng/m³ (Ref. 237). BaP concentration at both areas were almost in the same degree.

Table 3.4.4 BaP Concentrations

(Unit : ng/m³)

January	February	March	April	May	June
1.5	1.1	-	0.41	0.26	0.34

July	August	September	October	November	December
2.8	2.3	5.6	3.0	-	1.8

(Unit : ng/m^3)

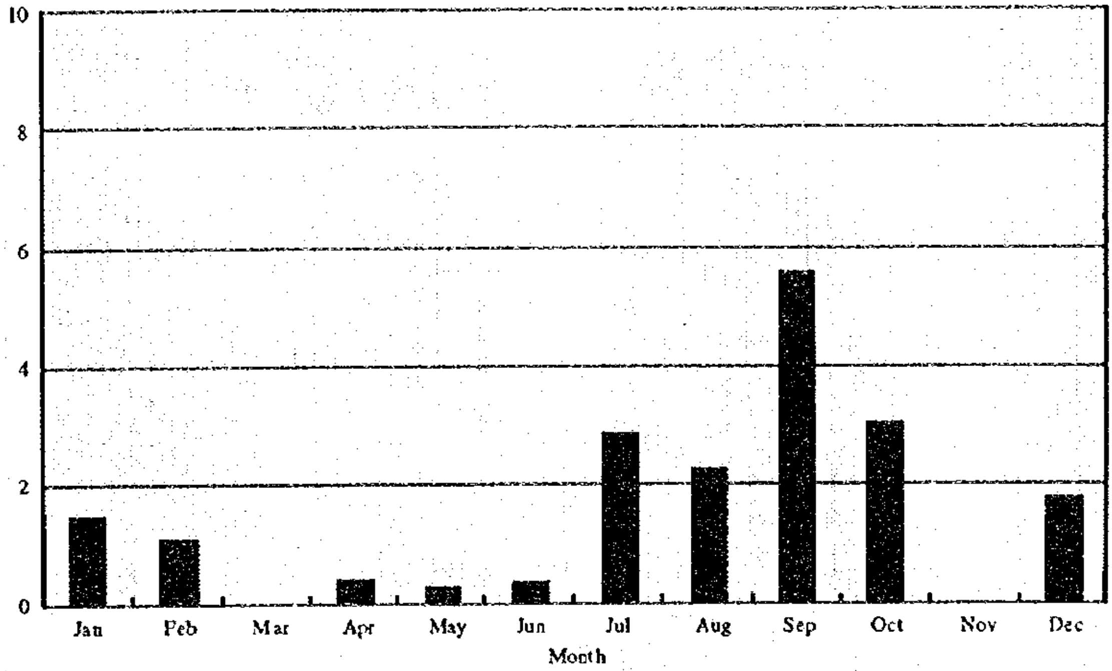


Figure 3.4.3 Monthly Change of BaP concentration at JICA Office

(4) Size Distribution of TSP

Size distribution analyses of TSP as observed in 1996 at EMC and JICA Office are shown in Tables 3.4.5 and 3.4.6. The ratio of fine particles smaller than 2 μm is high, accounting for 49.0 % at EMC and 51.5 % at JICA Office. On the other hand, the ratio of coarse particles the larger than 11 μm is 14.3 % at EMC and 17.8% at JICA Office, and the ratio at the roadside (JICA) is higher.

Table 3.4.5 Size Distribution of TSP at EMC

(Unit : %)

Month	<0.43 μm	<0.65 μm	<1.1 μm	<2.1 μm	<3.3 μm	<4.7 μm	<7.0 μm	<11.0 μm	11.0 μm<
Jan.	17.1	8.4	8.8	5.8	6.7	9.5	8.3	7.5	27.9
Feb.	24.6	5.0	6.4	4.8	6.1	2.6	29.8	10.2	10.4
Mar.	-	-	-	-	-	-	-	-	-
Apr.	-	-	-	-	-	-	-	-	-
May	24.1	14.9	14.3	6.6	8.4	9.3	6.8	6.0	9.8
Jun.	-	-	-	-	-	-	-	-	-
Jul.	21.8	10.9	11.3	7.5	8.8	12.1	10.5	9.6	7.5
Aug.	24.7	6.7	6.1	5.6	4.6	2.4	1.6	29.5	18.7
Sep.	23.3	10.3	8.7	3.2	6.3	9.2	10.3	9.5	19.1
Oct.	-	-	-	-	-	-	-	-	-
Nov.	23.9	14.6	16.9	6.8	8.0	11.5	5.7	6.3	6.4
Dec.	-	-	-	-	-	-	-	-	-

Table 3.4.6 Size Distribution of TSP at JICA Office

(Unit : %)

Month	<0.43μm	<0.65μm	<1.1μm	<2.1μm	<3.3μm	<4.7μm	<7.0μm	<11.0μm	11.0μm<
Jan.	19.9	5.7	6.7	5.2	4.8	8.9	11.0	12.5	25.2
Feb.	17.6	6.7	3.7	6.2	4.7	2.2	1.0	35.0	22.9
Mar.	-	-	-	-	-	-	-	-	-
Apr.	18.5	7.8	6.4	6.0	5.3	8.1	9.2	10.9	27.8
May	20.0	8.8	7.6	6.0	4.7	9.9	12.5	11.0	19.6
Jun.	-	-	-	-	-	-	-	-	-
Jul.	74.9	2.1	2.4	2.0	1.8	3.3	4.1	4.7	4.7
Aug.	7.9	27.2	32.9	2.5	1.9	0.8	0.5	16.7	9.5
Sep.	14.4	7.2	5.9	4.9	4.6	10.4	12.9	13.9	25.9
Oct.	-	-	-	-	-	-	-	-	-
Nov.	52.2	11.9	4.9	5.9	3.8	6.2	4.5	3.7	6.9
Dec.	-	-	-	-	-	-	-	-	-

3.4.2 Analysis of SPM/TSP for CMB Method

(1) Carbons

Total carbon (Ct) is divided into organic carbon and elemental carbon. Two thirds of total carbon is elemental carbon, and one third organic carbon at all the stations. Total carbon accounts for around 60% of SPM and around 30% of TSP (Figure 3.4.4). Because the ratio of coarse particles is higher in TSP, the ratio of total carbon is lower in TSP.

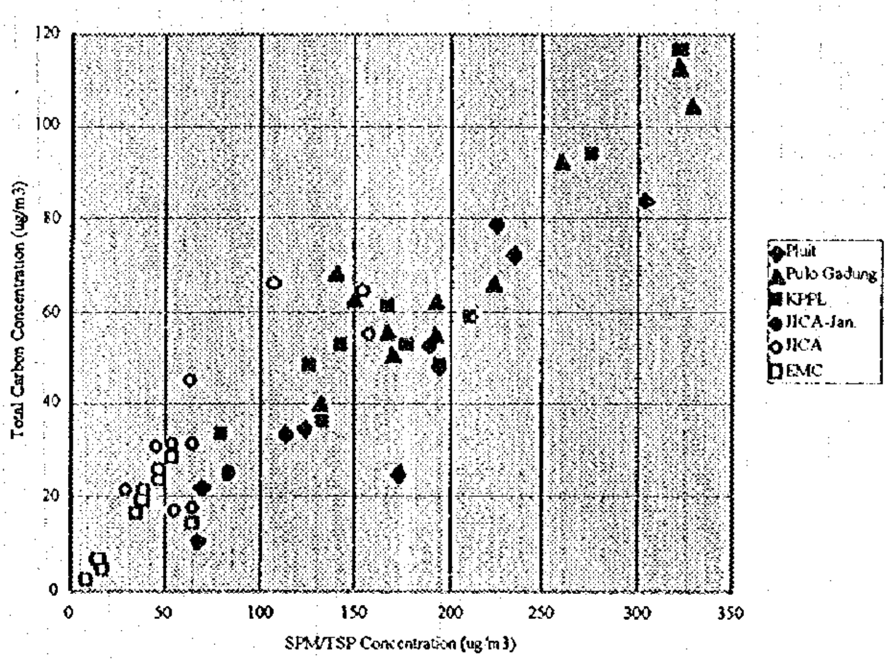
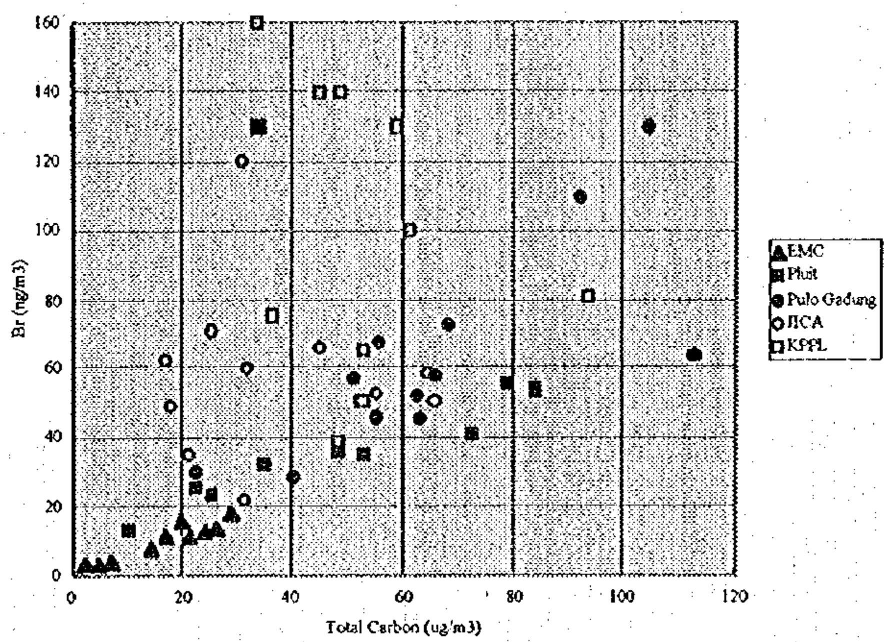


Figure 3.4.4 Total Carbon in SPM and TSP

Bromine (Br) as well as lead (Pb) are good indicators of exhaust particles from vehicles using leaded gasoline. The Bromine/Ct ratio is around 0.001 in the outskirts of DKI Jakarta, and more than 0.001 with big fluctuations in the center of the city. The reason for this phenomenon is that Br disperses into the ambient air during the transportation from the city center to the outskirts (Figure 3.4.5).



Note: The value of 1,000 ng/m^3 of Br and 116.95 μg/m^3 of Ct at KPPL are placed the outside of the figure and are omitted.

Figure 3.4.5 Br and Total Carbon Ratio

(2) Ionic Components

Ions like chloride (Cl^-), nitrate (NO_3^-), sodium (Na^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}) show a remarkable difference in concentration between SPM and TSP. These ions show higher concentration in TSP. On the other hand, ions like sulfate (SO_4^{2-}), potassium (K^+) and ammonium (NH_4^+) show little difference in concentration between SPM and TSP. This fact means that the former ions like chloride and so on exist mainly in coarse particles and the latter exist mainly in fine particles (Appendix 2.4).

(3) Elements

The following features were clarified so far (Appendix 2.4) :

1) Aluminum (Al), calcium (Ca) and iron (Fe) are indicators for soil particles, showing high concentrations in coarse particles.
2) Vanadium (V) and nickel (Ni) are good indicators of fine emission particles from oil combustion. Observation data, however, show high concentrations in coarse particles. The high concentration of vanadium is due mainly to V content of around 200 μg/g in the soil.
3) Br and Pb are good indicators of exhaust emission from vehicles using leaded gasoline. Bromine concentrations become high in the city center as mentioned (1) above.
4) SPM concentration at EMC is low, however, Pb and antimony (Sb) components are high. Some unknown source(s) of these components is/are expected.
5) Although TSP is sampled on the roof of a building at KPPL, soil components like Al and Ca are high. Construction works in the neighborhood would affect the components.
6) Lead concentrations at EMC exceeded the proposed AAQS of 24-hour average (2.0 $\mu g/m^3$) once out of 10 times of sampling, and lead concentration at the other four stations were below the standard.

3.4.3 Overall Analysis of Supplemental Monitoring Results

According to the supplemental monitoring results, SPM concentrations are low and seem to be not a serious problem in the Jabotabek area. On the other hand, TSP concentrations at the three stations are relatively high so that dust problem in Jakarta is restricted to coarse particles. But they have small influence on human respiration. The coarse particles have their origin in road dust, construction dust and so on. It thus seems to be necessary to keep the road and roadside clean and to regulate the generation of dust from construction activities.

Mercury concentrations are high and exceed WHO criteria in the three months. Although the origin of mercury is said to be incineration of dry battery, it is difficult to be considered for this case. The measurements of mercury were conducted at only one station at JICA. It is necessary to conduct the mercury measurements in wide area to confirm, if it is general problem in JABOTABEK, and potential emission source could be discussed after the wide area measurement.

Because Benzo (a) pyrene (BaP) concentration is almost the same degree compared with the ones in Bangkok and Tokyo, it seems to be a small problem.

3.5 Evaluation of Current Air Quality

THC concentrations at all the five stations seem to be big problem. However, THC itself is not so harmful for human body at the concentration level and the standards are usually set to reduce photochemical oxidant formation. O_3 and O_x are produced by photochemical reactions including NO_x, and hydrocarbons accelerate the reaction and produce more O_3.

Annual average of O_3 at Pulo Gadung and annual average of O_x at EMC exceed the proposed National AAQS. Hourly values of O_3 and O_x concentrations at all of the stations exceed the current and the proposed hourly standards at least one hour during a year. However, the hourly standards were exceeded below 20 hours out of 8,760 hours for a year at the other four stations except EMC. Because O_3 and O_x are secondarily produced by photochemical reaction as mentioned above, NO_x and Hydrocarbons should be reduced to decrease the O_3 and O_x concentrations.

Annual averages of SPM at the four stations exceed the annual standard of DKI Jakarta, and the 24 hours standard of DKI Jakarta are exceeded 17 days and one day at Pulo Gadung and KPPL respectively. SPM concentration at Pulo Gadung is higher than the other stations, and Pulo Gadung is located in the industrial estate. SPM is considered as a problem at certain areas, and TSP may be more problematic based on overall analysis of supplemental monitoring.

NO_2 concentrations satisfy the annual standard. However, the proposed 24 hours standard is exceeded 15 days and the proposed hourly standard is exceeded 18 hours at Thamrin. The high NO_2 concentration at Thamrin may be mainly caused by heavy traffic, and NO_2 concentration at curbside may be higher because the sampling hole at Thamrin station is elevated. Adding to the toxicity of NO_2 itself, NO_2 is primary pollutant to O_3 and O_x and very important pollutant to be controlled.

SO_2 and CO concentrations measured at the monitoring stations satisfy all of the standards in Indonesia, and not problem at present.