# MALAYSIA

# AIR QUALITY MANAGEMENT STUDY FOR KLANG VALLEY REGION

## FINAL REPORT

## MAIN REPORT

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VOL.2

MAIN REPORT



AUGUST 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

# PREFACE

In response to a request from the Government of Malaysia, the Government of Japan decided to conduct a Master Plan Study on Air Quality Management Study for Kelang Valley Region in Malaysia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Malaysia a study team headed by Mr. Makoto Miyakawa, SUURI-KEIKAKU CO., LTD. and composed of members from SUURI-KEIKAKU CO., LTD. and Pacific Consultants International seven times between December 1991 and June 1993.

The team held discussions with the officials concerned of the Government of Malaysia, 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 Malaysia for their close cooperation extended to the team.

August 1993

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

# EXECUTIVE SUMMARY

## 1. Introduction

### 1.1 Background and Objective of the Study

Kelang Valley Region (2,830 km², about 2.95 million people) consisting of Kuala Lumpur (the capital of Malaysia) and its vicinity has been experiencing worsening air pollution in recent years as a result of the rapid growth of the traffic volume, urbanization and industrial activities.

The objective of the Study was to prepare a guideline for air quality management for Kelang Valley Region with special emphasis on improving air quality monitoring capability, identification of major pollution sources, prediction of future air pollution and proposition of feasible control measures. At the same time, the Study was expected to contribute to tangible technology transfer to Malaysian counterparts.

### 1.2 Outline of the Study

The Study area is the Kelang Valley Region, approximately 60 km from east to west and 40 km from south to north, consisting of the Federal Territory (Kuala Lumpur) and Klang, Petaling, Gombak and Hulu Langat of Selangor State.

The Study was conducted from December 1991 to August 1993. The Study consisted of the basic and analytical study with the following components as shown in Fig. 1.1.

### 1.3 Overview of the Study Area

#### (1) Natural Environment

The Study area is a basin located in the southwestern part of the Malaysian Peninsula, surrounded by mountains exceeding 1,500 m height on the east and the Straits of Melaka on the west.

Malaysia experiences a tropical rain forest climate, which is influenced by monsoons from the South China Sea and the Indian Ocean. The

Northeast monsoon season from December through February and the Southwest monsoon from June through August are generally the dry seasons for the western part of Peninsular Malaysia. Two transitional seasons from March through May and September through November are rainy seasons with high humidity. The monthly mean values of temperature range from about 26°C to about 28°C.

The wind is very weak throughout the year; the Study showed the annual average of wind speed is about 1 m/s in the Region and that low inversion layers appeared frequently. Hence, air pollutants tend to accumulate in the Region.

(2) Social Conditions

According to the latest census carried out in August 1991 and a preliminary count report released in March 1992, the total population in Malaysia is 17.57 million. Among them, 2.95 million people (about 17% of the total population) live in the Kelang Valley Region.

The Malaysian economy has been expanding rapidly. The average growth rate was 6.7% during the period 1971-1990, and is expected to be 7.0% between 1991-2000. In Kuala Lumpur, the growth of big industries is expected to decline. Future growth will be in the small scale industries, repair and service activities and medium-sized industries with higher employment densities. In Selangor State, industries such as electrical & electronics and machinery & transport equipment are expected to develop rapidly.

Kuala Lumpur is the most urbanized area (80% of the total area), followed by Petaling (33%). Agricultural fields occupies the largest area in Klang (47%) whereas forest occupies the largest area in Gombak (55%) and Hulu Langat (40%).

(3) Traffic and Transportation

Motor vehicles are the major means of land transportation in the Region. The total number of registered vehicles in the Federal Territory of Kuala Lumpur and Selangor State is about 1.57 million at the end of 1991 and the percentage of petrol and diesel vehicles were 91% and 9% respectively. As to the percentage of types of vehicles, motorcycle accounts for 44%, followed by motor car at 43% and they account for 87% of the total vehicles. However, introduction of mass transportation system such as Light Rapid Train System and improvement of existing railways are expected to start in the near future.

For air transport, Subang International Airport is the only commercial airport in the Region which is being operated at full capacity. The new "Sepang International Airport" will be completed by 1997.

Port Klang handles cargo traffic. However, since the port is becoming congested, the west port will be constructed at first in Pulau Lumut during the 6th Malaysian Plan Period.

(4) Energy

The main facilities in Kelang Valley Region are boilers, They use mainly heavy fuel oil, while most other facilities burn light fuel oil.

In this Region, natural gas will be supplied to households and factories in the near future.

Several thermal power plants are now under construction or planned by the year 2000.

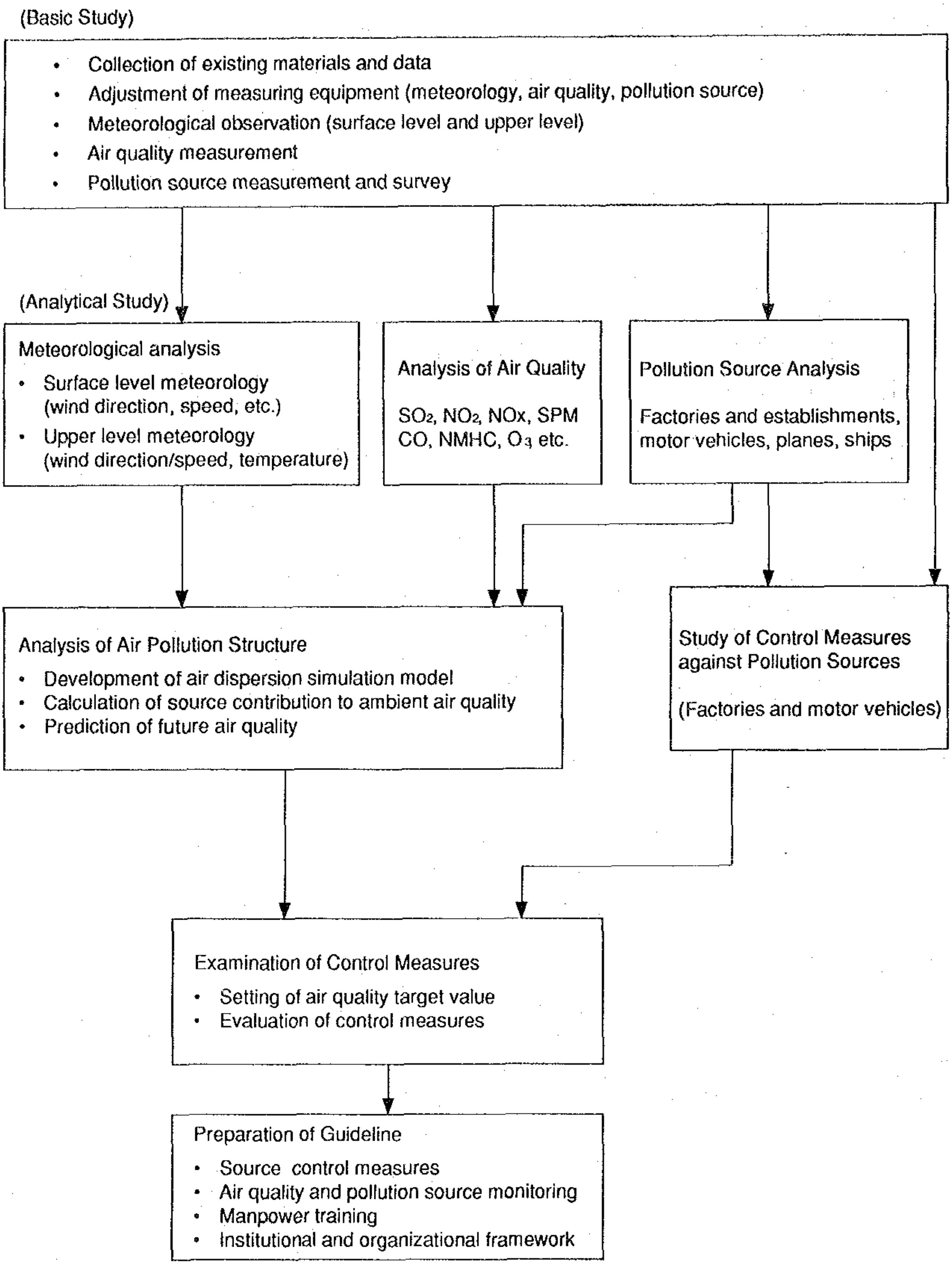



Fig. 1.1 Outline of the Study

## 2. Present State of Ambient Air Quality

### 2.1 Features of Air Quality

Ambient air quality was monitored at five fixed stations from March 1992 to February 1993. Table 2.1 shows average concentrations throughout the period at these stations.

The $SO_2$ value ranged from 7.7 to 13.3 ppb in average. The $NO_2$ value ranged from 8.6 to 21.7 ppb while the CO value from 0.7 to 2.8 ppm in average. As regards SPM, the average value ranged from 24.1 to 67.6 $\mu g/m^3$.

Table 2.2 shows the state of compliance with the air quality guidelines. It is noticed that the TSP and PM10 values were estimated indirectly from the SPM values.

Values of, $SO_2$, $NO_2$ and TSP were all below the guidelines. As for CO, 8 hours value exceeded the guideline at City Hall and Petaling Jaya.

For PM10, both of yearly and daily values exceeded the guidelines at Shah Alam. For $O_3$, all stations did not satisfy the guidelines.

Table 2.1 Average Concentration at Fixed Stations (1992)

| Station | $SO_2$ ppb | $NO_2$ ppb | NOx ppb | CO ppm | SPM $\mu g/m^3$ | $O_3$ ppb | NMHC 10 ppbC |
|---|---|---|---|---|---|---|---|
| City Hall | 10.4 | 21.7 | 103.3 | 2.7 | 50.7 | 9.5 | - |
| UPM | 8.0 | 8.6 | 18.1 | - | 24.1 | 10.0 | - |
| Petaling Jaya | 13.3 | 19.3 | 49.4 | 2.8 | 58.8 | 9.7 | 79.1 |
| Shah Alam | 7.7 | 15.2 | 31.4 | 0.7 | 67.6 | 10.9 | 22.5 |
| Klang | 8.5 | 11.4 | 26.6 | - | 60.8 | 12.4 | - |

Table 2.2 Compliance State with Air Quality Guidelines (1992)

| Pollutant | $SO_2$ | | $NO_2$ | CO | | TSP | | PM10 | | $O_3$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Guidelines | Daily | Hourly | Hourly | 8 Hours | Hourly | Yearly | Daily | Yearly | Daily | 8 Hours | Hourly |
| | 40 | 130 | 170 | 9 | 30 | 90 | 260 | 50 | 150 | 60 | 100 |
| | (ppb) | | (ppb) | (ppm) | | (μg/g) | | (μg/m3) | | (ppb) | |
| City Hall | o | o | o | x | o | o | o | o | o | x | x |
| UPM | o | o | o | - | - | o | o | o | o | o | x |
| Petaling Jaya | o | o | o | x | o | o | o | o | o | x | x |
| Shah Alam | o | o | o | o | o | o | o | x | x | x | x |
| Klang | o | o | o | - | - | o | o | o | o | x | x |

o: satisfy
x: exceed
-: no measurement

## 2.2 Diurnal Change of Pollutant Concentration

Fig. 2.1 shows diurnal change of pollutant concentration at fixed stations in 1992 as an example.

There are mainly three typical patterns on the diurnal changes.

The first one is a 'two peak pattern' with a sharp peak in the morning and a moderate peak in the evening through the night. Most of the diurnal changes of CO and Nitrogen Oxides showed this pattern. Some diurnal changes of SPM and Hydrocarbons also showed this pattern. This two peak pattern is considered to indicate influence of motor vehicles.

The second one is a 'single minimum pattern' with the minimum in the daytime. Some diurnal changes of SPM showed this pattern. It is noticed that SPM concentration rose up in the evening through the night and the concentration did not decrease till the morning.

The third is a 'single peak pattern' with the peak in the afternoon. $O_3$ diurnal changes at all stations showed this pattern. This pattern is mainly caused by sunshine.

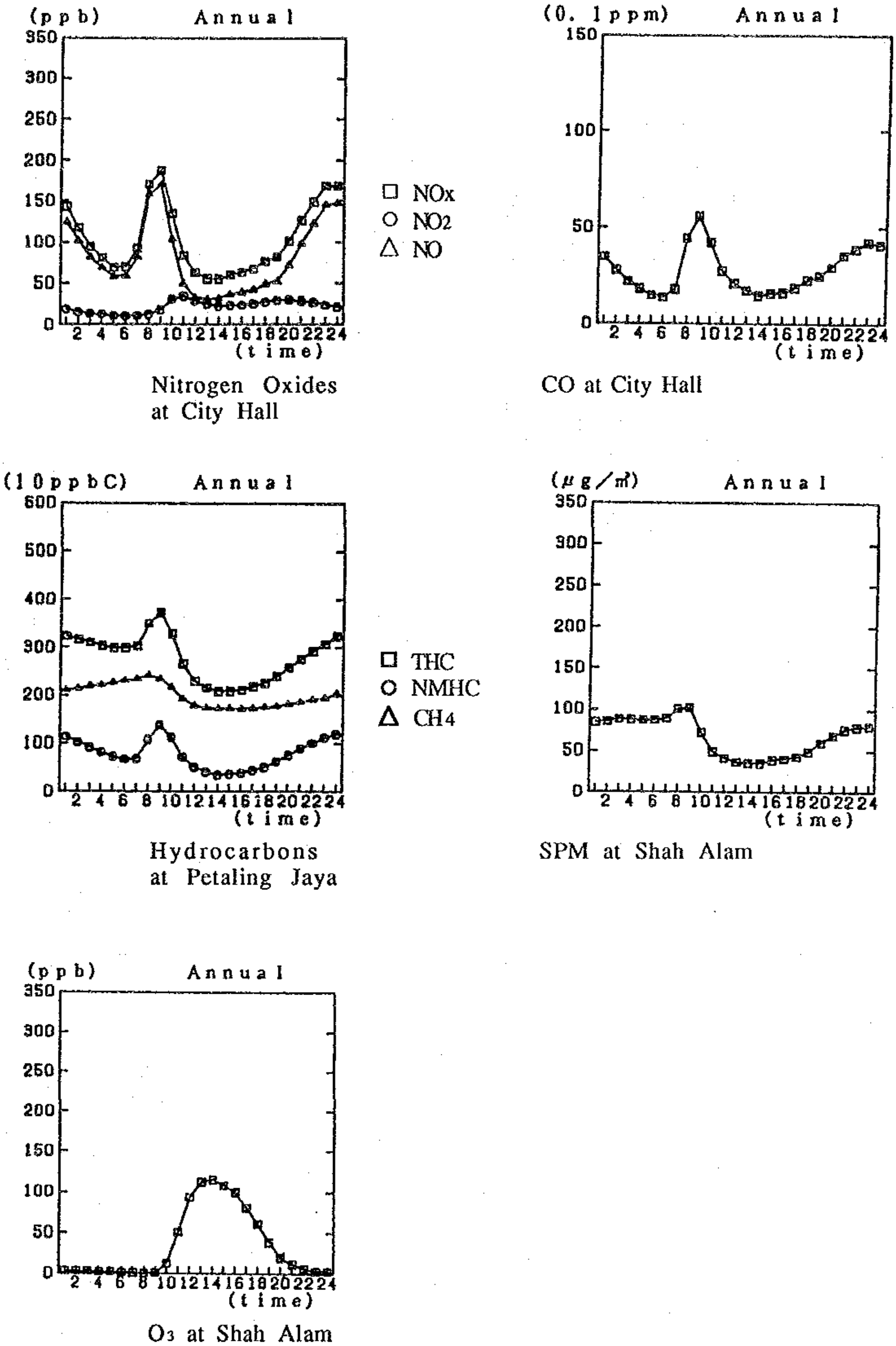



Fig. 2.1 Diurnal Change of Pollutant Concentration (1992)

## 3. Structure of Air Pollution

The present air pollution load by source in 1992 in the Kelang Valley Region was estimated as shown in Table 3.1. The SOx emission from factories is 31,000 tons/year (86%) among the total of 36,000 tons/year. The NOx emission from motor vehicles was 36,000 tons/year (67%) among the total of 54,000 tons/year. The PM emission from factories was 9,000 tons/year (71%) among the total of 13,000 tons/year. CO and HC emissions were solely calculated for motor vehicles as 290,000 tons/year and 73,000 tons/year respectively.

Table 3.1 Current Air pollution Load from Various Sources (1992)

(Unit: ton/year)

| | SOx | NOx | PM | CO | HC |
|---|---|---|---|---|---|
| Factories | | | | | |
| Power stations | 19,522 | 12,792 | 1,969 | - | - |
| General factories | 11,047 | 2,979 | 7,034 | | |
| Sub-total | 30,569 | 15,771 | 9,003 | - | - |
| | (85.7) | (29.0) | (71.4) | | |
| Motor vehicles | 3,117 | 36,212 | 3,243 | 290,407 | 73,445 |
| | ( 8.7) | (66.5) | (25.7) | (100) | (100) |
| Airplanes | 416 | 1,320 | 115 | - | - |
| | ( 1.2) | ( 2.4) | ( 0.9) | | |
| Ships | 1,552 | 989 | 200 | - | - |
| | ( 4.4) | ( 1.8) | ( 1.6) | | |
| Households | 0 | 162 | 44 | - | - |
| | ( 0.0) | ( 0.3) | ( 0.4) | | |
| Total | 35,654 | 54,454 | 12,605 | 290,407 | 73,445 |
| | (100) | (100) | (100) | (100) | (100) |

Figures in parenthesis are percentage values(%). Air pollutant emission from open burning activities and earthworks are not included in this Table.

PM emission from petrol and diesel vehicles is given in Table 3.2.

Diesel vehicles account for 59% of the total PM emission from motor vehicles.

Table 3.2 Current PM Emission from Petrol and Diesel Vehicles (1992)

| Engine Type | PM Emission (ton/year) | |
|---|---|---|
| Petrol | 1,327 | ( 40.9) |
| Diesel | 1,914 | ( 59.1) |
| Total | 3,241 | (100.0) |

## 3.2 Contribution to Concentration by Source

Using an air dispersion simulation model, annual average concentration of $SO_2$, $NO_2$ and CO at each monitoring station and mesh point was calculated. Contribution to SPM concentration by source was calculated by Chemical Mass Balance (CMB) method because no reliable simulation model for SPM has not been developed yet.

Contribution to concentration of $SO_2$ and NOx by source at each fixed station and the maximum concentration point is shown in Figs 3.1 and 3.2 respectively. Average contribution to SPM concentration by source is shown in Fig. 3.3.

(1) $SO_2$

The contribution ratio to the estimated value was 7 - 88% for factories and 7 - 71% for motor vehicles.

The contribution ratio of factories is higher than that of other sources at all points excluding City Hall.

(2) NOx

The contribution ratio of motor vehicles to the estimated value was very high at 44 - 98%.

(3) SPM

The major contributors to SPM are combustion of diesel oil (mainly diesel vehicles) accounting for 36% of the total, and wood combustion including open burning (15%).

Fig 3.1　Contribution of Sources to $SO_2$ Concentration (1992)

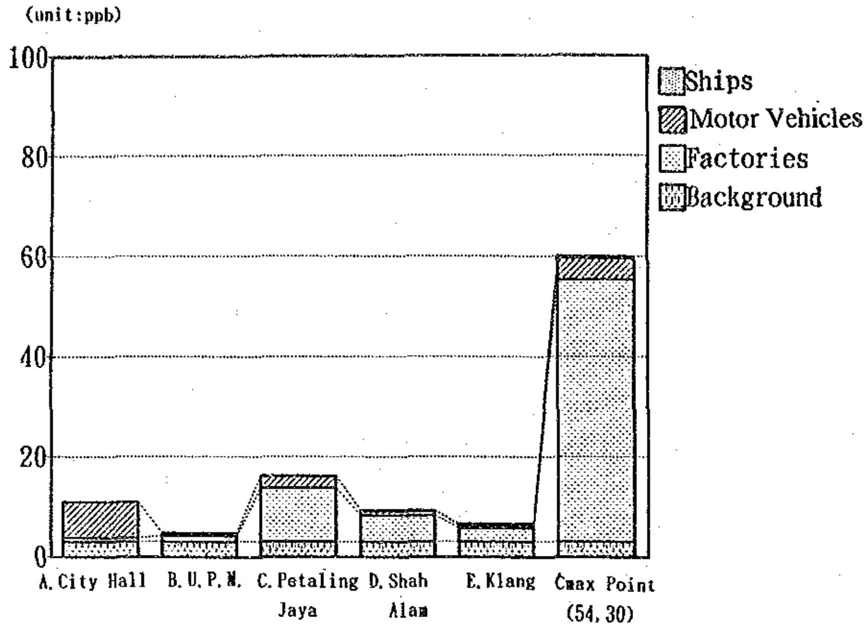



Fig 3.2　Contribution of Sources to NOx Concentration (1992)

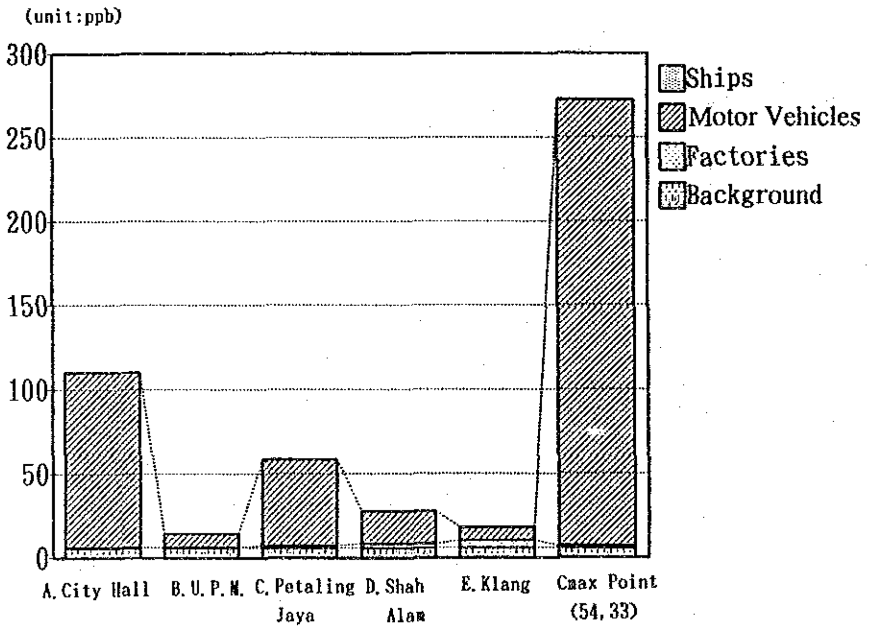
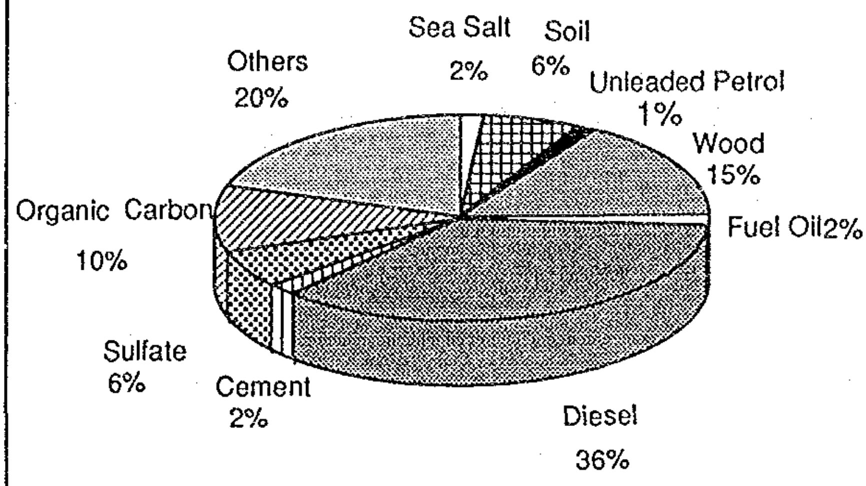


Fig 3.3 Average Composition of SPM




## 3.3 Regional Distribution of Air Pollutant Concentration

Regional concentration distribution simulated by air dispersion simulation for $SO_2$, $NO_2$ and CO is summarized as follows.

(1) $SO_2$

Concentration is high in Petaling Jaya area and in areas east of Klang. The Maximum concentration is 59.7 ppb, exceeding the air quality target value (20 ppb). The high concentration areas are located in the industrial zones in Petaling Jaya, Shah Alam, and Klang.

(2) $NO_2$

Concentration is high in Kuala Lumpur and Petaling Jaya areas where vehicle traffic is very dense. The maximum concentration is 41.1 ppb, exceeding the target value (37 ppb).

(3) CO

Concentration is high in Kuala Lumpur and Petaling Jaya areas where traffic volume is very high. The maximum concentration is 4.9 ppm, exceeding the target value (4 ppm).

## 4. Future Situation of Air Pollution

### 4.1 Future Air Pollution Load (2005) (without measures)

The air pollution load in the future (2005) (without measures) is summarized in Table 4.1.

The annual total emission is 52,000 tons for SOx, 115,000 tons for NOx, 18,000 tons for PM, 660,000 tons for CO, and 170,000 tons for HC.

The growth rate of air pollutants between 1992 and 2005 is 1.45 times for SOx, 2.12 times for NOx, 1.47 times for PM, 2.27 times for CO and HC.

Table 4.1 Future Air Pollution Load from Various Sources (2005) (without control measures)

(Unit: ton/year)

| | SOx | NOx | PM | CO | HC |
|---|---|---|---|---|---|
| Factories | | | | | |
| Power stations | 30,040 | 26,038 | 2,423 | - | - |
| General factories | 11,283 | 4,415 | 8,163 | | |
| Sub-total | 41,323<br>(80.1) | 30,453<br>(26.4) | 10,586<br>(57.2) | - | - |
| Motor vehicles | 7,079<br>(13.7) | 82,199<br>(71.3) | 7,359<br>(39.8) | 659,223<br>(100) | 166,720<br>(100) |
| Airplanes | 360<br>( 0.7) | 574<br>( 0.5) | 123<br>( 0.7) | - | - |
| Ships | 2,836<br>( 5.5) | 1,840<br>( 1.6) | 365<br>( 2.0) | - | - |
| Households | 0<br>( 0.0) | 226<br>( 0.2) | 62<br>( 0.3) | - | - |
| Total | 51,598<br>(100) | 115,292<br>(100) | 18,495<br>(100) | 659,223<br>(100) | 166,720<br>(100) |

Figures in parenthesis are percentage values(%). Air pollutant emission from open burning activities and earthworks are not included, but that from PS-C Power Station outside KVR is included in this Table.

### 4.2 Air Quality Target Value

Pollutants to be covered by the guidelines are mainly $SO_2$, CO, and $NO_2$ originated from factories and motor vehicles. Air quality target values were set to evaluate predicted air quality concentration in the future and effectiveness of control measures.

The target value for $SO_2$ and CO was established based on the Malaysian guidelines while that of $NO_2$ was established based on the corresponding WHO's guideline.

The target values set in the Study are given in Table 4.2.

Table 4.2 Air Quality Target Value

| Pollutant | Target Concentration |
|---|---|
| $SO_2$ | 20 ppb |
| $NO_2$ | 37 ppm |
| CO | 4 ppm |

## 4.3 Predicted Air Quality after Implementation of Control Measures

Predicted concentration for $SO_2$, NOx, $NO_2$ and CO at fixed stations and the maximum concentration point in 2005 when proposed control measures are implemented is shown in Table 4.3.

Table 4.3 Predicted Annual Average Concentration (2005)
(with control measures)

| Items / Stations | $SO_2$ (ppb) | NOx (ppb) | $NO_2$ (ppb) | CO (ppm) |
|---|---|---|---|---|
| A. City Hall | 9.2 | 85.2 | 22.2 | 2.20 |
| B. UPM | 4.5 | 20.7 | 10.5 | 1.19 |
| C. Petaling Jaya | 8.5 | 51.9 | 17.1 | 1.51 |
| D. Shah Alam | 8.7 | 44.7 | 15.8 | 1.33 |
| E. Klang | 6.1 | 27.1 | 12.1 | 1.21 |
| Cmax Point<br>Mesh Index | 19.0<br>(76,15) | 137.2<br>(58,40) | 28.6<br>(58,40) | 2.84<br>(59,38) |
| Target Value | 20 | - | 37 | 4 |

The concentration of $SO_2$, $NO_2$ and CO at fixed stations and the maximum concentration point will shift from the present state as shown in Figs. 4.1 through 4.3; the future state is described separately by the case whether proposed measures are implemented or not.

(1) $SO_2$

When no control measures are taken, $SO_2$ concentration will rise in the future according to the increase of emission quantity. However, by taking proper control measures, the concentration at fixed stations will remain at the present level, and the target value will be achieved at all points in Kelang Valley Region.

(2) $NO_2$

$NO_2$ concentration will increase as well when no measures are taken. But, when proper measures are taken, the concentration at fixed stations will remain at the present level or below, and the target level will be satisfied at all points.

(3) CO

CO concentration will also increase in the future when no measures are taken. However, when proper control measures are taken, the concentration at fixed stations will remain at the present level or below, and the target level will be satisfied at all points.

Fig 4.1 Change of $SO_2$ Concentration from 1992 to 2005

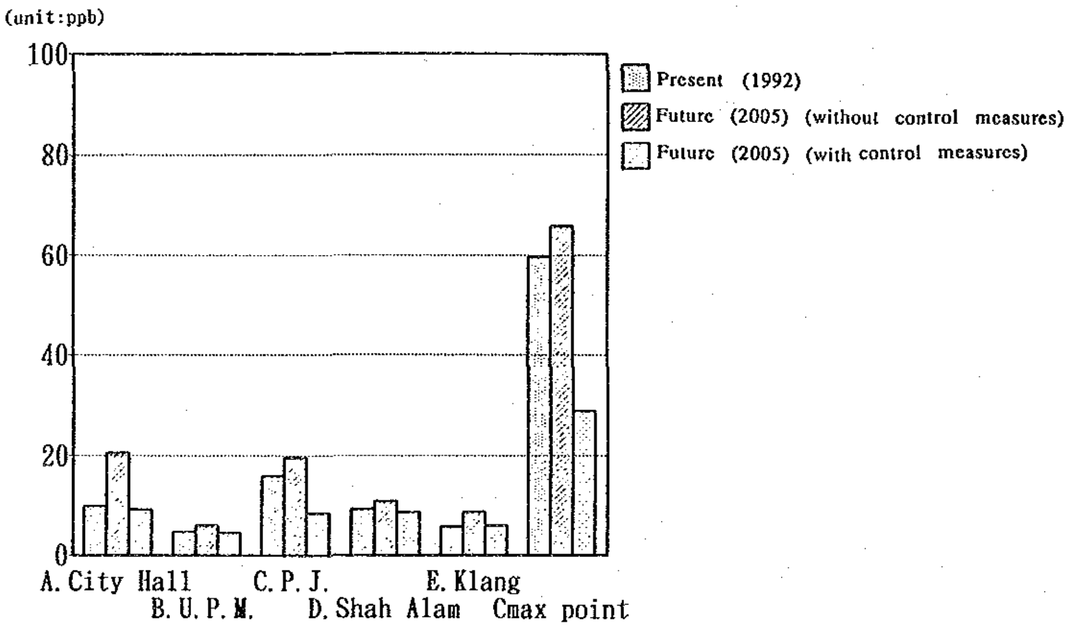


Fig. 4.2 Change of $NO_2$ Concentration from 1992 to 2005

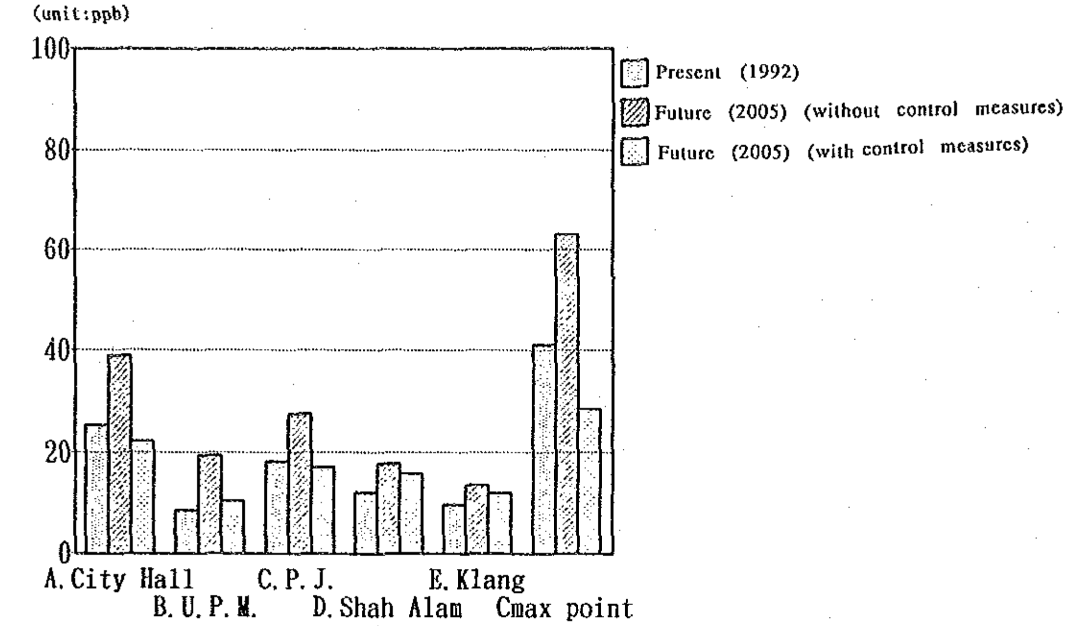
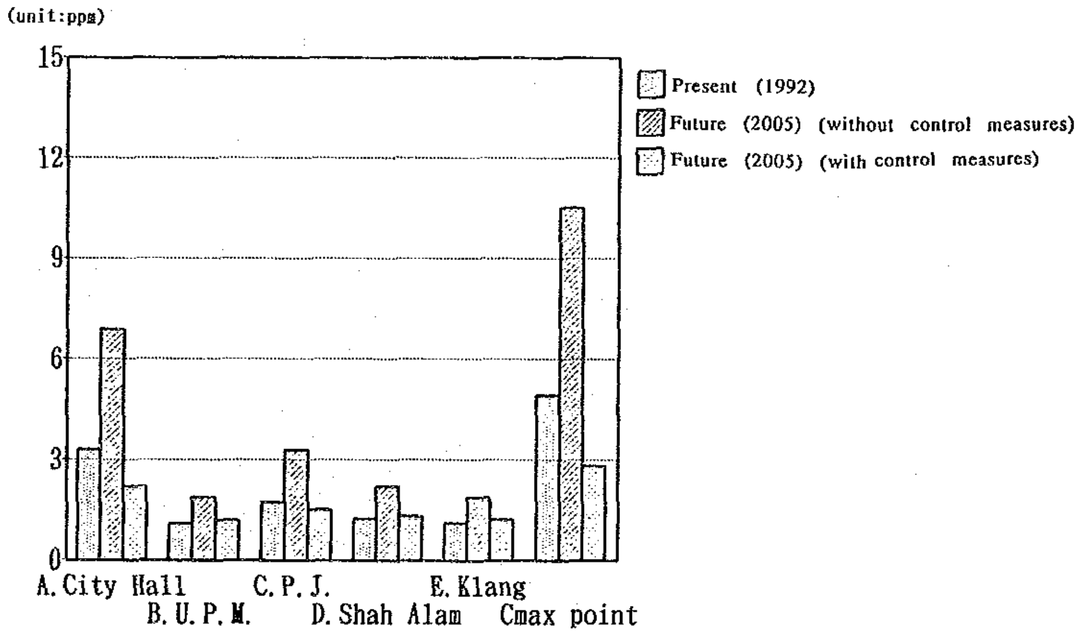



Fig. 4.3 Change of CO Concentration from 1992 to 2005



## 4.3 Evaluation of Control Measures

The major pollution source of $NO_2$ and CO are motor vehicles in Kelang Valley Region. Control measures against motor vehicles are classified into two categories as follows.

(1) Exhaust gas regulation

(2) Measures for traffic and transportation

For vehicle exhaust gas regulation, the Government of Malaysia is to implement Regulation 91/441/EEC for light duty petrol vehicles.

For traffic and transportation, it has been implementing the "Transportation Master Plan for 2005" proposed in Klang Valley Transportation Study by JICA, 1989.

In order to evaluate the effect of these two measures on $NO_2$ and CO concentrations, the following two cases were assumed and studied.

Case 1

Only the Transportation Master Plan is completed by 2005.

Case 2

Only Regulation 91/441/EEC is implemented in 1995.

The results are summarized in Table 4.4.

In Case 1, CO concentration at the maximum concentration point will exceed the target value. In Case 2, the $NO_2$ concentration at the maximum concentration point will exceed the target value. The CO concentration at City Hall and at the maximum concentration point will also exceed the target value.

These case studies show that if the target values for $NO_2$ and CO are to be satisfied throughout Kelang Valley Region, both measures, namely the vehicle exhaust gas regulation and the measures for traffic and transportation must be implemented simultaneously.

Table 4.4 Computed Concentration with Control Measures by Case

| Control Measure Case | Case 1 | | Case 2 | |
|---|---|---|---|---|
| Items / Stations | $NO_2$ (ppb) | CO (ppm) | $NO_2$ (ppb) | CO (ppm) |
| A. City Hall | 24.3 | 3.5 | 35.7 | 4.2 |
| B. UPM | 11.7 | 1.7 | 11.1 | 1.3 |
| C. Petaling Jaya | 19.3 | 2.2 | 24.1 | 2.1 |
| D. Shah Alam | 17.8 | 1.9 | 15.7 | 1.5 |
| E. Klang | 13.3 | 1.7 | 12.3 | 1.3 |
| Cmax Point<br>Mesh Index | 32.1<br>(57,34) | 4.6<br>(59,38) | 53.2<br>(54,33) | 6.3<br>(59,37) |

## 5. Presentation of Guideline for Air Quality Management

### 5.1 Basic Conditions

The Department of Environment has made efforts to prevent air pollution in Kelang Valley Region since the Environmental Quality Act was published in 1974. According to the result of the air quality monitoring at 5 fixed stations, however, concentration of carbon monoxide (CO) and suspended particulate matter (PM10) exceeded the air quality guideline at Shah Alam. Particularly, concentration of ozone ($O_3$) exceeded the guideline at all stations.

Malaysia is one of the most significantly developing countries in the world. Its average annual GDP growth rate is amazingly 6.7% from 1971 to 1990 and is expected to be 7.0% between 1991 - 2000. This economic growth is particularly apparent in urban area. The atmospheric deterioration of the KVR is foreseeable from its industrialization, population concentration, traffic growth and so on.

In order to protect the health of the citizens and to preserve the comfortable living environment, air quality management for the Region is indispensable.

## 5.2 Proposed Measures

### (1) General Consideration

Measures for air quality management should cover not only direct control of pollution sources (factories, motor vehicles, etc.), but also *their background conditions*, such as improvement of traffic and transportation, and road network, rationalization of land use, fuel improvement. They also should cover improvement of institutional and organizational framework and manpower training and improvement of air quality and pollution source monitoring.

Following measures were recommended to prevent the atmospheric deterioration with almost no adverse effects on economic growth. These measures are considered to be practical measures for implementation by the concerned agencies of the Malaysian Government. The proposed measures, their rough costs and their implementation schedule are summarized in Tables 5.1 through 5.3.

### (2) Stationary Sources

- Power Station

  Power Stations in KVR emitted 55% of total SOx, 24% of total NOx and 16% of total PM in 1992. Fuel conversion (fuel oil or coal to natural gas) was recommended as the practical measure. It will contribute to reduction of pollutant amount in comparison with the case of "2005 without measures": SOx 42%, NOx 13% and PM 66%.

- General Factories

  Genera factories emitted 31% of total SOx, 5% of total NOx and 55% of total PM in 1992. Six kinds of measures as follows were recommended. The effect of the measures will be 53% of SOx, 0.1% of NOx and 33% of PM reductions respectively. Proper combustion management will lead to energy saving and pollutant emission reduction. Energy saving by the proposed combustion management, etc. will lead to 10% reduction in fuel consumption.

  - Fuel conversion (fuel oil to light fuel oil/natural gas)
  - Combustion management
  - Use of natural gas (new facilities)

- Energy saving
- Enhancement of dust removal
- Extension of stacks

- Solid Waste Management System

  The Study could not deal adequately with open burning of solid wastes and others directly because of scant information about this practice. But its effect on air pollution in KVR can not be ignored. Though open burning is principally illegal, it is prevalent with solid wastes. Establishment of solid waste management system could reduce open burning to a considerable extent.

(3) Mobil Sources

Motor vehicles are the major pollution source among mobile sources in KVR.

The major source is motor cars for CO and NOx, diesel vehicles for PM and SOx, and motorcycles for CO and HC. Accordingly, following measures were recommended, based on the type of vehicle.

- Exhaust Emission Control

  - Installation of catalytic converters to petrol vehicles

    Oxidation catalytic converter can reduce 51% of CO 17% of NOx and 59% of HC from petrol vehicles.

  - Introduction of four stroke motorcycles

    The four stroke motorcycle emit only 14% of PM, 18% of HC, 42% of CO and 58% of SOx in comparison with the two stroke motorcycle.

  - Smokeless lub oil for two stroke motorcycles

    The use of smokeless lube oil into the two stroke motorcycle can reduce black smoke.

  - Quality control of fuel

    Use of unleaded petrol is necessary for oxidation catalytic converter. Reduction of sulphur content in diesel oil from 0.3% to 0.2% is necessary for reduction of SOx and PM.

- Restriction of light duty diesel vehicles

  Restriction of diesel vehicles is very important to reduce PM and SOx emission. To begin with, the restriction of light duty diesel vehicles, initially targeting taxies and commercial vehicles was recommended.

• Execution of Transportation Master Plan by 2005(*)

  The Transportation Master Plan was prepared to improve the traffic situation in KVR, where the transportation system is exceedingly dependent on motor vehicles, and hence to mitigate the traffic congestion in the Region. The simulated result showed that it will play quite a significant role in mitigating air pollution. Therefore, the realization of this master plan in time, as scheduled is quite essential for improving the air quality in the Region.

  * Source: JICA (1989), Klang Valley Transportation Study

  If the exhaust gas regulation for petrol vehicles and the Master Plan are implemented, vehicular pollutant emission of SOx, NOx, PM, HC and CO in the case of "2005 with control measure" will be reduced by 19%, 32%, 35%, 38% and 51% respectively in comparison with the case of "2005 without measures".

(4) Institution and Organization

In order to implement the countermeasures smoothly and to confirm their effectiveness, following supporting actions are essential.

1) Strengthening of DOE's capacity in institution and organization

DOE is one of the most important organizations concerned to air pollution control in KVR. However, shortage of staff is a serious problem at present which may worsen in future. In order to strengthen DOE, recruiting the qualified manpower and staff is a matter requiring urgent consideration.

2) Installment of ambient air quality and source monitoring systems

During the Study, five fixed stations and two monitoring cars were set up in KVR. However they are not adequate to monitor ambient air quality effectively. Eleven fixed stations, 20 mobile stations in all were recommended to be installed by 2005. Vehicle exhaust gas monitoring system with chassis dynamometers and flue gas measurement system for stationary source monitoring were also recommended.

3) Establishment of a combustion management system.

It was proposed to establish a regulation system which aims at controlling the combustion in factories with dual objectives of ambient air pollution control and energy conservation. It is also necessary to establish a system which subsidizes the activities relating to air pollution control.

4) Car Inspection System

It was proposed to establish a car inspection system which aims to keep in-use vehicles in good condition, which will lead to reduce air pollutant emission from them.

5) Foundation of Comprehensive Air Pollution Control Center

Considering the shortage in qualified engineers to participate in the activities for controlling air pollution at present in the country, it is necessary to train such engineers as soon as possible prior to the implementation of the measures which the Study proposed in the guidelines. In order to increase the number of such engineer, it was proposed to establish "the Comprehensive Air Pollution Control Center" in the earliest stage of the implementation. The center will consist of four centers as follows.

- Ambient Air Quality Central Monitoring Center
- Combustion Training Center
- Ambient Air Quality Monitoring Training Center
- Pollution Source Monitoring Center

The shortage of senior engineers for training such engineers is also a serious problem in the country. Such specialists and experts required for training the national engineers shall be supplemented with foreign expertise as required.

Table 5.1 (1) Implementation Plan of Measures against Air Pollution in Kelang Valley Region (Stationary Sources)

| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Cost Estimate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stationary Sources** | | | | | | | | | | | | | | | |
| **(1)Power Station** | | | | | | Operation | | | | | | | | | |
| **1) "A" Power Station** | | | | | | | | | | | | | | | |
| No.1(M.F.O,300Mw) | | | Fuel conversion M.F.O to N.G.(for SOx & SPM reduction) | | | | | | | | | | | | - |
| No.2(N.G. ,300Mw) | | | | | | | | | | | | | | | - |
| No.3(Coal,300Mw) | | | | Improvement of Electric Precipitatior's Efficiency | | | | | | | | | | | - |
| No.4(Coal,300Mw) | | | | | | | | | | | | | | | - |
| No.5(Coal ,500Mw) | | | | | | | | | | | | | | | - |
| No.6(Coal, 500Mw) | | | | | | | Fuel conversion coal to N.G.(for SOx & SPM reduction) | | | | | | | | - |
| No.7(N.G., 500Mw) | | | | | | | | | | | | | | | - |
| **2) "B" Power Station** (N.G. 840MW) | | 900MW | | | | | | Unnecessary measures | | | | | | | - |
| **3) "C" Power Station** (N.G.) | | | | | | | | Unnecessary measures | | | | | | | - |
| **(2)Factory** | | | | | | | | | | | | | | | |
| 1)Cement Factory | | | Improvement of Electric Precipitators' efficiency | | | | | | | | | | | | - |
| 2)General Factories | | | Fuel conversion (HFO to N.G) (Facilities with more150kg/h of M.F.O combustion in Petaling Jaya &Shah Alam) | | | | | | | | | | | | M$2.9 million |
| | | | Fuel conversion (MFO to L.F.O) (Facilitiese with more 200kg/h M.F.O combustion in other areas) | | | | | | | | | | | | - |
| | | | | | | Use of natural gas(new facilities) | | | | | | | | | |
| | | | Dust collector (Cyclon) 3 factories | | | | | | Dust collector (Cyclon) 3 factories | | | | | | M$3.0 million |
| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | |

Table 5.1 (2) Implementation Plan of Measures against Air Pollution in Kelang Valley Region (Stationary Sources)

| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Cost Estimate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Raise of stack height | | | | | | | | | | M$0.2 million |
| | | | | | | | Replacement of wood combustion boiler | | | | | | | | M$3.1 million |
| | | | | | | | Combustion management | | | | | | | | - |
| | | | | Energy saving | | | | | | | | | | | - |
| **(3)Combustion Training Center** | | | | | | | | | | | | | | | M$5.7 million |

Table 5.2 Implementation Plan of Measures against Air Pollution in Kelang Valley Region (Mobile Sources)

| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Cost Estimate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1. Motor Vehicles** | | | | | | | | | | | | | | | - |
| **(1) Emission Control** | | | | | | | | | | | | | | | - |
| **1)Combustion Improvement of Motorcycle** | | | | | | | | | | | | | | | - |
| a) Shift from 2-cycle M/C to 4-cycle M/C | | | | | | | | Almost Completion | | | | | | | 10% cost up |
| b) Use of Smokeless Lube Oil | | | Preparation | | | | Supply and regulation | | | | | | | | M$20/liter (40% cost up) |
| **2) Application of EC Regulation** a) Motor Car | | ECE15-04 | | | | 91/441/EEC | | | | | | 3-way catalytic converter | | | Oxidation catalytic converter M$1,400/unit cost up |
| **3) Restriction of Diesel Motor Vehicles** | | | Shift from diesel taxi to petrol taxi | | | | | | | | | | | | - |
| **4) Introduction of CNG Taxi** | | | | | | | | | | | | | | | - |
| **(2) Fuel Control** | | | | | | | | | | | | | | | |
| **1) Unleaded fuel** | using ratio 50% | | using ratio 80-90% | | | | | | | | | | | | - |
| **2) Low Sulphur Diesel Fuel** | Sulphur content 0.32% | | Sulphur content 0.2% | | | | | | | | | | | | - |
| **(3) Trafic control** | | | | | | | | | | | | | | | |
| **1) Mass Rapid Transit Railway System (MRT)** | | | | | | | | | | | | | | | - |
| **2) Improvement of Bus System** | | | | | | | | | | | | | | | |
| **3) Road Net Work Plan** | | | | Transportation Master Plan in 2005 Source; JICA (1987): " KELANG VALLEY TRANSPORTATION STUDY" | | | | | | | | | | | |
| **2. Organization & Institution for Motor Vehicles** | | | | | | | | | | | | | | | - |
| **(1) Car Inspection System** | | | | | | | | | | | | | | | M$9.0 million |
| **(2) Introduction of Flexitime System** | | | | | | | | | | | | | | | - |

Table 5.3 Implementation Plan of Air Pollution Monitoring in Kelang Valley Region
(Ambient Air Quality and Air Pollution Source Monitoring)

| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | Cost Estimate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1. Ambient Air Quality Monitoring** | | | | | | | | | | | | | | | |
| **(1) Fixed Station** | | | | | | | | | | | | | | | |
| 1) Residential Area | | | | | | | | | | | | | | | |
| a) UPM | | | ○ Replacement | | | | | | | | | | | | M$2.11mil. |
| b) P.J. | ● | | | | | | ○ | | | | | | | ○ | M$2.69mil. |
| c) S.A. | ● | | | | | | ○ | | | | | | | ○ | M$2.69mil. |
| d) Klang | | ○ | | | | | | | ○ | | | | | | M$2.11mil. |
| 2) Road Side | | | | | | | | | | | | | | | |
| a) City Hall | | ○ | | | | | | | ○ | | | | | | M$2.69mil. |
| b) New station | | | | ● | | | | | | | ○ | | | | M$1.65mil. |
| c) New station | | | | | ● | | | | | | | ○ | | | M$1.62mil. |
| d) New station | | | | | | ● | | | | | | | ○ | | M$1.59mil. |
| 3) High Concentration Area | | | | | | | | | | | | | | | |
| a) New station | | | | ● | | | | | | | ○ | | | | M$1.56mil. |
| b) New station | | | | | ● | | | | | | | ○ | | | M$1.52mil. |
| c) New station | | | | | | ● | | | | | | | ○ | | M$1.48mil. |
| **(2) Mobile Station** | | | | | | | | | | | | | | | |
| 1) Existing Monitoring Car | | | | | | | | | | | | | | | |
| No.1 | ● | | | | | | | ○ | | | | | | | M$2.44mil. |
| No.2 | ● | | | | | | | | ○ | | | | | | M$2.44mil. |
| 2) New Monitoring Car | | | | | | | | | | | | | | | |
| No.3 | | | ● | | | | | | | ○ | | | | | M$4.32mil. |
| No.4 | | | | ● | | | | | | | ○ | | | | M$4.28mil. |
| **Total** | | | | | | | | | | | | | | | M$35.19mil. |
| **2. Air Pollution Source Monitoring** | | | | | | | | | | | | | | | |
| (1) Factory Existing | | | | | | | | ○ | | | | | | | |
| new | | | | ● | | | | | | | ○ | | | | M$ 0.24 mil. |
| (2) Motor Vehicle | | | ● | Instration of Chasiss Dynamometer | | | | | | | | | | | M$ 4mil.(Petrol) M$ 8 mil.(Diesel) |
| **3. Central Monitoring Center** | | | | | | | | | ● | | | | | | M$ 35.2 mil. |
| **4. Training Center** | | | | | | | | | | | | | | | |
| (1) Ambient Air Quality Monitoring Training Center | | - - - | | | | | | | | | | | | | M$ 0.76 mil. |
| (2) Pollution Source Monitoring Training Center | | - - - | - - - | | | | | | | | | | | | - |

## 6. Future Requirements

- Publishment of enforceable air quality standards

  Malaysian Air Quality Guidelines (1989) actually don't have any legal enforcement. Hence, it is necessary to establish Ambient Air Quality Standards to control air pollution fundamentally.

- Study of air pollution effects on public health and ecosystem

  According to the result of ambient air quality monitoring in KVR, there may be some people whose health is affected due to air pollution in KL, Shah Alam or Petaling Jaya. It is important to study such air pollution effects on health in particular and ecosystem in general.

- Reconstruction of the simulation model

  The simulation result in the Study was based on only one year data. Hence, it is necessary to check the validity of the simulation model after accumulation of air quality and source data for two to three years period.

- Development of simulation model for SPM and HC

  Though simulation model for air pollution can apply only to $SO_2$, $NO_2$ and CO so far, development of new simulation models for SPM and HC is expected in future in order to make their quantitative assessment.

- Accurate survey of air quality in high pollution areas and on road sides

  The objective of the Study was to clarify the overall situation of the air pollution in and around the city of KL, but not at any particular local point or an area in the city. It is difficult to clarify the local air pollution by the method and the model applied for the simulation. The results of this simulation does not indicate the local situation of any small spot or strip even when the pollution situation thereof exceeds the target value. For instance, pollutant concentration along main roads with heavy traffic may exceed the air quality guidelines. Therefore, the measures proposed herein for 2005 may not guarantee improvement of such local pollution situation. A more detailed study in each area is necessary to identify the pollution situation of such areas. For this objective, the data obtained by the proposed monitoring system can be effectively utilized.

- Study of haze causes

Though the Study did not aim to clarify the cause of haze in the Region, ambient SPM samples were collected and analyzed. However, no haze was observed during the survey period. Nevertheless, it is recommended to carry out study on haze, centering on its chemistry.

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## Glossary of Abbreviations

| | |
|---|---|
| 1ry | primary |
| 2ry | secondary |
| 8HAV | 8 Hour Average Value |
| | |
| AAGR | Actual Average Annual Growth |
| ADB | Asian Development Bank |
| A/F | Air Fuel Ratio |
| Af | Tropical Rainforest Climate |
| AI | Secondary Air Injection System |
| AMV | Annual Mean Value |
| AQM | Air Quality Management |
| AS | Secondary Air Suction System |
| Auxil (Aux) | Auxiliary |
| | |
| Cf | Referred to (Numbered, Corresponded Article of Item) |
| CH | City Hall |
| $CH_4$ | Methane |
| CLD | Chemiluminescence |
| CMB | Chemical Mass (or Element) Balance |
| CNG | Compressed Natural Gas |
| CO | Carbon Monoxide |
| CONC | Concentration or Concentrated |
| COP | Conformity of Product |
| CVS | Constant Volume Sample |
| C-zone | smallest segment of an area, especially in traffic |
| | |
| DAHV | Daily Average of Hourly Value |
| deg.C | difference of two centigrade temperatures |
| De- | removal of -- |
| DF/R | Draft Final Report |
| DOC | Department of Chemistry, MSTE |
| DOE | Department of Environment, MSTE |
| DP | Dash Pot System |
| DPF | Diesel Particulate Filter |
| DR | Differential Growth Rate |

| | |
|---|---|
| EC | European Community |
| ECE(EEC) | European Economic Community |
| E.F. | Emission Factor |
| EFI | Electronic Fuel Injection System |
| EGR | Exhaust Gas Recycle |
| EIA | Environment Impact Assessment |
| EM | Engine Modification |
| EP | Electrostatic Precipitator |
| EPA | Environmental Protection Agency of the U.S.A. |
| EPU | Economic Planning Unit, Prime Minister's Department |
| EQA | Environmental Quality Act |
| ESP | Electrostatic Precipitator |
| ETBE | Ethyl Tertiary Butyl Ether |
| EVAP | Fuel Evaporation Control System |
| FGD | Flue Gas Desulfurization |
| F. H. | *Federal Highway* |
| FID | Flame Ionization Detection Gas Chromatography |
| Fig. | Figure |
| FO | Fuel Oil |
| FT | Federal Territory |
| F/R | Final Report |
| GDP | Growth Domestic Product |
| GRDP | Gross Regional Domestic Product |
| GRT | Gross Tonnage |
| GVW | Gross Vehicle Weight |
| HC | Hydrocarbons |
| HCs | Analyzer measuring NMHC, THC and $CH_4$ separately |
| HFO | Heavy Fuel Oil |
| IC/R | Inception Report |
| IDO | Industrial Diesel Oil |
| IFO | Industrial Fuel Oil |
| IMP | Industrial Master Plan |
| IT/R | Interim Report |

| | |
|---|---|
| J | Japan |
| JACTIM | Japan Chamber of Trade and Industry, Malaysia |
| JEA | Japan Environment Agency |
| JICA | Japan International Cooperation Agency |
| JIS | Japanese Industrial Standards |
| JKR | Jabatan Kerja Raya (District Public Works Department) |
| Jln | Jalan (Street) |
| | |
| KL | Kuala Lumpur |
| HL. S | KL-Serembar (Expressway) |
| HL.K | KL-Karal (Highway) |
| KPA | Klang Port Authority |
| KTM | Keretapi Tanah Malayu (Malayan Railway) |
| KVEIP | Kelang Valley Environmental Improvement Project |
| KVPP | Kelang Valley Perspective Plan |
| KVPS | Kelang Valley Planning Secretariat |
| KVR | Kelang Valley Region |
| KVTS | Klang Valley Transportation Study (#6007) |
| | |
| L | Long Term |
| LFO | Light Fuel Oil |
| LNB | Low NOx Burner |
| LPG | Liquefied Petroleum Gas |
| LRT | Light Rail Transit or Light Rapid Train |
| | |
| M$ | Malaysian Ringgit (Malaysian Dollar) 50 Yen (1992 prio) |
| MAQG | Malaysian Air Quality Guidelines |
| MFO | Middle Fuel Oil |
| MIC | Manufacturing Industry Code |
| MIER | Malaysian Institute of Economic Research |
| MMS | Malaysian Meteorological Service |
| MP | Malaysia Plan (such as 5MP = the fifth MP) |
| MRT | Mass Rapid Transit |
| MSTE | Ministry of Science, Technology and Environment |
| MTBE | Methyl Tertiary Butyl Ether |
| M/C | Motor Cycle |

| | |
|---|---|
| N | Nitrogen or Gas at normal condition such as $m^3N$, $Nm^3$ |
| NDIR | Non-Dispersive Infrared Absorption |
| NG | Natural Gas |
| NMHC | Non-Methane Hydrocarbons |
| NO | Nitrogen Monoxide |
| NOx | Nitrogen Oxides |
| NOxs | Analyzer measuring $NO_2$, NOx and NO separately |
| $NO_2$ | Nitrogen Dioxide |
| N.R. | Net Radiation |
| | |
| OC | Oxidation Catalyst |
| OD | Origin/Destination of Traffic |
| OPP | Outline Perspective Plan |
| $O_2$ | Oxygen |
| $O_3$ | Ozone |
| | |
| P | Pasquill's Atmospheric Stability Number |
| P.a. | Preannum |
| $PbO_2$ | Lead dioxide method for $SO_2$ simplified measurement |
| PCR | Preliminary Count Report |
| PCV | Positive Crankcase Ventilation System |
| PETRONAS | Petroliam Nasional Berhad |
| PFBC | Pressurized Fluidized Bed Combustion |
| P-G | Pasquill Gifford |
| PG- | code for fuel; see Appendix |
| PIB | Poly Iso Butylene |
| PJ | Petaling Jaya |
| PM | Particle Matter |
| PMG | Premium Motor Gasoline |
| $PM_{10}$ | Inhalable Particulate |
| PORIM | Palm Oil Research Institute of Malaysia |
| ppb | parts per billion |
| ppbC | parts per billion Carbon |
| pphmC | parts per hundredth million Carbon |
| ppm | parts per million |
| PR/R | Progress Report |
| PS- | code for Power Station A, B or C |

| | |
|---|---|
| RMG | Regular Motor Gasoline |
| RTD | Road Transport Department |
| RW | Reference Weight |
| S | Short Term |
| SA | Shah Alam |
| SC | Ignition Timing Control System |
| SCFT | Standard Cubic Feet |
| SGR | Self Gas Recirculation |
| SIRIM | Standards and Industrial Research Institute of Malaysia |
| SOF | Soluble Organic Fraction |
| SOx | Sulphur Oxides |
| | |
| TNB | Tenaga Nasional Berhad |
| TP | Throttle Postioner System |
| TSP | Total Suspended Particulate Matter |
| TV | Traffic Volume |
| TWC | Three Way Catalyst |
| | |
| UM | Universiti Malaya |
| UPM | Universiti Pertanian Malaysia |
| UV | Ultraviolet Fluorescence |
| W.D. | Wind Direction |
| WHO | World Health Organization |
| W.S. | Wind Speed |

# CHAPTER 1 INTRODUCTION

# CHAPTER 1 INTRODUCTION

## 1.1 Background and Objective of the Study

### 1.1.1 Background of the Study

Kelang Valley Region (2,830 $km^2$, about 2.95 million people) consisting of Kuala Lumpur (the capital of Malaysia) and its vicinity has been experiencing worsening air pollution in recent years as a result of the rapid growth of traffic volume, urbanization and industrial activities.

The Department of Environment of Ministry of Science, Technology and Environment (DOE) started ambient air quality monitoring in the late 1970s, centering on suspended particulate (TSP), carbon monoxide (CO), sulphur dioxides ($SO_2$) and ozone ($O_3$). And in 1984 automatic monitoring systems for SPM, CO, $SO_2$, $O_3$ and NOx (nitrogen oxide) were installed at three sites by the University Pertanian Malaysia (UPM). But DOE has not established a basic system necessary for air pollution control yet.

Malaysia is expected to further develop its national economy, which will necessitate more efficient and effective anti-pollution steps. In this context, an air pollution control plan is required to prevent air pollution problems.

Under a technical assistance grant from the Asian Development Bank (ADB) to the Government of Malaysia, the Kelang Valley Environmental Improvement Project (KVEIP) was carried out over a period from August 1986 to April 1987. This survey included the formulation of a preliminary Air Quality Management (AQM) plan as one of its project components, and recommended the preparation of a detailed AQM plan and its implementation.

Upon this recommendation, the Government of Malaysia asked the Government of Japan in January 1989 for technical cooperation to conduct a study on the present state of air pollution, air pollution control, improvement of air quality monitoring system and formulation of an air pollution control plan in the Kelang Valley Region, and training of engineers in DOE through the study.

In response to this request, the Government of Japan decided to conduct an Air Quality Management Study for Kelang Valley Region (hereinafter referred to as "the Study"). Accordingly, Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched a preliminary survey team to Malaysia in March 1990 and both JICA and the representative of Economic Planning Unit on behalf of the Government of Malaysia agreed to the Scope of the Work for the Study, on which basis the Study was conducted. The Study was undertaken from December 1991 to August 1993. This report describes the results of the Study.

### 1.1.2 Objective of the Study

The Study aimed to prepare an implementable guideline for air quality management for Kelang Valley Region with special emphasis on improving air quality monitoring capability, identification of major pollution sources, prediction of future air pollution and recommendation of feasible control measures. At the same time, the Study was expected to contribute to tangible technology transfer to Malaysian counterparts and the formulation of manpower training programs.

## 1.2 Outline of the Study

(1) Study Area

The Study area is Kelang Valley Region which is shown in Fig. 1.2.1. It is approximately 60 km from east to west and 40 km from south to north, consisting of the Federal Territory (Kuala Lumpur) and Klang, Petaling, Gombak and Hulu Langat of Selangor State.

(2) Scope of the Study

The Study work was executed in Kelang Valley Region and Japan. As shown in Fig. 1.2.2, the Study included a basic study and an analytical study.

1) Basic Study

a) Collection of Existing Data

- Meteorology and climate
- Ambient air quality
- Stationary sources: factories and establishments, and households
- Mobile sources: motor vehicles, airplanes and ships

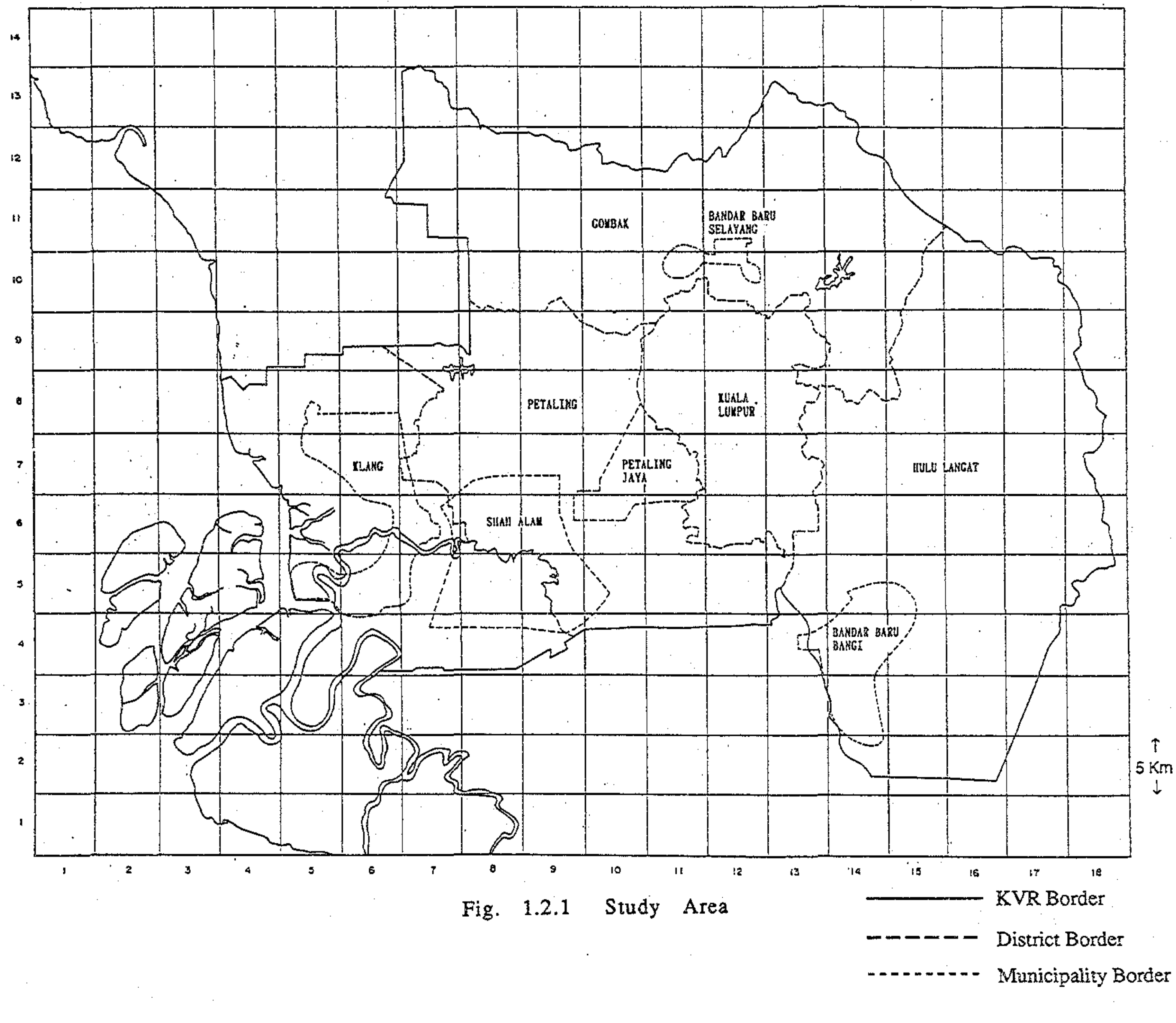


Fig. 1.2.1 Study Area

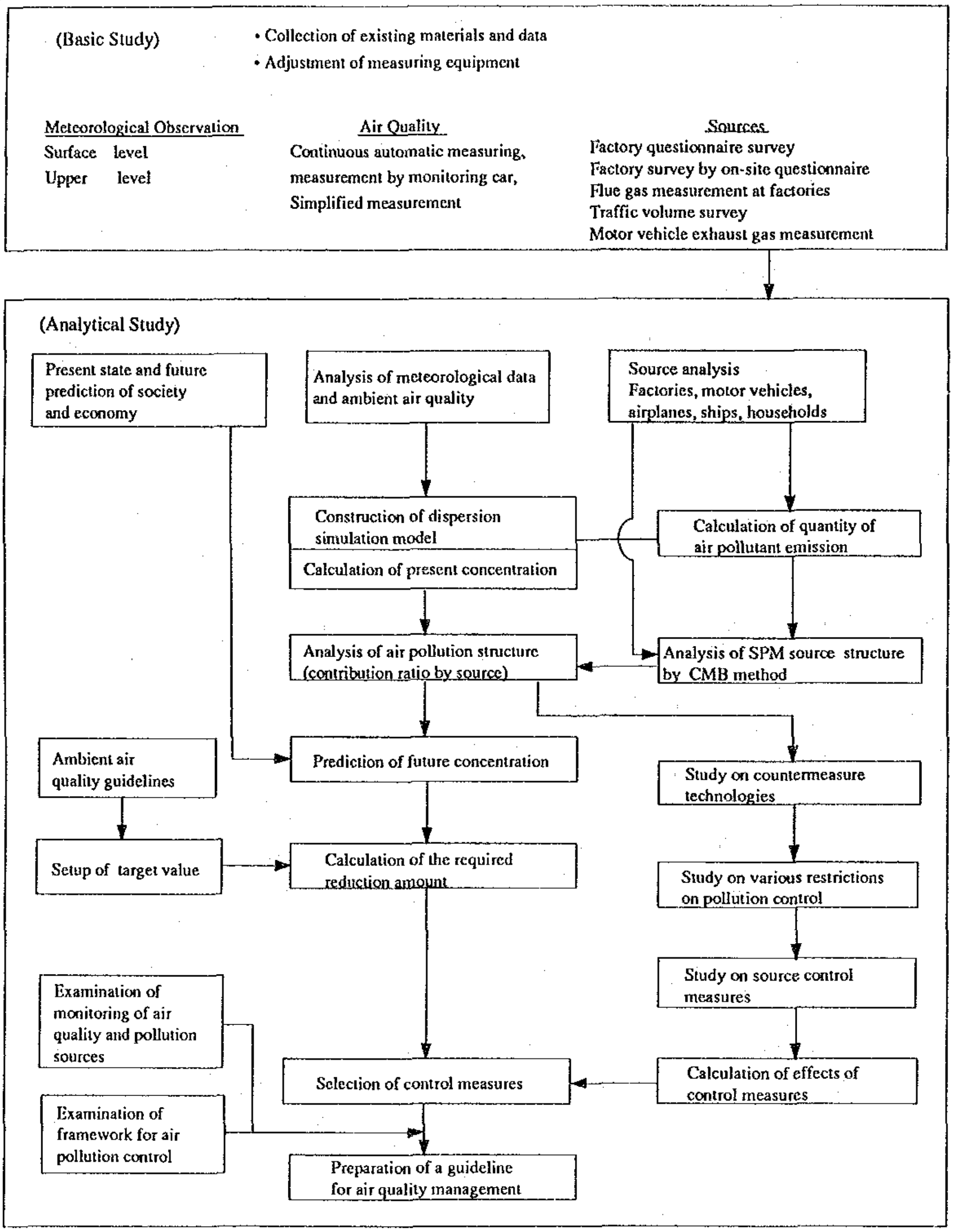


Fig. 1.2.2 Outline of the Study

- o Socio-economic conditions
- o Pollution control measures
- o Air pollution control: laws, regulations, standards and guidelines

b) Installation and Adjustment of Measuring Equipment

- o Ambient air quality monitoring
  - continuous measurement
  - simplified measurement
- o Meteorological observation
  - surface level meteorology
  - upper level meteorology
- o Factory flue gas measurement
- o Vehicle exhaust gas measurement at idling state

c) Field Investigation

- o Surface level meteorology
  - wind direction and wind speed
  - solar radiation and net radiation
- o Upper level meteorology
  - vertical profile of wind direction, wind speed and temperature
- o Ambient air quality
  - continuous measurement at fixed and mobile stations ($SO_2$, NO, $NO_2$, NOx, SPM, CO, NMHC, $CH_4$, THC and $O_3$)
  - simplified measurement in wide area ($SO_2$, $NO_2$ and NOx)
  - simplified measurement across roads (CO)
  - ambient SPM sampling
- o Factories and establishments
  - questionnaire survey (facility type, fuel consumption and stack)
  - on-site questionnaire survey (facility, operation and air pollution control)
  - flue gas measurement (Dust, $SO_2$, NOx, $O_2$ and flue gas volume)
  - analysis of fuel components
- o Motor vehicles
  - traffic volume survey
  - travel speed survey
  - exhaust gas measurement by chassis dynamometer test (HC, CO, NOx and fuel economy)
  - exhaust gas measurement at idling state (HC, CO and NOx)
  - analysis of fuel components

d) Implementation of air dispersion simulation system in MMS computer

2) Analytical Study

- o Analysis of socio-economic conditions
  - society, population, economy, industry, land use, transport and energy
- o Analysis of air pollution control
  - laws, regulations, standards, guidelines and administrative organizations
- o Analysis of meteorological data
  - surface level meteorology
  - upper level meteorology
- o Analysis of ambient air quality
  - continuous monitoring data at fixed and mobile stations
  - measurement data by simplified method
- o Analysis of pollution sources and estimation of pollution load
  - stationary sources (factories and establishments, and households)
  - mobile sources (motor vehicles, airplanes and ships)
- o Development of air dispersion simulation model and analysis of air pollution structure ($SO_2$, $NO_x$, $NO_2$ and CO)
  - construction of air dispersion simulation model
  - calculation of regional pollutant concentration
  - contribution to concentration by sources
- o SPM component analysis by CMB method
  - PM component of emission sources
  - SPM components of ambient air
  - contribution to SPM by sources
- o Prediction of air quality in the future and estimation of required reduction amount of air pollution load
  - prediction of air pollution load from sources
  - prediction of ambient air quality
  - setting of air quality target value
  - reduction amount of air pollution load
- o Study of air pollution control
  - control measures for sources (factories and motor vehicles)
  - technical and social restrictions
  - cost estimates
  - effect of control measures on pollution load and air quality

- o Monitoring of air quality and pollution sources
  - air quality monitoring system
  - monitoring of emission from factories and motor vehicles
- o Formulation of guideline
  - air quality target
  - target year
  - air quality monitoring
  - pollution control measures
  - rough cost
  - schedule
  - execution organization
- o Preparation of air dispersion simulation system

(2) Study Schedule

The Study was conducted from December 1991 to August 1993. The Study schedule and study work flowchart are shown in Figs. 1.2.3 and 1.2.4 respectively.

(3) Technology Transfer

The Study team was able to transfer technology to the Malaysian counterparts regarding fundamental knowledge of measurement principles, measurement methods and equipment maintenance on meteorological observation, air quality monitoring, exhaust and flue gas measurements and chemical analysis. Technology transfer was also made on the analytical study. During the Study, three counterparts were trained in Japan in areas of air quality monitoring, air dispersion simulation and air quality management. Besides, the air dispersion simulation system for Kelang Valley Region was installed in the MMS computer. The substance of technology transfer is described below.

1) Field Work

- o Meteorological observation
  - surface level meteorology
  - upper level meteorology
- o Measurement of ambient air quality
  - continuous monitoring at fixed and mobile stations
  - measurement and chemical analysis by simplified method
- o Factory flue gas measurement
- o Vehicle exhaust gas measurement at idling state

2) Analytical Work

- o Analysis of measured data
  - meteorological data
  - ambient air quality
  - SPM analysis by CMB method
  - emission factor
- o Estimation of air pollution load
- o Air dispersion simulation model
- o Air pollution control measures
- o Air quality management plan

(4) Equipment Used for the Study

Table 1.2.1 shows the major equipment used in the field investigations. The equipment used for the field investigations will be handed-over to the Malaysian relevant counterpart agencies after the Study is completed to continue monitoring of air quality and pollution sources.

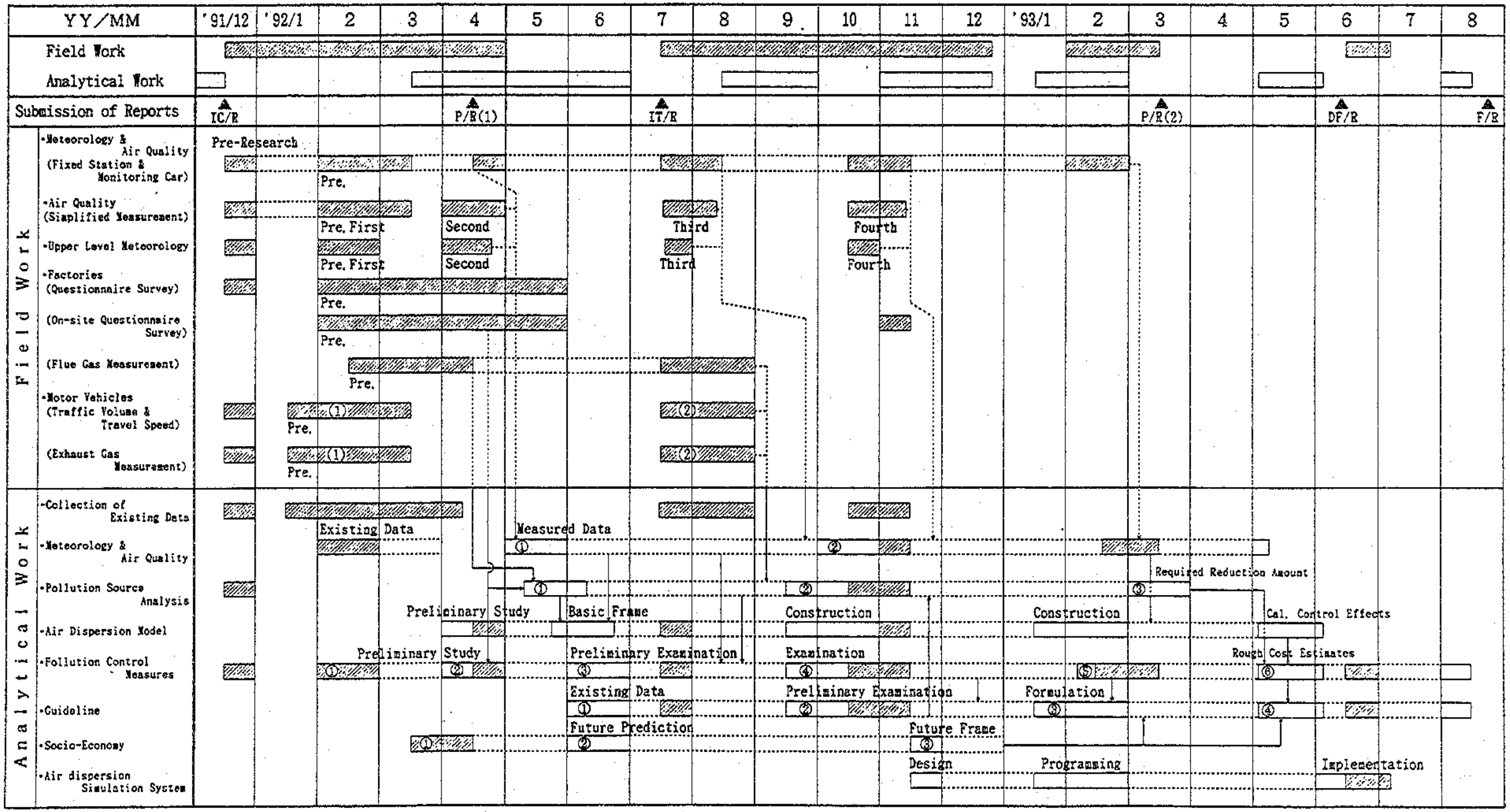


Fig. 1.2.3 Study Schedule

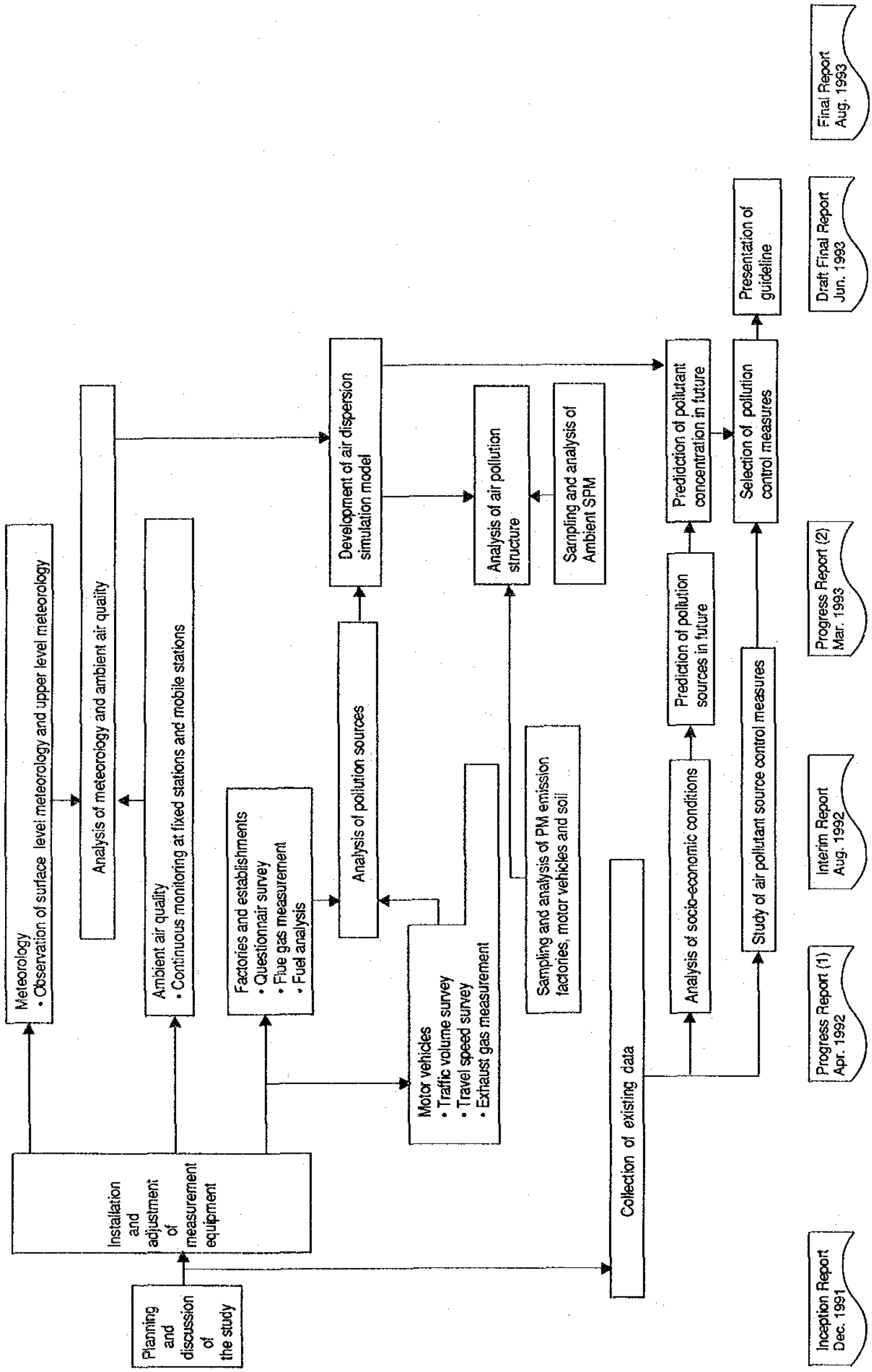


Fig. 1.2.4 Study Work Flow

Table 1.2.1 Major Equipment Used in the Study

| | |
|---|---|
| Upper level meteorological observation | |
| - Upper level sonde observation system | 1 Set |
| - Digital theodolite system | 1 Set |
| Surface level meteorological observation | |
| - Solar and Net radiation system | 1 Set |
| - Wind direction and Wind speed | 1 Set |
| Ambient air quality monitoring at fixed monitoring station | 2 Sets |
| - Container | |
| - Monitors for $SO_2$, NOx, SPM, CO, HC and $O_3$ | |
| - Wind direction and Wind speed | |
| Ambient air quality monitoring at mobile monitoring station | 2 Sets |
| - Monitoring vehicle | |
| - Monitors for $SO_2$, NOx, SPM, CO, HC and $O_3$ | |
| - Wind direction and Wind speed | |
| Factory flue gas measurement | |
| - Sampler and Analyzer for Dust, $SO_2$, NOx, $O_2$ and gas velocity | 1 Set |
| Motor vehicle flue gas measurement | |
| - Flue gas measurement system for HC, CO and NOx | 1 Set |
| Traffic volume survey | |
| - Tally counter | 100 Sets |
| Chemical analysis | |
| - Analysis equipment | 1 Set |
| Data processing system | |
| - Personal computer system | 2 Sets |

## 1.3 Organization for the Study

The Study was carried out jointly by JICA and the Government of Malaysia in cooperation with related agencies.

### 1.3.1 Malaysian Organization

The Economic Planning Unit of the Prime Minister's Department (EPU) was the main coordinator for the Study, and the main counterpart agency was the Department of Environment, Ministry of Science, Technology and Environment (DOE). Counterpart Team was formed to execute the Study smoothly. Steering Committee and Technical Committee were formed to provide advice and consultations. Members of the Steering Committee, Technical Committee and leaders of the Counterpart Team are shown in Tables 1.3.1, 1.3.2 and 1.3.3 respectively.

Table 1.3.1 Members of the Steering Committee

| No. | Name | Department |
|---|---|---|
| 1. | Abdul Rahman Jamal<br>Director<br>Regional Economics Section<br>(Chairman) | EPU |
| 2. | Hasnol Zam Zam Ahmad<br>(Secretary) | EPU |
| 3. | YM. Tengku Azman bin Tengku Mat | Ministry of Housing & Local Government |
| 4. | R. Letchumanan | Ministry of Energy, Telecommunication and Post |
| 5. | Ismail Mohamad | Ministry of Transport |
| 6. | Leong Chow Peng | MMS |
| 7. | Arisfadilah bin Sariat | EPU |
| 8. | Noor Aini Ahmad | MOSTE |
| 9. | Harvinder Kaur | EPU (Industry) |
| 10. | Abdul Rahman Hj. Ahmad | Health Department, City Hall |
| 11. | YM. Tengku Bakry Shah b. Tengku Johan | DOE |
| 12. | Nor A'zman Rosli | DOE |
| 13. | Mohd. Suhaimi Ahmad | EPU (Energy) |
| 14. | Mohamad Yazi Md. Din | EPU (Energy) |
| 15. | Mohd Fazi Matori | Ministry of Works |

Table 1.3.2 Members of the Technical Committee

| No. | Name | Agency |
|---|---|---|
| 1. | Ir. Tan Meng Leng<br>Deputy Director<br>(Chairman) | DOE |
| 2. | YM Tengku Bakry Shah<br>Tengku Johan<br>(Secretary) | DOE |
| 3. | Mrs. Wan Ramlah Bt.<br>Hj. Wan Ibrahim | DOE |
| 4. | Mr. Ismail Isnin | DOE |
| 5. | Ms. Azuri Azizah Saedon | DOE |
| 6. | Mr. Marzuki B. Mokhtar | DOE |
| 7. | Mr. S. Madhi B. S. Junaidi | DOE |
| 8. | Mr. Masami Mizuguchi | DOE (JICA) |
| 9. | Mr. Terutaka Ishikawa | DOE (JICA) |
| 10. | Mr. Nor A'zman Rosli | DOE |
| 11. | Mr. Hassan Mat | DOE (S'GOR) |
| 12. | Mr. Ahmad Samsudin Che Abas | DOE |
| 13. | Mrs. Wan Noraini Bt.<br>Wan Hamzah | DOE |
| 14. | Ms. Rosnani Bt. Ahmad Kasrin | DOE |
| 15. | Mr. Abdul Rahman B.<br>Hj. Ahmad | CITY HALL |
| 16. | Mr. Dzulfakar B. Maisran | CITY HALL |
| 17. | Mr. Wong Kok Fah | DOC |
| 18. | Mrs. Leong Chow Peng | MMS |
| 19. | Dr. M. Subramaniam | MMS |
| 20. | Mr. Tan Choon Kim | SAMC |
| 21. | Mr. Harjeet Singh | SSS |
| 22. | Mrs. Latifah Bt. Hj.<br>Mohd. Yatim | UPLK |
| 23. | Ass. Prof. Dr. Azizan<br>B. Abu Samah | UM |
| 24. | Mr. Azman Zainal Abidin | UPM |
| 25. | Ms. Lee Tzee Wan | PETRONAS |
| 26. | Mr. Cheah Wai Kong | TNB |

Table 1.3.3 Leaders of the Counterpart Team

| | | |
|---|---|---|
| 1 | YM. Tengku Bakry Shah Tengku Johan<br>DOE | Supervision |
| 2 | Mrs. Wan Noraini Wan Hamzah<br>DOE | Socio-economic Analysis and Development Plan |
| 3 | Mrs. Hajah Rosnani Ibrahim<br>DOE | Guideline |
| 4 | Mr. Nor A'zman Rosli<br>DOE | Stationary Source Control |
| 5 | Mr. Mohd Izzuddin Abd Ghani<br>DOE | Mobile Source Control |
| 6 | Mr. Nor A'zman Rosli<br>DOE | Equipment Management |
| 7 | Dr. Azizan Abu Samah<br>UM | Modelling and Simulation |
| 8 | Mrs. Rahani Hussin<br>DOE | Pollution Source Investigation |
| 9 | Mr. Azman Zainal Abidin<br>UPM | Air Quality Monitoring |
| 10 | Mrs. Leong Chow Peng<br>MMS | Meteorological Observation |
| 11 | Mr. Lum Koon Woon<br>DOC | Chemical Analysis |

### 1.3.2 Japanese Organization

JICA, the official agency of the technical cooperation, chose Suuri keikaku Co., Ltd. and Pacific Consultants International as the consultants in charge of the Study. JICA formed Advisory Committee to ensure smooth execution of the Study. Members of the Study Team and Advisory Committee are *shown in Tables 1.3.4 and 1.3.5 respectively.*

Table 1.3.4 Members of the Study Team

| | | |
|---|---|---|
| 1 | Mr. Makoto Miyakawa<br>Suuri-Keikaku Co., Ltd. | Overall Supervision/Organization and Institution |
| 2 | Mr. Ikuo Inoue<br>Japan Machinery & Metals Inspection Institute | Meteorological Observation |
| 3 | Mr. Masanori Fuzikawa<br>Japan Machinery & Metals Inspection Institute | Air Quality Monitoring |
| 4 | Mr. Mitsuru Fukuhara<br>Japan Machinery & Metals Inspection Institute | Stationary Source Investigation |
| 5 | Mr. Yoichi Enokido<br>Pacific Consultants International | Mobile Source Investigation |
| 6 | Mr. Ikushi Okada<br>Japan Machinery & Metals Inspection Institute | Monitoring System |
| 7 | Mr. Akeo Fukayama<br>Suuri-Keikaku Co., Ltd. | Meteorology and Air Quality Analysis |
| 8 | Mr. Seisuke Suzuki<br>Suuri-Keikaku Co., Ltd. | Pollution Source Analysis |
| 9 | Mr. Haruo Kikuchi<br>Suuri-Keikaku Co., Ltd. | Modeling and Simulation Analysis |
| 10 | Mr. Yukihiro Nakano<br>Suuri-Keikaku Co., Ltd. | Air Dispersion Simulation System |
| 11 | Mr. Hidenori Kaku<br>Suuri-Keikaku Co., Ltd. | Mobile Source control |
| 12 | Mr. Shinzo Hirasawa<br>Suuri-Keikaku Co., Ltd. | Stationary Source control |
| 13 | Mr. Norifumi Yamamoto<br>Pacific Consultants International | Air Pollution Control Planning |
| 14 | Mr. Fumiaki Onoda<br>Pacific Consultants International | Socio-economic Analysis/Development Plan |
| 15 | Mr. Tetsuaki Yokochi<br>Japan Machinery & Metals Inspection Institute | Equipment Management/Chemical Analysis |

Table 1.3.5 Members of the Advisory Committee

| | | |
|---|---|---|
| 1 | Dr. Hidetsuru Matsushita<br>Professor, Graduate School of Nutritional and Environmental Science, University of Shizuoka Prefecture | Chairman/Overall Supervision |
| 2 | Mr. Susumu Ota<br>Deputy director of Planning and Coordination Division, Planning and Coordination Bureau, Environment Agency | Air Pollution control |
| 3 | Mr. Naoya Tsukamoto<br>Global Environment Specialist, Control and Coordination Division, Global Environmental Department, Environment Agency | Atmospheric Environment Analysis |
| 4 | Mr. Fumio Ueno<br>Assistant Director, Office of Industrial Development, Industrial Base Division, Department of Commerce, Industry, Labor and Tourism, Hokkaido Government | Pollution Source Measurement |

### 1.3.3 Counterpart Assignments

Counterpart assignments are shown in Table 1.3.6.

### 1.3.4 Organizational Structure

The organizational structure for the Study is shown in Fig. 1.3.1.

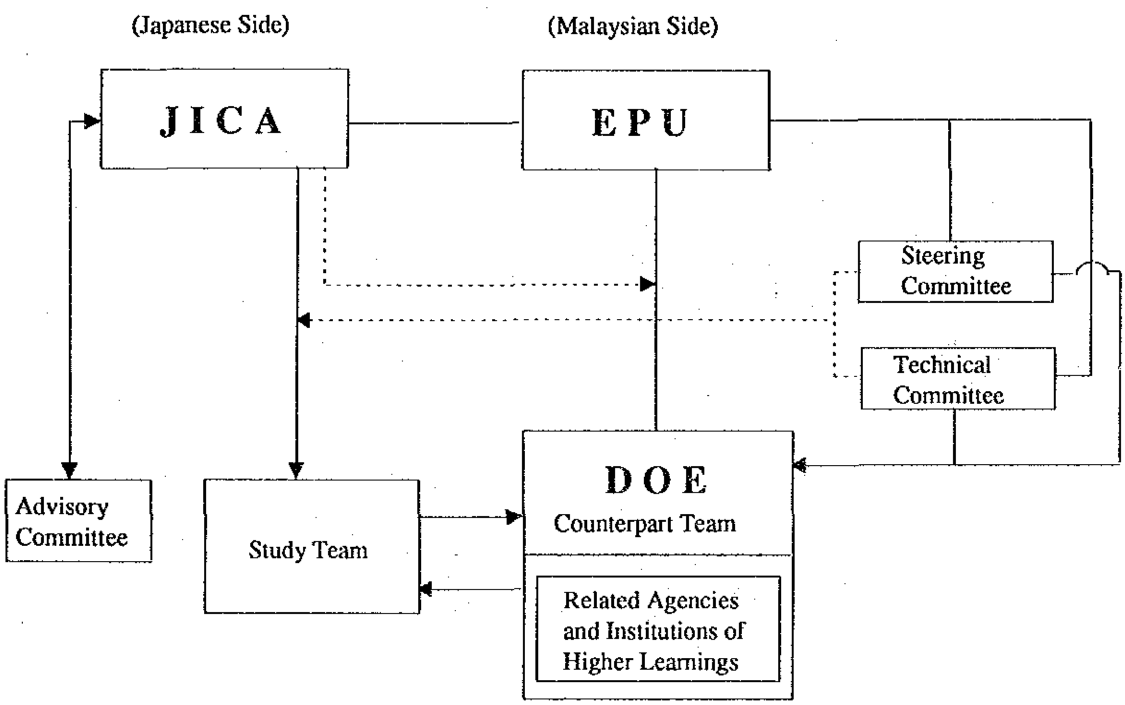


Fig. 1.3.1 Organizational Diagram for the Study

## Table 1.3.6 Counterpart Assignments

| No. | Work Field | Members of the Counterpart Team | Agency | Members of the Study Team |
|---|---|---|---|---|
| 1 | Supervision of the Entire Study | Leader : Mr. Tengku Bakry Shah Tengku Johan | DOE | Mr. Makoto Miyakawa |
| 2 | Socio-Economic Analysis/ Development Plan | Leader : Mrs. Wan Noraini Wan Hamzah<br>Member : Mrs. Hariyah Amy Yahya | DOE | Mr. Fumiaki Onoda |
| 3 | Guideline | Leader : Mrs. Hajah Rosnani Ibrahim<br>Member : Mrs. Wan Ramlah<br>Mrs. Mariana Mohd Nor | DOE | Mr. Norifumi Yamamoto |
| 4 | Stationary Source Control | Leader : Mr. Nor A'zman Rosli<br>Member : Mr. Ahmad Samsudin Che Abas | DOE | Mr. Shinzo Hirasawa<br>(Staionary Source Control)<br>Mr. Ikushi Okada<br>(Monitoring System) |
| 5 | Mobile Source Control | Leader : Mr. Mohd Izzuddin Abd Ghani<br>Member : Mr. Marzuki Mokhtar<br>Mr. Razali Yaakob | DOE | Mr. Hidenori Kaku |
| 6 | Equipment Management | Leader : Mr. Nor A'zman Rosli<br>Member : Mr. Ahmad Samsudin Che Abas<br>Mrs. Wan Noraini Wan Hamzah<br>Mrs. Hariyah Amy Yahya | DOE | Mr. Tetsuaki Yokochi<br>(Equipment Management)<br>Mr. Masanori Fuzikawa<br>(Monitoring System) |
| 7 | Modelling and Simulation | Leader : Dr. Azizan Abu Samah<br>Co-Leader: Mr. Azman Zainal Abidin<br>Co-Leader: Mr. Tengku Bakry Shah Tengku Johan<br>*Member : Mrs. Leong Chow Peng*<br>: Mr. Subramaniam Moten<br>Mr. Chang Tin Yee | UM<br>UPM<br>DOE<br>MMS<br>MMS<br>MMS | Mr. Haruo Kikuchi<br>(Modelling and Simulation)<br>Mr. Akeo Fukayama<br>*(Meteorology and Air Quality)*<br>Mr. Yukihiro Nakano (Air Dispersion Simulation System) |
| 8 | Pollution Sources<br>(On-site questionnaire)<br><br><br>(Flue gas measurement)<br><br><br><br><br><br><br>(Mobile sources) | Leader : Mrs. Rahani Hussin<br>Member : Mr. Nor A'zman Rosli<br>Mr. Ahmad Samsudin Che Abas<br>Member : Mr. Nor A'zman Rosli<br>Mr. Ishak Rauf<br>Mr. Muhd. Ruzita Abdul Hamid<br>Mr. Tham Chee Man<br>Mr. Othman Mustam<br>Mr. Yazid Suaidi<br>Member : Mr. Mohd Izuddin Abd Ghani<br>Mr. Marzuki Mokhtar<br>Mr. Razali Yaakob<br>Mr. Nor A'zman Rosli<br>Mr. Ahmad Samsudin Che Abas | DOE<br><br><br><br><br><br><br><br><br>DOE | Mr. Seisuke Suzuki<br>Mr. Shinzo Hirasawa<br><br>Mr. Mitsuru Fukuhara<br><br><br><br><br><br>Mr. Yoichi Enokido |
| 9 | Air Quality Monitoring | Leader : Mr. Azman Zainal Abidin<br>Member : Mr. Nor A'zman Rosli<br>Mr. Ahmad Samsudin Che Abas | UPM<br>DOE | Mr. Masanori Fujikawa |
| 10 | Meteorological Observation | Leader : Mrs. Leong Chow Peng<br>Co-Leader: Mr. Azman Zainal Abidin<br>Member : Mr. Lim Sze Fook | MMS<br>UPM<br>MMS | Mr. Ikuo Inoue |
| 11 | Chemical Analysis | Leader : Mr. Lum Kon Woon<br>Member : Mr. Pua Hiang | DOC | Mr. Tetsuaki Yokochi |

# CHAPTER 2 OVERVIEW OF THE STUDY AREA

# CHAPTER 2 OVERVIEW OF THE STUDY AREA

The natural and social environment of the Study area summarized from existing data is as follows.

## 2.1 Natural Environment

### (1) Topography

The Study area, Kelang Valley Region, a basin located in the southwest part of the Malaysia Peninsula (Fig. 2.1) is surrounded by mountains exceeding 1,500 m on the east, and the Straits of Melaka on the west.

The Klang River is the main river, which is joined by many branch rivers and flows into the Straits of Melaka through the Straits of Klang.

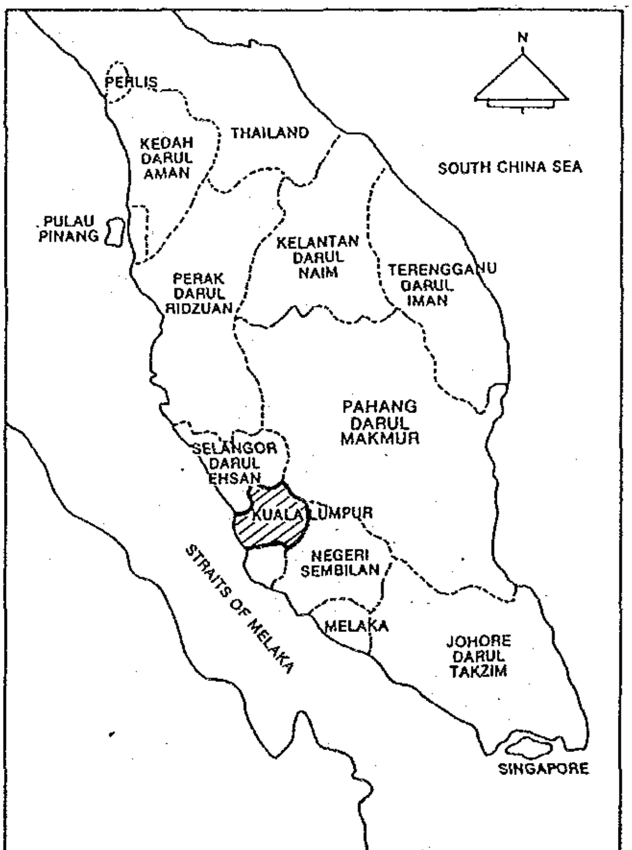


Fig. 2.1 Location of Kelang Valley Region

(2) Climate

Malaysia adheres to a tropical rainforest climate (Af), which is influenced by monsoons from the South China Sea and the Indian Ocean. The Northeast monsoon season from December through February and the Southwest monsoom season from June through August are the dry seasons. Two transitional seasons from March through May and September through November are rainy seasons with high humidity.

## 2.2 Social Environment

### 2.2.1 Society and Administration

(1) Society

Malaysia is a constitutional monarchy consisting of 13 states, under which local authorities are established.

(2) Administration and Government Structures

Kampung is the smallest administrative division. Fig. 2.2.1 is a conceptual model of administrative structure in a district. Municipalities are established along trunk roads. Rubber or oil-palm estates are private land. As for the administrative structure, each state is divided into districts, which in turn are divided into smaller divisions called mukim and kampung (Fig. 2.2.2).

At the district level and below, local authorities, such as district councils and municipal councils, exist along with district offices. There are exceptions. Two cities, Kuala Lumpur and Ipoh have a mayor and a city council. Estates lie outside the sphere of various administrative services because they are private properties.

Administratively, the Kelang Valley Region consists of the Federal Territory of Kuala Lumpur, four districts, i.e., Gombak, Hulu Langat, Petaling and Klang, and four municipalities, i.e., Shah Alam, Petaling Jaya, Klang and newly born Ampang Jaya of the state of Selangor at present. And new municipalities such as Bangi and Selayang will be established in the near future. Kuala Lumpur is a federal territory. Each of Ampang Jaya, Klang, Petaling Jaya, and Shah Alam has a municipal council; each of Gombak, Hulu Langat, and Petaling has a district council.

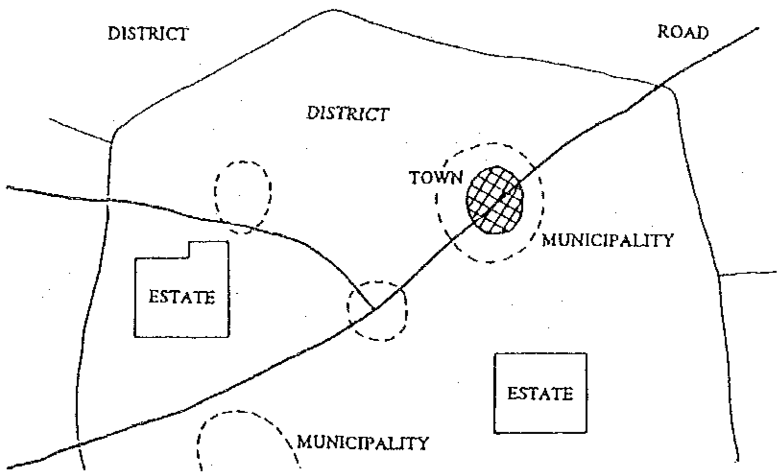


Fig.2.2.1 Conceptual Model of Administrative Structure in a District

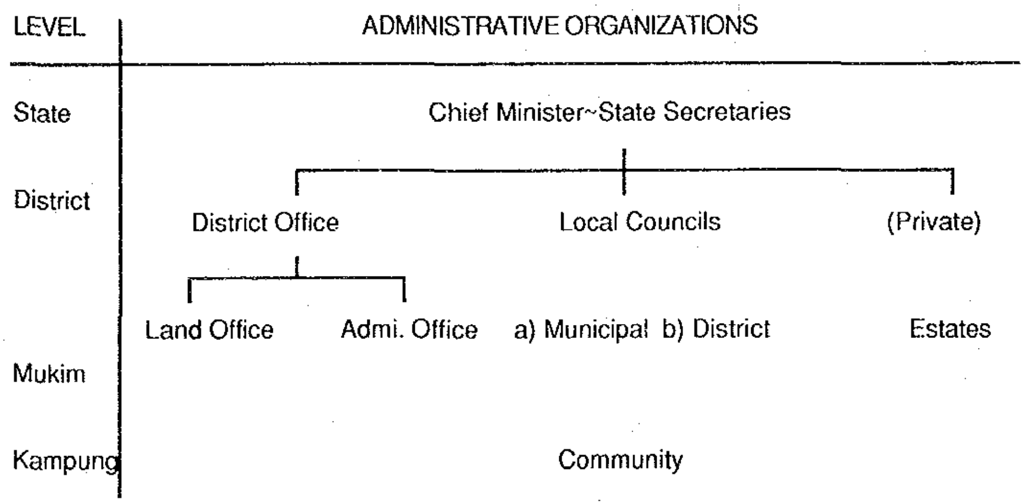


Fig.2.2.2 State Government and Local Authorities

### 2.2.2 Development Plans and Population

#### (1) Development Plans

Each of the constituent administrative bodies in KVR has its own structural development plan (some of them have been published). To ensure smooth execution and coordination of these development plans in the Kelang Valley Region, the federal government set up the Kelang Valley Planning Secretariat (KVPS) in the prime minister's office. KVPS consolidated these plans into a Kelang Valley Perspective Plan in 1984, which was revised in 1988 (KVPP'88). Our forecast mainly relies on this revised plan.

Among the official prognosis for future course of the national economy, the most far reaching is in the Second Outline Perspective Plan (OPP2) which provides basic forecasts for the beginning of the next century. We are bound to make use of actual trends to the present and planned ones set by the OPP2 to 2000 as the basis of our forecast.

(2) Population

The latest census was carried out in August 1991 and a preliminary count report (PCR) was released in March 1992. According to this report, the total population in Malaysia is 17.57 million. Of the total, 2.95 million people ( about 17% of the total population) live in the Kelang Valley Region.

Table 2.2.1 shows the area, population and population density in the Kelang Valley Region according to the 1980 census and KVPP'88's estimates.

The 1991 population census has revealed the following two facts.

1) The actual average annual growth rate (AAGR) of the region's population during the period between 1980 and 1991 is about one point lower than the prediction because of lower migratory inflow from other states than predicted.

2) The population sprawl from the Federal Territory of Kuala Lumpur is more conspicuous and is directed more toward the north and east than estimated in the predictions. This phenomenon culminated in the birth of the Ampang Jaya municipality, adjacent to Kuala Lumpur at its northeast boundary in March 1992.

(3) Prospects for Development

We have compared the PCR and KVPP'88 figures and calculated tentative figures for the year 2005 (see Table 2.2.2). The AAGR figure for the population for the period of 1991 and 2000 for all of Malaysia was derived from the OPP2. We did not delve into the population and household estimates made in the KVPP'88, as the figures will soon change whenever a new series of population statistics based on the latest census are published.

Furthermore, planning has begun on the construction of a new international airport in Sepang district, which is not mentioned in the KVPP'88. This will surely influence not only the air and related transport infrastructures but also the general pattern of land use in the region, and further the boundary of the region itself.

Topographically, Kelang Valley Region includes the upper reach of the Selangor basin in its northeastern part and the upper and middle reaches of the Langat basin in its eastern part. In the future, Kuala Langat district, the lower reach of the Langat, and Sepang district will be administratively integrated into the greater Kuala Lumpur metropolitan region.

Table 2.2.1 Population 1980 Census and Estimates

| | *1 | Census 1980 | | | Population | | Estimate(*2) AAGR:%(*2) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Area | Dens. AHhn. | | | 1990 | 2000 | 80-85 | -90 | -95 | -00 |
| | km2 | 1000 / km2 | | | 1000 | 1000 | | | | |
| KUALA LUMPUR | 243 | 1036.9 | 4267 | 4.75 | 1550 | 2200 | 4.1 | 4.1 | 3.6 | 3.6 |
| GOMBAK | 650 | 175.9 | 271 | 5.03 | 245 | 344 | 3.6 | 3.0 | 3.4 | 3.4 |
| Selayang | 1 | 3.5 | 3500 | | 5 | 7 | 3.6 | 3.0 | 3.4 | 3.4 |
| Ampang Jaya # | 5 | n.a. | | | | | | | | |
| Other UA | 14 | 70.2 | 5014 | | | | | | | |
| Non-UA | 630 | 102.1 | 162 | | | | | | | |
| HULU LANGAT | 826 | 188.4 | 288 | 5.32 | 289 | 406 | 4.5 | 4.1 | 3.4 | 3.4 |
| Ampang Jaya # | 4 | 13.0 | 3250 | | | | | | | |
| Bangi | n..a. | 33.3 | | | 73 | 103 | 8.2 | 7.6 | 3.4 | 3.4 |
| Other UA #2 | 41 | 65.6 | | | | | | | | |
| Non-UA | 781 | 76.4 | 98 | | | | | | | |
| PETALING | 484 | 382.3 | 790 | 4.61 | 659 | 926 | 4.4 | 6.5 | 3.5 | 3.4 |
| Shah Alam | 135 | 20.2 | 150 | | 155 | 218 | 14.5 | 26.3 | 3.43 | 3.4 |
| Petaling Jaya | 43 | 220.1 | 5119 | | 306 | 430 | 3.6 | 3.0 | 3.4 | 3.4 |
| Other UA | 22 | 58.4 | 2655 | | | | | | | |
| Non-UA | 284 | 83.7 | 295 | | | | | | | |
| KLANG | 627 | 296.1 | 472 | 5.60 | 412 | 597 | 3.6 | 3.0 | 3.4 | 3.4 |
| Klang | 61 | 203.4 | 3334 | | 283 | 398 | 3.6 | 3.0 | 3.4 | 3.4 |
| Other UA | 0 | | | | | | | | | |
| Non-UA | 566 | | | | | | | | | |
| Other UA | 77 | | | | 47 | 66 | 3.6 | 3.0 | 3.4 | 3.4 |
| Non-UA | 2261 | | | | 735 | 1032 | 3.6 | 3.0 | 3.4 | 3.4 |
| KELANG VALLEY | 2830 | 2079.6 | 735 | 4.90 | 3155 | 4454 | 4.0(J) | 4.3(K) | 3.4(L) | 3.4(M) |
| MALAYSIA | 329758 | 13136 | 40 | | | | | | | |

Legend : UA=Urban Area, Dens=Density, AHhn=Average Household Number
# Data on Ampang Jaya : New Strait Times, Mar.19,20
#2 Other UA includes Bangi's
*1 Yearbook 90 : Bureau of Statistics
*2 KVPP' 88