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URBAIR
Urban Air Quality Management Strategy in Asia

METRO MANILA
City Specific Report

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Notice

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

Preface

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

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

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

The participating institutions and agencies from Metro Manila were as follows:

- Department of Environment and Natural Resources (DENR)
- Environmental Management Bureau (EMB)
- Department of Transportation and Communication (DOTC)
- Land Transportation Office (LTO)
- Land Transportation Franchising and Regulatory Board (LTFRB)
- Department of Trade and Industry (DTI)
- Bureau of Product Standards (BPS)
- Bureau of Import Services (BIS)
- Board of Investments (BOI)

- Export Processing Zone Authority (EPZA)
- Department of Energy (DOE)
- Energy Industry Administration Bureau (EIAB)
- Energy Resources Development Bureau (ERDB)
- Energy Regulatory Board (ERB)
- Phil. Atmospheric Geophysical & Astronomical Service Administration (PAG-ASA)
- Department of Health (DOH)
- Department of Interior and Local Government (DILG)
- National Economic and Development Authority (NEDA)
- Department of Budget Management (DBM)
- Metro Manila Authority (MMA)
- Laguna Lake Development Authority (LLDA)
- Phil. Chamber of Commerce and Industry (PCCI)
- Pollution Control Association of the Phils. (PCAPI)
- Department of Science and Technology (DOST)
- Traffic Management Command
- CORD-NCR
- Department of Public Works and Highways
- Bureau of Customs
- National Security Council
- Municipality of Makati
- Municipality of Madaluyong
- City of Manila
- City of Quezon
- Phil. Environmental Network (PEN)
- Phil. Institute of Chemical Engineers (PIChE)
- Phil. National Oil Company (PNOC)
- National Power Corporation (NPC)
- Pilipinas Shell
- Caltex (Phils) Inc.
- Petron Corporation
- Amptron Group of Companies
- Ecological Society of the Philippines
- Lingkod Tao Kalikasan (LTK)
- Philippine Business for the Environment (PBE)
- Concerned Citizen Against Pollution (COCAP)
- Green Forum
- Haribon Foundation
- Green Coalition
- Earthsavers Movement
- Soroptimist International
- Girl Scouts of the Philippines
- Recycling Movement of the Philippines
- Kabisig People's Program

- Center for Advanced Phil. Studies
- California Bus Lines
- Kawasaki Motors

The reports conclude with an action plan for air pollution abatement produced by the local working groups as a result of the deliberations and discussions during the second workshop. NILU/IVM carried out cost/benefit analysis of some selected abatement measures, showing the economic viability of many of the technical control options.

It is expected that the local institutions, based upon the results from the analysis, as presented in this report, formulate a prioritized plan of action. Here, prioritized measures to reduce the urban air pollution should be listed and given a term for start and completion. This prioritized action plan is expected to be the basis for the air quality work of the municipal authorities, in developing a control strategy, and an investment plan.

The report is organized as follows:

- An extensive Summary.
- Background information (Ch. 1), summarizing the development in the city over the last decade regarding population, pollution sources such as industry and road traffic, and fuel consumption.
- Air quality assessment (Ch. 2), containing summary of the present air pollution situations, emissions, inventory, dispersion and population exposure calculations, and suggestions for improving the data base for the assessment.
- Projections of air pollution emissions (Ch. 3).
- Air pollution impact (damage/assessment and its valuation (Ch. 4), describing and calculating the health damage from the air pollution.
- Description of institutional framework (Ch. 5).
- Abatement measures (Ch. 6), describing the effectiveness and costs of selected technical control measures.
- Future air quality for some abatement scenarios (Ch. 7).
- Draft action plan (Ch. 8), containing the full Action Plan as developed by the local working groups, and a summary of the cot-benefit analysis of the selected technical control options.
- References (Ch. 9).

An Appendix report contains more detailed descriptions of the air quality data, the emissions inventory and emission factors, population exposure calculations, and laws and regulations.

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At the World Bank, the URBAIR was managed by Jitendra Shah and Katsunori Suzuki, and under the advice and guidance of Maritta Koch-Weser and David Williams. Colleagues from Country Departments commented on the numerous drafts. Management support was provided by Sonia Kapoor and Ronald Waas.

Many international institutions (WHO, US Environmental Protection Agency, US Asia Environment Partnership) provided valuable contribution through their participation at the workshops. Their contribution made at the workshop discussions and follow-up correspondence and discussions has been very valuable for the result of the project.

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Summary

Past and present development of Metro Manila

Metro Manila, like other megacities in developing nations, is increasing rapidly in size and diversity. The concentration of population and industry in these cities is high and still getting higher. This situation creates urban air pollution problems in these cities caused by increasing emissions from vehicular traffic, industry and domestic heating, cooking and refuse burning. In the future, potential risk for air pollution exposures will increase at an alarming rate, if the emissions are allowed to develop uncontrolled.

Metro Manila has experienced strong growth over the past decade in general, although the political difficulties of 1983-1985 caused a temporary drop in the GDP growth, affecting all societal sectors.

The population grew 38% from 1981 to 1992 when the population was about 8.4 million inhabitants. The 1994 population was 8.85 million. The Philippine GDP/capita was in 1992 US$ 730, with an average annual increase of +1.6% over the period 1965-1989. This is the same rate as for the USA. For 1985-1990, the annual increase was 2.9% and the projections for 1990-1995 was a 5.2% annual increase.

In 1993, the vehicle fleet counted totally 901,000 vehicles, with 40% cars and taxis, 41% utility vehicles, 8% trucks/buses and 11% two and three-wheelers. This is 70% more than in 1981. The rate of increase during the period of 1985-1990 is 9.5% per year, and the projected rate for 1990-2000 is 6%. This could mean 1,200,000 vehicles in 2000. Utility vehicles and two-wheelers are projected to grow fastest.

The increasing number of vehicles among other developments have caused a substantial fuel consumption increase in Metro Manila for the period 1988-1992. The total increase in consumption was 287%, 57% and 15% for diesel oil, gasoline and fuel oil respectively. In 1992, per capita annual consumption was 144 liters of gasoline, 370 liters of diesel oil, and 503 liters of fuel oil. The substantial increase in diesel consumption is only partly explained by increased traffic. Increased industry diesel combustion and small-to-medium scale power generation during the frequent brown-out periods are also contributing factors.

These developments are reflected in the air pollution concentrations in Metro Manila. Annual average TSP concentrations increased substantially during the period 1988-1992, especially in the areas experiencing the largest population increases. Air pollution development over the last decade is not well documented, due to changes in methods and quality control problems. At present, TSP concentrations significantly and frequently exceeds the National and WHO Air Quality Guidelines.

The continued growth of population and GDP in Metro Manila is expected to worsen air pollution in the metropolis substantially, unless corrective actions are taken.

Air Quality Assessment

Metro Manila's air quality has been assessed by reviewing available air quality measurements, constructing an emissions inventory, performing dispersion model calculations of long-term average concentrations, and, based on this, calculating the distribution of population exposure to air pollution.

Air pollution measurements show that TSP and PM_{10} represent Metro Manila's major air pollution problem. Concentrations exceed national and WHO air quality guidelines substantially and frequently in large parts of Metro Manila, with maximum concentrations of TSP as much as 5 times the WHO guidelines. Hot-spot exposure occurs near main roads and in industrial areas. The long term measured lead levels exceed the AQ standards/guidelines given by the Philipines and by the WHO. SO_2 pollution is not as serious as TSP and PM_{10}. CO and ozone have not been extensively measured.

The emission inventory was based upon available information, and many assumptions were made. **Main sources** of TSP and PM_{10} emissions were (relative contributions):

	TSP	PM_{10}
High sulfur fuel oil (BOF) combustion	22%	34%
Resuspension from roads (rough estimate)[1]	33%	15%
Diesel vehicle exhaust	9%	16%
Refuse burning (rough estimate)	8%	14%
Industrial processes (rough estimate)	8%	7%

Population exposure distribution to TSP and PM_{10} were calculated based on:

- calculated long-term average concentrations in a km^2 grid net using a gaussian, multisource dispersion model;
- population distribution in the same km^2 grid net; and
- estimated additional exposure in hot-spot areas (main road network and industrial areas)

It was calculated that 80% of the population lives in areas where the national AQ Standard for TSP annual average is exceeded. The national AQ Standard for TSP equals the WHO AQ guidelines of 90 $\mu g/m^3$.

Estimated exposure in exceedance of two times AQG for TSP annual average is:

- 3% of the population in their residences;
- 11% of the population, when estimated exposure in industrial areas is added; and
- 29% of the population, when roadside exposure is also added.

[1] The calculation of resuspension from roads may represent an overestimate, as it is based on an overall emission figure of 2 g/km.

The exposure is due to the following main sources:

- For TSP: Resuspension from roads and construction, diesel vehicles and refuse burning.
- For PM_{10}: Diesel vehicles, refuse burning, and resuspension and construction.

Additional exposure in industrial areas is due to BOF combustion and process emissions.

The highest exposure is due to roadside concentrations, which affect drivers (estimated at 300,000 people), commuters (estimated at 2.4 million people) and roadside residents (estimated at 65,000 people).

The concept of Air Quality Management Strategy (AQMS)

The basic concept for an Air Quality Management Strategy (AQMS) contains the following main components:

- Air Quality Assessment
- Environmental Damage Assessment
- Abatement Options Assessment
- Cost Benefit Analysis or Cost Effectiveness Analysis
- Abatement Measures Selection (Action plan); and
- Optimum Control Strategy

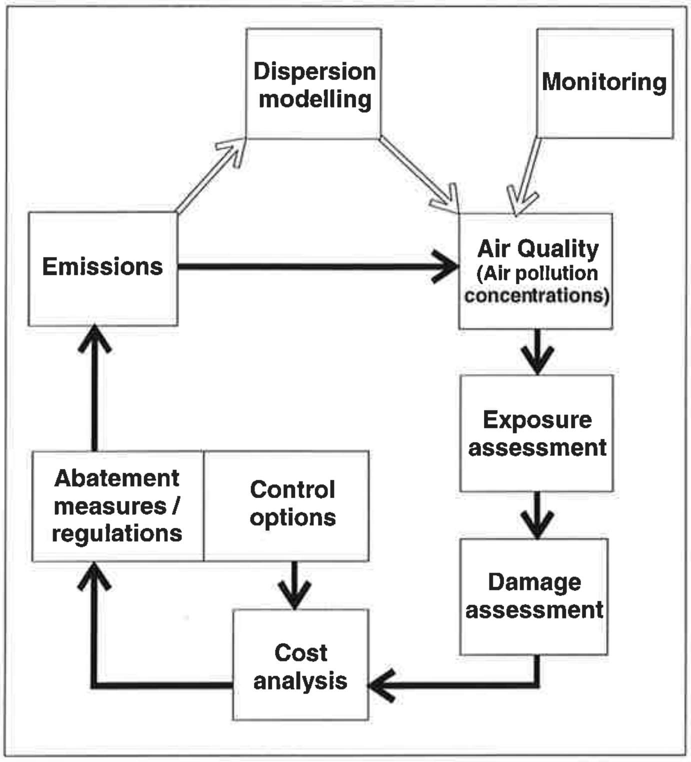
The Air Quality Assessment, Environmental Damage Assessment Abatement Options Assessment provide input to the **Cost/Benefit Analysis**, or a **Cost Effectiveness Analysis**, which is also based on established Air Quality Objectives (i.e. guidelines, standards) and Economic Objectives (i.e. reduction of damage costs). The analysis leads to an **Action Plan** containing abatement/control measures, for implementation in the short/medium/long term. The final result of this analysis is **Optimum Control Strategy**.

A successful AQMS requires the establishment/completion of an integrated system for continued air quality management. This requires continuing activities on the urban scale in the following fields:

- inventory of air pollution activities and emissions;
- monitoring of air pollution and dispersion parameters;
- calculation of air pollution concentrations, by dispersion models;
- inventory of population, materials and urban development;
- calculation of the effect of abatement and control measures; and
- establishment and improvement of air pollution regulations.

These activities, and the institutions necessary to carry them out, constitutes the **System** for AQ Management that is a prerequisite for establishing the **Strategy** for AQ Management (AQMS).

The figure below represents a simple visualisation of the elements of the System for Air Quality Management, and the flow of information between them.



The process of developing an Air Quality Management Strategy (AQMS), for an urban area includes many steps. The most important of these are:

* identifying sources * quantifying sources	emission inventory	Assessment
* monitoring air pollution		
* assessing the exposure (impact) situation		
* identifying source - exposure relations	→ modeling	
* estimating the relative importance of various air pollution sources		
* assessing environmental damage		
* investigating short and long term control (abatement) options including urban planning needs		Control
* performing cost-benefit or cost-effectiveness analysis		
* developing a control strategy and an investment plan		
* developing institutions/regulations/enforcement		
* awareness raising		
* establishing an Air Quality Information System (AQIS)		Surveillance

As shown above, the AQMS consists of two main components, which are **assessment and control**. In parallel with the AQMS development, and to facilitate checking the effectiveness of the air pollution control actions, a third component is necessary, which is **surveillance** (monitoring).

The process of attaining acceptable urban air quality is dynamic and long term. As the urban areas develop, population, pollution sources and technology change. Throughout this process, it is very important to have an operating Air Quality Information System (AQIS), in order to:

- keep the authorities and the public well informed about the short-term and long-term AQ development
- assess the results of abatement measures, and thereby
- provide feed-back information to the abatement strategy process.

Needs for improvement of the Air Quality Assessment

The present **system of air quality measurements** in Metro Manila is based on rather infrequent 24 sampling (2-4 times per month at each site) of TSP and SO_2. PM_{10}, lead, SO_2 and CO are not measured routinely. It is clear that it is important to improve the air pollution monitoring system of Metro Manila, to include continuous monitors in routine, long-term operation. It is recommended that the system includes at least:

- a number (2-5) of city background sites
- some (1-3) traffic exposed sites
- some (1-5) industrial area/hot-spot sites
- monitors (continuous) for PM_{10}, CO, NO_x, SO_2, O_3, depending upon the site
- on-line data retrieval system directly to lab database, via telephone/modem.

The main shortcomings of the **emission inventory** concerns:

- industrial emissions (use and combustion of fuel, process emissions)
- resuspension from roads
- other coarse particle sources, such as construction
- domestic refuse burning.

Less important shortcomings regard the traffic distribution data which forms the background for the car exhaust emission distribution, and also the use and distribution of fuel in the commercial and domestic sector, including generator sets.

It is necessary to fill the data gaps in the inventory, and up grade the inventory in general. The emission inventory database must cover both the DENR-NCR and LLDA jurisdiction areas.

The determination of the **population exposure** to air pollution in NCR, and the contributions to this exposure from various sources, is based on a combination of dispersion modeling and air pollution monitoring.

A population exposure distribution of good quality is important since it is the basis for:

- estimating health damage costs
- assessing the effects on health of various measures to reduce the exposure, as part of a cost/benefit analysis.

To improve the population exposure calculations beyond what has been developed as part of the 1. phase of URBAIR, the following is needed:

- Improved data for distributing the population in km^2 grids. Such data (barangay data) exist already, and should be used.
- Dispersion modeling expertise in Metro Manila should be identified, and the use of dispersion modeling should be integrated in the Air Quality Management work of the control agencies.

The dispersion modeling expertise, and appropriate models for air pollution management and control strategies should rest within the NCR.

Reference scenario 1992-2010

The reference scenario is defined by the future developments inherent in the projections for future growth in the population, GDP and thus growth in e.g. the vehicle population and traffic activity. The total traffic activity is here projected to grow at a 25% less rapid rate than that estimated from the growth in vehicle ownership, since it is expected that part of the traffic activity increase will take place outside the study area.

In the reference scenario, the power production inside Metro Manila does not change. Increased power production will take place outside the area. Other fuel combustion is projected to grow 5.5% annually in the study area. Industrial emissions are assumed not to change. Their total contribution is limited, and very little specific is known about the present emissions. Emissions from construction and refuse burning is assumed to increase by 3% and 1% annually. Current environmental policies are built into the reference scenario, such as reduction of sulfur contents in fuels.

These combined developments of the reference scenario leads to a substantial increase in extent of population exposure above AQ standards. While in 1992 about 30% of the population was exposed to PM_{10} concentrations above 90 $\mu g/m^3$ (as annual average, corresponding to 2 times the AQG for TSP), in 2010 in the reference scenario this is increased to about 48%, and the highest exposures are also increased corresponding.

Health impacts and their valuation

The damage caused by air pollution consists of various components: damage to human health, materials, vegetation and crops, buildings and monuments, ecosystems and tourism. In this study, only damage to human health is estimated by using US dose-effect relationships. Damage to health consists of mortality and morbidity. The valuation of loss of life is difficult and no more can be given than an estimate of the order of magnitude. If estimated with the human capital approach (i.e. lost earnings due to premature death), the value of a statistical life in Manila amounts to about US$ 10,000.

Costs of morbidity (illness) are more reliable. They consist of foregone wages and costs of medical treatment. Estimates were made specifically for Manila, of costs of morbidity due to concentrations of PM_{10}. This valuation of damage to human health contains a tendency of underestimation as the suffering due to illness or premature death is not included.

The Table below presents the result of a calculation aimed at attributing air-pollution (PM_{10}) impacts to source categories. The valuation is based on the Manila data.

Air pollution impacts attributed to source categories 1995, annual figures.

Source category	Mortality no. of deaths	RSD, millions	Costs (mill pesos)
Gasoline cars	44	1.2	151
Motorcycles	22	0.6	75
Jeepneys	112	3	395
Utility vehicles (diesel & gasoline)	177	5	614
Trucks and buses (diesel & gasoline)	555	15	1,924
Combustion of heavy fuel oil (BOF)	200	5	695
Refuse burning	435	12	1,519

Health damage due to lead is less reliable, as no good exposure figures are available and as the cost figures of illness were based on US figures, corrected for differences in per capita income differences in USA and Philippines. Both factors lead to serious underestimation. This underestimation of health damage due to lead amounts to about US$ 70 million in 1992.

Other health damage (e.g. due to ozone, NO_x, SO_2) could not be estimated for lack of exposure figures.

As is indicated elsewhere in this report, lead pollution is bound to decrease sharply with the initiatives to reduce the lead content of gasoline taking effect. In contrast, PM_{10} pollution tends to increase: if no environmental measures are taken the health situation will severely deteriorate, while the associated costs will increase from about US$ 100 million - a conservative estimate - to about US$ 500 million in the year 2010. Clearly there is an economical justification for addressing air quality in Metro Manila.

Existing institutions, laws and policies regarding air pollution

The Department of Environment and Natural Resources (DENR) is the main air pollution management institution in the Philippines. Its Environmental management Bureau (EMB) is responsible for developing environmental management programs and strategies, and the DENR regional offices implements laws and regulations locally. Among these are the DENR-NCR office of Metro Manila. In Metro Manila the Laguna Lake Department Authority (LLDA) has jurisdiction over a major part of the Metro Manila Region.

Other institutions and agencies with responsibilities on environmental matters include the Local Government Units (LGU) with local-scale environmental protection responsibilities the Land Transportation Office (LTO) which inspects and regulates vehicles and engines, the Department of Trade and Industry (DTI) which regulates stationary sources, and the National Economic and Development Authority (NEDA) which has the task of integrating the concept of sustainable development into the national economy.

Existing laws and regulations include:

- The Philippine Clean Air Act of 1994;
- AQ Standards, comparable to US EPA standards but less stringent than WHO Guidelines;
- Emission standards for stationary sources, which are comprehensive, although
- less stringent than US EPA standards;
- Regulations on fuel quality, specifying for example upper limits of sulfur or lead contents. These limits are rather less stringent;
- An Environmental Impact Assessment;
- Emission standards for motor vehicles, with rather lax emission limit values, comparable to those enforced in Europe in 1975-1979; and
- Traffic regulations aimed at improving traffic flow.

These rules and regulations are considered sufficient to form a basis for improving Metro Manila's air quality, when adequately implemented. Limit values need to be tightened.

Campaigns to enforce regulations have been carried out, most notably the Anti-Smoke Belching Campaign, which has been more or less active since 1977, apprehending up to 18,000 smoke belchers annually.

Various policies and action plans have been or are being formulated regarding Metro Manila's environmental and air pollution conditions:

- The OPLAN Clean Air Metro Manila (PD1181) intends to improve air quality during 1993 to 1998. This is also called the Anti-Smoke Belching Campaign;
- The Clean Air 2000 Action Plan for Metro Manila; and
- The Air Quality Management Master Plan of the Environmental Management Bureau (EMB) by the Departement of Environment and Natural Resources of the National Capital Region (DENR-NCR), finalized in 1994

In most of these policy plans, emphasis is on cleaner fuels, inspecting and mainting vehicles, improving vehicle technology, reviewing fuel pricing mechanisms, and making the public more aware and involved in environmental issues through information, education and communication campaigns.

Abatement measures

A number of measures are appropriate for improving the air quality in Manila. Several aspects of the measures are dealt with: their effectiveness, costs, benefits, how to implement the measures and the time-frame, and the institutions/authorities involved. An important issue is to indicate the benefits, the reduced health impacts and reduced damage costs, based on the estimate of reduced population exposure. Together with the costs of the measures, this information gives clues for prioritization of measures. It should be noted that the quantitative information presented often has to be characterized as rough estimates.

Traffic measures described include: reinforcing the Anti Smoke Belching campaign, improving diesel fuel quality, implementing an inspection/maintenance scheme, fuel switching within the transport sector, clean vehicle emission standards, addressing road dust resuspension, mass-transport systems.

For other fuel combustion, cleaner fuels and emission controls were considered.

The identification of measures to address traffic emissions was rather straightforward as some of the major causes of the air pollution are obvious. The listing of measures addressing other sources was also straightforward. However, lack of specific enough information regarding those sources prevented somewhat the elaboration of costs and benefits. Nevertheless, the information is useful for drafting a first action plan.

Future air quality for some abatement scenarios

In order to be able to draw overall conclusions regarding the possibility to improve the air pollution situation in Metro Manila, two combined future scenarios have been defined:

- "Common environmental technology scenario", based on a comprehensive strategy to address "smoking" diesel fuelled vehicles including introduction of clean diesel fuel; introduction of unleaded fuel and clean vehicle emissions standards; further reduction of sulfur contents in fuel oils.
- "A fuel shift scenario", involving gradual shift to LNG for energy production, and introduction of LPG (and CNG) as automotive fuel for buses and trucks particularly.

From the present analysis of the current and future air quality in Metro Manila and from a review of the possibilities for its improvement, several conclusions can de drawn:

- Even if obvious measures - from an exclusively monetary point of view - are taken, such as addressing diesel fuelled vehicles and improving the quality of heavy fuel oil, the air quality will not detoriate further, but will not improve either. As the number of exposed people tends to increase, the impacts will also increase.
- The monetary benefits assessed relate only to the health impacts of PM_{10} and lead. Improvement of the situation with respect to other air pollutants (SO_2, NO_x, CO and VOC) have not been evaluated.
- Industrial combustion emissions can be addressed by improving fuel quality. Other measures, such as flue gas treatment, could not be evaluated due to lack of information.
- The importance of road traffic as a source of pollution (from vehicles and through resuspension) will not decrease. This emphasizes the necessity - from an environmental point of view - to strive for a further development of mass transit systems.
- A similar recommendation is to change the energy stucture and, if feasible, strive for introduction of natural gas as an industrial fuel.
- Due to a lack of information the possibilities for addressing emissions from refuse burning, process emissions and resuspension have not been evaluated.

It is acknowledged that these conclusions are based on numerous assumptions, which we were forced to make due to a considerable lack of appropriate information. Decisions to take the "obvious measures" appear to be justified just from the monetary point of view alone. Other benefits come in addition.

Action plan

Through the work carried out in the local working groups, a large number of proposed actions and measures has been listed, and categorized within the following categories:

- Improved fuel quality.
- Technology improvements.
- Fuel switching.
- Traffic management.
- Transport demand management.

Each of the proposed actions were described regarding its effect (benefit), costs, policy instruments, time-frame of instigation, and institutions responsible.

A selection of “obvious” technical measures for possible short-term introduction was made, and cost-benefit analysis carried out for each measure separately.

The Table below gives a summary of the cost-benefit analysis. For all of the selected measures except cleaner fuels in power plants, the calculated benefits are very substantial, in the tens of millions of USD annually, and the benefits are, as a rule, much higher than the estimated costs.

Benefits and costs of selected abatement measures, annual figures.

Abatement Measure	Benefits		Cost of measure mill USD	Time frame, effect of measure
	Avoided effects	Reduced costs mill USD		
Address gross polluters (Anti Smoke Belching Campaign)	160 deaths 4 mill RSD	16-20	0.08	Short-term
Improving diesel quality, vehicles	94 deaths 2.5 mill RSD	10-12	10	2-5 years
Inspection/maintenance, vehicles	310 deaths 8 mill RSD	30-40	5.5	2-5 years
Clean vehicle standards	895 deaths 24 mill RSD	94-116	10-20	5-10 years

The selected actions incorporate the following measures:

Adressing gross polluters: Reinforcing the antismoke belching program:

- Strict enforcement of smoke opacity regulation.
- Success is dependent upon the maintenance/adjustment of engines actually taking place. Routines for ensuring that must be a part of the action.

Improving diesel quality:

- Import of quality low-sulfur diesel (0.2%), or
- Modifications in Philippine refineries
- Taxes/subsidies to differentiate fuel price according to fuel quality.

Inspection/Maintenance

- Annual (or bi-annual) inspection
- Establishment of I/M stations (government or private)
- Basic legislation is in place (PD 1181)

The potential for reduced emissions is the largest for diesel vehicles. The I/M might, at the start, be concentrated on diesel vehicles.

Fuel switching: Diesel-to-gasoline in vehicles:

- Changes in tax/subsidy structure to make gasoline the preferred fuel
- Establish a loan scheme to cover cost of engine replacement

Fuel switching to gasoline will result in increased emissions of VOC, CO, and also to somewhat increased fuel consumption. This is a drawback of this measure, but it can be counteracted by establishing clean vehicle emission standards.

When evaluating this measure the annual flooding situation on Metro Manila streets must also be considered, since flooded streets pose a bigger problem to internal ignition (gasoline) engines.

Clean vehicle emission standard:

- Establish state-of-the-art vehicle emission standards for new gasoline cars, diesel vehicles and motorcycles.
- Ensure the availability of lead-free gasoline, at a lower price than the leaded gasoline.

Cleaner fuel oil:

- Substantial reduction of the sulfur content of heavy fuel oil, initially to 2%.

The Table below lists other selected abatement measures, also of other categories, for which cost/benefit analysis has not been performed, which could be introduced in the short term, and have a beneficial effect on the air quality.

Additional measures for short/medium-term introduction.

Abatement measure/action		Time frame	
		Introduction of measure	Effect of measure
Vehicles			
Address dilution and adulteration of fuel		Short term	Short term
Restrict life time of public UVs and buses		Short term	Medium term
Traffic management			
Improve capacity of existing road network	- improve surface - remove obstacles - improve traffic signals	Short term	Medium term
Extend/develop road network: Improve/eliminate bottlenecks		Short/medium term	Medium term
Transport demand management			
Improve existing bus system	- improve time schedules - improve junctions/stations - make integrated plan	Short term	Medium term
Develop parking policy	- restrictions in central area - parking near mass transit terminals - car-pooling	Short term	Short term Short term Short term

URBAIR

Urban Air Quality Management Strategy in Asia

METRO MANILA
City Specific Report

1. Background information

1.1 Scope of the study

The present city specific report on Air Quality Management for the Metropolitan Manila Region has been produced as part of the URBAIR program.

The major objective of the URBAIR program is to develop a generalized Air Quality Management Strategy (AQMS) to be used for Asian cities, and to apply this strategy to develop Action Plans for improvement the air quality in the following cities: DKI Jakarta, Greater Bombay, Kathmandu Valley and Metro Manila.

The developed AQMS is based on the costs and benefits analysis of proposed actions and measures for air pollution abatement. Benefits include the reduced costs of health and other damage due to air pollution, which results from the implementation of abatement measures. In this study, emphasis is put on health damage, which is estimated based on the calculation of the distribution of population exposed to air pollutants, based again on measured and calculated concentrations of air pollution, through emission inventories and dispersion modeling.

The generalized strategy is described in a separate URBAIR Guidebook on Air Quality Management Strategy. City specific reports are produced for each of the four cities, based on city-specific analysis. The city specific reports conclude with prioritized Action Plans for air quality improvement, including costs and benefits figures. The Action Plans are based on a comprehensive list of proposed measures and actions developed by local working groups in each of the four cities and evaluated by the URBAIR consultants.

1.2 General description of the Metropolitan Manila Region

The Metropolitan Manila Region is situated at a plain on the south-western coast of the Luzon Island, around the mouth of the Pasig river in the Manila Bay. The Metropolitan Manila Region (MMR), also called the National Capital Region (NCR), covers a total land area of 636 km^2 and consists of 7 cities and 10 municipalities. Figure 1.1 shows a map of the Metro Manila area. The population density was in 1990 about 12, 500 persons per km^2, and in 1994 close to 14, 000 persons per km^2. The population is projected to grow at the rate of 2.35% per year during the 1990's, corresponding to a 26% increase during the decade.

In the following text, the name Metro Manila is used as a short form for the Metropolitan Manila, or National Capital Region.

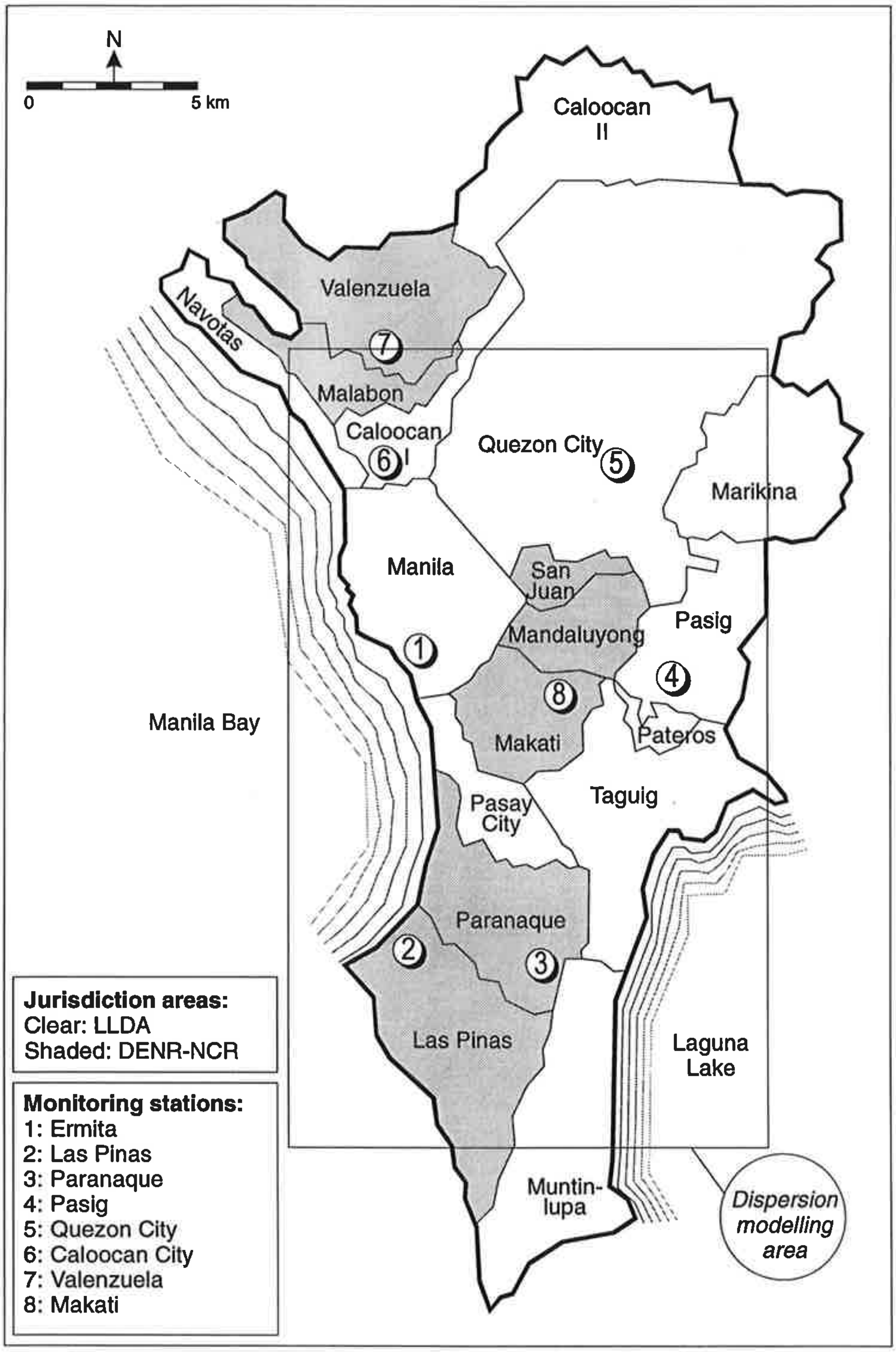


Figure 1.1: National Capital Region (NCR) of the Philippines.

- *Cities and Municipalities*
- *DENR-NCR and LLDA jurisdiction areas*
- *Monitoring stations*
- *Dispersion modeling area*

Around the central part of Metro Manila runs EDSA, the principal circumferencial highway. It is a 12-lane highway running in a demi-circle with a radius of about 7 km (see Figure 1.3). It was built as an outer ring road, but the growth of city centers such as Makati and Quezon City has changed the city's structure. Commercial and administrative development have shifted from the centre to areas outside EDSA, which has become the spine of the city. At Guadalupe, the busiest point, traffic peaks at 11-12, 000 vehicles per hour and daily volumes exceeding 140-150 000 vehicles are common. Traffic congestion is frequent along many sections of EDSA. Daily 2.34 million passengers travel along EDSA, 1.43 million of them by bus. With the projected rise in population and traffic it is expected that there will be a total breakdown in the traffic within a few years unless something is done. Several proposals have been advanced: highway improvements, alternative routes and for public transport a Light Rail Transit System (LRT) along EDSA or a sepatate transitway system.

About 37% of NCR's total land area is used for housing which includes single family residences, multiple residential units, slums and squatter areas. Generally, higher density poor housing areas are located around the commercial and tourist areas which provide informal employment opportunities. Better housing areas are located along EDSA at the Southern edge of Quezon City, at Greenhills in San Juan, near Ortigas in Mandaluyong and Pasig and near the Makati Commercial Center in Makati.

About 8% of Metro Manila is devoted to commercial land use. The old commercial areas are located in Ermita, Malate, Quiapo, Divisoria Sta. Cruz and Binondo of Manila. Recent commercial developments occur in Sta. Mesa, (Manila), Cubao, Balintawak, and Monumento (Quezon City), Makati, Greenhills (San Juan), and the EDSA-Ortigas-Shaw areas at the confluence of Pasig and Mandaluyong. Industrial development claimed about 15% of NCR's land in 1990. The factories are concentrated in strategic areas that provide easy access to transportation in Pasig, Port Area, Paco, Pandacan and Mandaluyong. Other areas of recent industrial concentration are along MacArthur Highway and Tandang Sora in the north and along Pasong Tamo and the South Superhighway in the south. Industries are currently expanding in provinces immediately adjacent to the Metro Manila (Laguna, Cavite, Batangas).

1.3 Data sources

Previous studies

Several institutions have studied and reported the air pollution situation in Metro Manila has. The most important studies, which formed part of the background for the URBAIR work on an Air Quality Management Strategy for Metro Manila, include:

- "Urban Air Pollution in Megacities in the World" from the GEMS/Air-program of WHO/UNEP (WHO/UNEP, 1992).

- "Model for Air Pollution Planning", by Dr. P. Manins, a study for the Environmental Management Bureau, presenting dispersion modeling results for Metro Manila (Manins, 1991).

- The ADB/EMB project on "Vehicular Emission Control Planning in Metro Manila" (ADB/EMB, 1992).

- The DENR/EMB-study "Air Pollution Emission Inventory for Metro Manila, 1990" by P.M. Ayala (Ayala, 1993).

URBAIR data collection

Further data on various aspects of population, pollution sources, dispersion, air quality, health aspects, and the like, have been collected during the URBAIR process, starting in Metro Manila in August 1993. The following local consultants have provided additional useful data according to the project description given in Appendix 8:

- Dr. Reynaldo M. Lesaca and collegues, of Test Consultants Inc., providing data on population, pollution sources, fuel vehicle and traffic statistics, and air quality measurements (see Appendix 8 for summary description of collected data).

- Dr. Emmanuel G. Anglo of the Meteorology Department of the University of the Philippines, at Diliman, Quezon City, providing data on Manila's meteorological and dispersion conditions, and also doing dispersion modeling work (Anglo, 1994).

- Prof. Elma B. Torres and Dr. Ronald D. Subida of the College of Environmental and Occupational Health of the University of Philippines and Dr. Herminia A. Francisco, of the University of the Philippines Los Banos, providing data on health effects of air pollution on the Metro Manila population, and on associated health costs (Torres et al., 1994)

1.4 Summary of development in the National Capital Region (NCR), 1980-1992

Figure 1.2 gives a summary of the available data regarding population, vehicles, fuel consumption and air quality, and development over the last decade. As can be seen, data are not available on all these items for the whole decade. The data shown and summarized here are described in greater detail in the subsequent chapters.

The National Capital Region of the Philippines is shown on the map in Figure 1.1, which also shows the cities and municipalities under the jurisdiction of LLDA (Laguna Lake Development Agency) and DENR-NCR.

The population has grown steadily, from about 6.1 million in 1981 to about 8.4 million in 1992, an increase of about 38%. The total number of vehicles has grown by about 73% over the same period, utility vehicles most significantly. Fuel consumption data for Metro Manila is available only for 1988, 1990 and 1992. The consumption of gasoline and diesel oil has increased substantially. Diesel consumption more than doubled from 1990 to 1992, according to the available data. Diesel is consumed by vehicles, industry and power generation. It is assumed that most of the increase took place in the industrial and small-scale power generation sector. Data available for the Philippines as a whole show consumption increases of 32%, 96% and 43% for gasoline, diesel and fuel oil respectively, for 1985-1991. There was a general decrease in consumption for 1982-1985, reflected somewhat in the car population curve, probably caused by severe economic conditions during that period. In 1990 the GNP/capita figure for the Philippines was US$ 730. During 1965-1990 the growth rate in GNP/capita was +1.3%, while there has been a drop over the last decade, at an average rate of -1.2%.

The development of air quality over the whole decade is not adequately documented. The quality of the measurements before 1986 has been questioned (Lodge, 1992). Since 1986 the measurements have shown substantial increase in Total Suspended Particles (TSP) at some measuring sites, and not at others, such as Ermita in downtown Manila. There has not been a general increase in SO_2-concentrations (see Ch. 2.1).

The TSP concentrations (annual average) are up to 5 times higher than the Air Quality Guidelines (AQG, 90 $\mu g/m^3$) at many of the measuring sites. The SO_2 AQG for 24-hour average is exceeded at times.

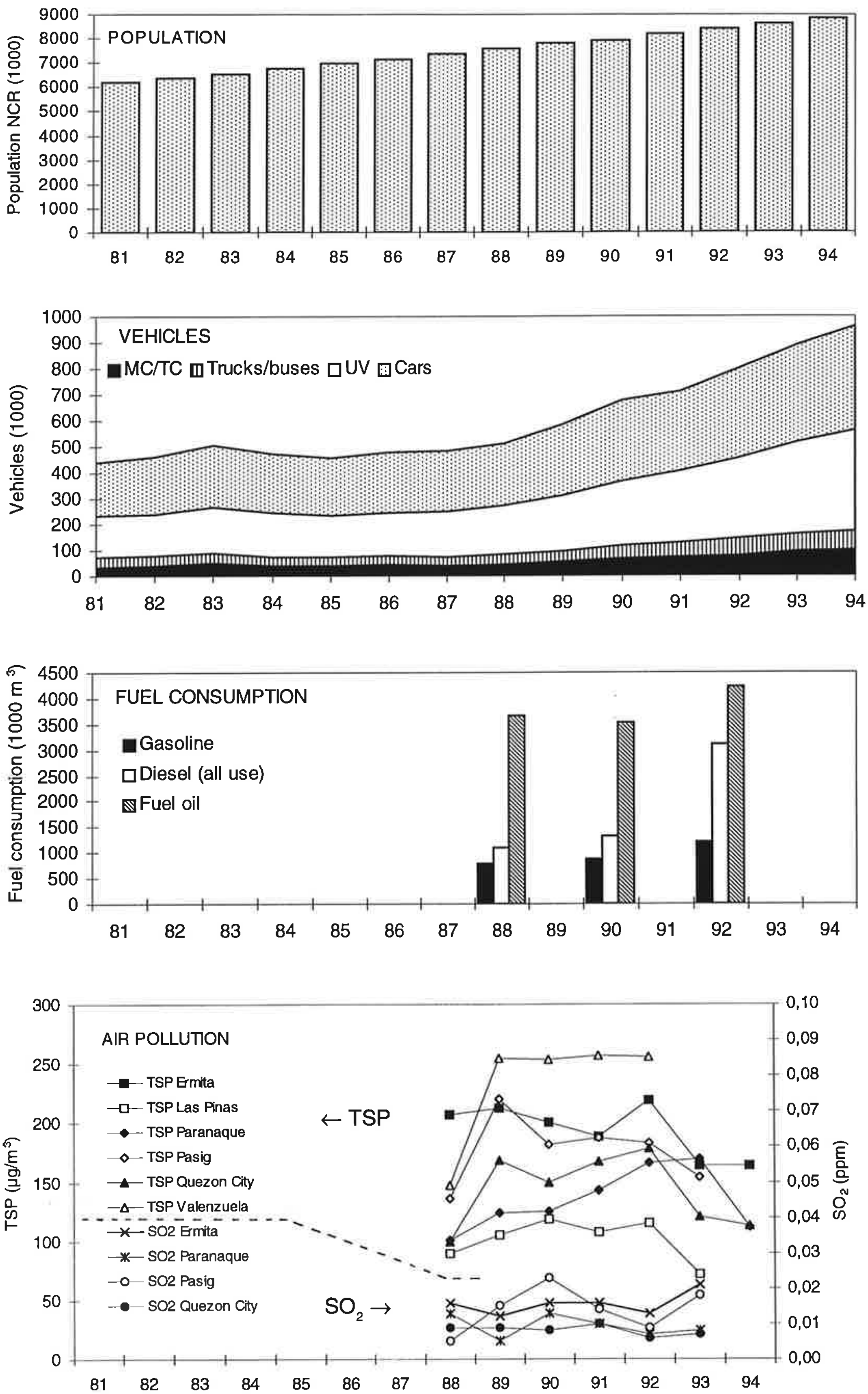


Figure 1.2: Metro Manila development 1981-1992: Population, vehicle fleet, fuel consumption and air quality (annual average concentrations).

1.5 Population

Table 1.1 gives population data for 1980, 1985 and 1990, for the National Capital Region (NCR) and various sub-regions. The Metro Manila population increase of 33% occurred mainly south and north of Central Manila, with the largest increase in the southern municipalities of Paranaque, Las Pinas and Muntinlupa, where the population density is the lowest.

Table 1.1: Population and growth rate 1980-1990, NCR.

	1980	1985	1990	1980-1985	1985-1990	Pop. density 1980	Pop. density 1990
	thousands			percent		(10^3/km^2)	
NCR	5 926	6 940	7 948	+17	+14	9.3	12.5
				1980-1990 percent			
Manila	1 630		1 601	- 2		42.5	41.8
Quezon city	1 998		2 669	+43		7.0	10.0
Near city, South	996		1 197	+20			
- San Juan,						12.5	12.2
- Mandaluyong						7.9	9.5
- Makati						12.5	15.2
- Pasay						20.7	26.5
North	1 016		1 571	+55			
- Caloocan city						8.4	13.7
- Navotas						48.0	72.0
- Malabon						8.2	12.0
- Valenzuela						4.5	7.2
South	482		884	+83			
- Paranaque						5.4	8.0
- Las Pinas						3.3	7.2
- Muntinlupa						2.9	6.0

The average population density of Metro Manila was 12 500 per km^2 in 1990. Navotas and Manila have the highest density, about 72 000 and 42 000 per km^2 respectively, in 1990. The lowest densities in the far North and the far South were 3-7 000 per km^2.

Table 1.2 shows the age distribution of the Metro Manila population in 1990. About 33% was less than 14 years, and about 64% was 15-64 years. The median age was 22.4 years. The sex ratio (males for 100 females) was 94.

Table 1.2: Age distribution of the Metro Manila population, 1990.

Years	%	Years	%
<1	2.8	40-44	5.2
1- 4	9.7	45-49	3.6
5- 9	11.0	50-54	3.0
10-14	10.1	55-59	2.1
15-19	10.7	60-64	1.6
20-24	11.7	65-69	1.0
25-29	10.5	70-74	0.6
30-34	8.8	>74	0.7
35-39	6.9		

1.6 Vehicle fleet

The vehicle fleet in Metro Manila is separated into four categories:

- cars (passenger cars, taxis, light duty vehicles);
- utility vehicles, UV (light duty trucks, jeepneys);
- trucks and buses; and
- motorcycles and tricycles (MC/TC).

Table 1.3 gives the fleet data. Of the 760 million vehicles in 1992, 40% were cars, 41% were UV, 8% were trucks (and buses), and 11% were MC/TC.

Table 1.3: Vehicle fleet data, NCR.

	Vehicles (1000)				
	Cars	UV	Trucks/ Buses	MC/TC	Total
1980	267	105	27	42	
1981	206	163	37	33.9	439
1982	223	164	38	38.6	464
1983	237	179	40	47.6	504
1984	227	169	34	40.4	471
1985	222	166	32	37.6	458
1986	229	170	33	43.3	474
1987	231	179	34	39.4	484
1988	241	189	37	43.7	511
1989	269	216	42	53.7	581
1990	307	252	50	66.6	675
1991	309	278	51.6	73.9	713
1992	343	313	62.4	80.4	799
1993	370	356	65.8	97.0	889
1994	397	389	70.6	102.7	959

Table 1.4 shows that the growth rate was substantial for 1986-1994, and especially after 1992. The average total annual increase was 10.1%, largest for UV's and MC/TC (14-15% annual growth).

Table 1.4: Vehicle growth rate, annual average (percent).

	1981-1986	1986-1992
Passenger cars	2.3	5.4
Utility vehicles	0.8	14.1
Trucks	-1.7	13.8
Buses	-6.6	10.2
MC/TC	5.5	14.8
Total	1.6	10.1

The number of vehicles per capita in Metro Manila, by type, were, in 1992:

Cars : 36 per 1 000 inhabitants
UV : 37 per 1 000 inhabitants
Trucks/buses : 7.4 per 1 000 inhabitants
MC/TC : 9.8 per 1 000 inhabitants

The percentage of diesel-powered vehicles is given in Table 1.5. For buses and trucks this percentage has grown substantially since 1980. In 1990, about 90% of these vehicles were diesel powered. Utility vehicles were about 50/50% gasoline/diesel powered. The diesel percentage for cars have also grown somewhat, and was somewhat less than 5% in 1990.

Table 1.5: Diesel vehicles (percentage).

Vehicle category	1980	1985	1990
Passenger cars	2.3	4.2	4.7
Utility vehicles	36.4	48.2	45.4
Buses	32.3	94.3	93.3
Trucks	30.4	85.3	86.7
MC/TC	1.8	0.55	≈0

1.7 Road and transport

The demand for passenger transport (and almost certainly freight transport) has increased rapidly in Manila during the last decade (Table 1.6). The number of person-trips in 1990 corresponds to an average of 2 trips per day per capita, an increase of 35% during 1985-1990. The public transport share is still very high (about 70%) although decreasing. The private vehicle share of the trips was 30% in 1990.

The trips are almost exclusively on the road system, with only 2% of the trips on the one existing light rail line.

Table 1.6: Road network and person transport data, Metro Manila.

	1980	1983	1985	1990	Growths
Road network, km		2 647		2 987	83-90: +13%
Unpaved roads		15.5%		10.8%	
Transport demand, NCR					
Daily person trips (10^6)	10.97		13.08	17.65	80-85: +19%
					85-90: +35%
Modal share (%)					
Private vehicle	25.6		27.5	30.4	
Jeepney	58.5		56.5	44.1	
Bus	15.8		15.6	23.6	
Commuter train	0.1		-	-	
Light rail	-		0.4	1.9	

The expansion of the road system has not to date matched the increase in transport demand. This A has resulted in a considerable increase in traffic congestions on the roads.

The present main road system is shown in Figure 1.3.

1.8 Industrial sources

Metro Manila has a large and diversified industrial structure. A complete emissions survey from industries in the city does not exist. Table 1.7 gives an overview of the number of companies as of 1994 (references: DENR-NCR, and Lesaca, 1994). Totally, more than 3,000 industrial companies are included, of which more than 1,100 are listed as air polluting. Quite a few of them operate without permit.

Table 1.7: Number of industrial firms in Metro Manila 1994.

	DENR-NCR jurisdiction			LLDA jurisdiction
	North	South	West	
No. of firms	282	567	780	1,429
No. of air polluting firms	95	197	416	430
• with APCF				
-with permit to operate	26	101	230	
-without permit to operate	13	53	33	
• without APCF				
-with permit to operate	26	9	70	
-without permit to operate	30	34	66	

As for the distribution into industrial sectors in 1986 Manins (1991) gives the figures listed in Table 1.8. This may still be representative of the present distribution. The industries are located in industrial areas which are dispersed throughout Metro Manila.

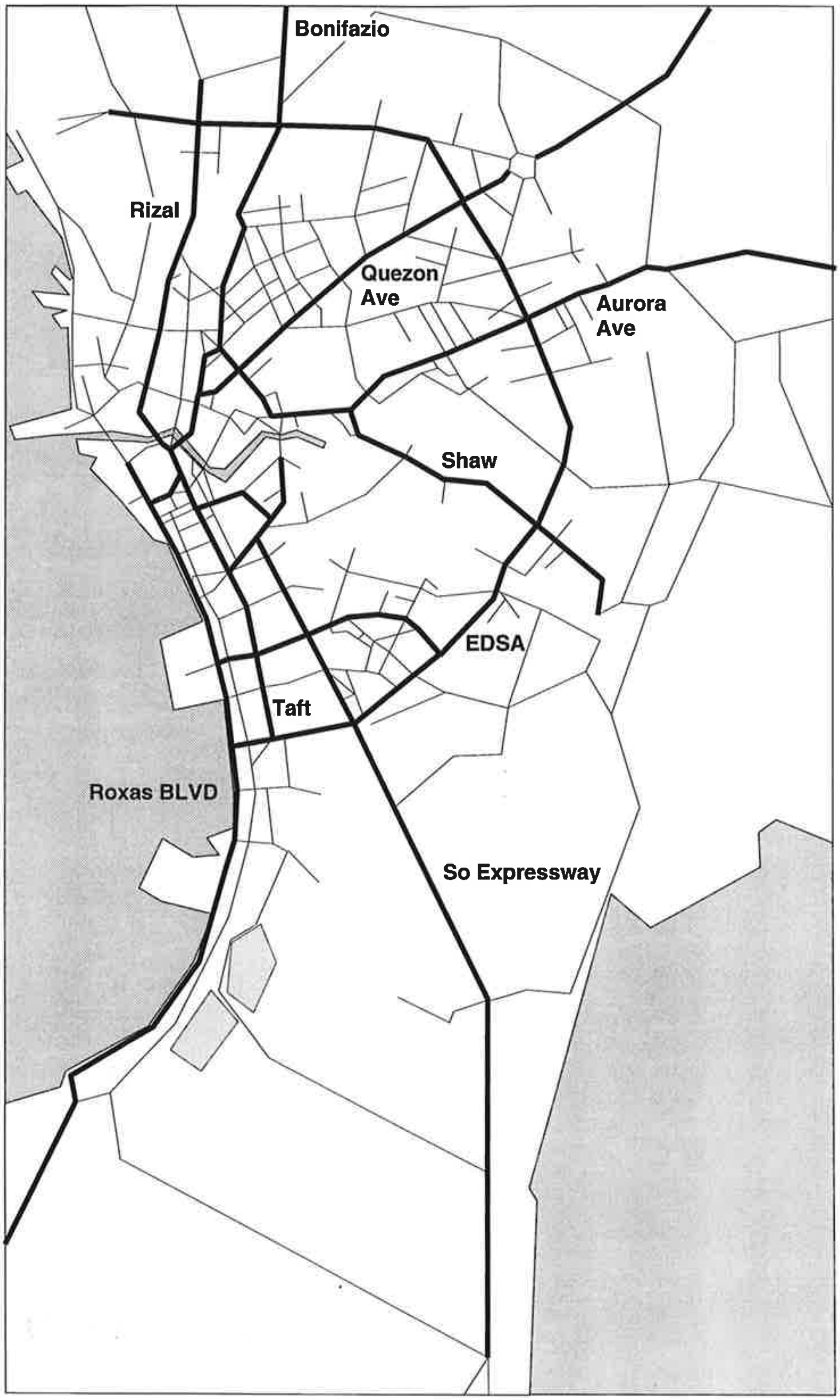


Figure 1.3: Metro Manila main road network.

Table 1.8: Number of industries in Metro Manila, DENR-NCR jurisdiction areas, 1986 (Manins, 1991).

Food manufacturing industries	352
Textile	223
Footwear	351
Paper and paper products	73
Rubber products	59
Chemical and related industries	372
Non-metallic mineral industries	91
Basic metal industries	180
Metal products	218
-	
-	
-	
Total in DENR-NCR	2,861

Ayala attemptes an industrial emissions survey for the DENR-NCR areas. According to her inventory, the main air polluting industrial source categories are (not ranked):

- Textile mills (SO_2);
- Food and related products manufacturing (SO_2);
- Paper and related products (PM);
- Petroleum and coal products (PM); and
- Fabricated metal products (PM).

As part of this URBAIR contract, E. Anglo has found the locations of more than 1, 800 industries in NCR, obtained from 1:10 000 scale maps. The locations are shown in Figure 1.4. So far the database does not include plant, stack and emissions data, which obviously need to be included in the future.

1.9 Fuel consumption

Fuel consumption data for Metro Manila are available only for 1988, 1990 and 1992. Table 1.8 gives data for gasoline, diesel oil, fuel oil, kerosene, liquified petroleum gas (LPG) and aviation fuels. The primary data source was the Energy Regulatory Board (Lesaca, 1994).

The increase in fuel consumption over this 4-year period is substantial for some products of importance to air pollution: 57% for gasoline and 187% for diesel oil. Fuel oil consumption is also increasing somewhat, about 15%. Kerosene and LPG consumption has increased also substantially, but the total amount of air pollution emissions from these fuels are insignificant.

There have been power shortage problems in the Metro Manila area since 1992, resulting in scheduled, periodic brown-out periods. This has caused a substantial increase in the use of generator sets for power supply during the brown-out periods, resulting in a substantial use of diesel oil. No estimate is available on the

Table 1.9: Petroleum product sales, Metro Manila (10^6 l). (Reference: 1988: Manins (1993); 1990, '92: Lesaca (1994)).

Product	1988 Total	1990					1992 Total	1990-1992
		Re-seller	Ind'l consumers	PI Govt	US bases	Total[1]		
Road traffic								
Premium gasoline	772	679	62	68	3	812	1 018	+ 42%
Regular gasoline		28	10	3	0	41	194	
Diesel oil[2]	1 080	599	583	84	16	1 282 (+24)	3 102	+138%
Power generation								
Fuel oil, total	3 669	0	3 508	2	0	3 510 (+48)	4 225	+ 19%
Fuel oil, in power plants	1 409					1 131	1 662	+ 47%
Domestic/Commercial								
Kerosene	406	110	65	0	0	175	312	+ 78%
LPG	334	255	231	0	0	486	682	+ 40%

1 Number in brackets: Int'l sales.
2 Used partly for road traffic, partly for medium-to-small scale power generation.

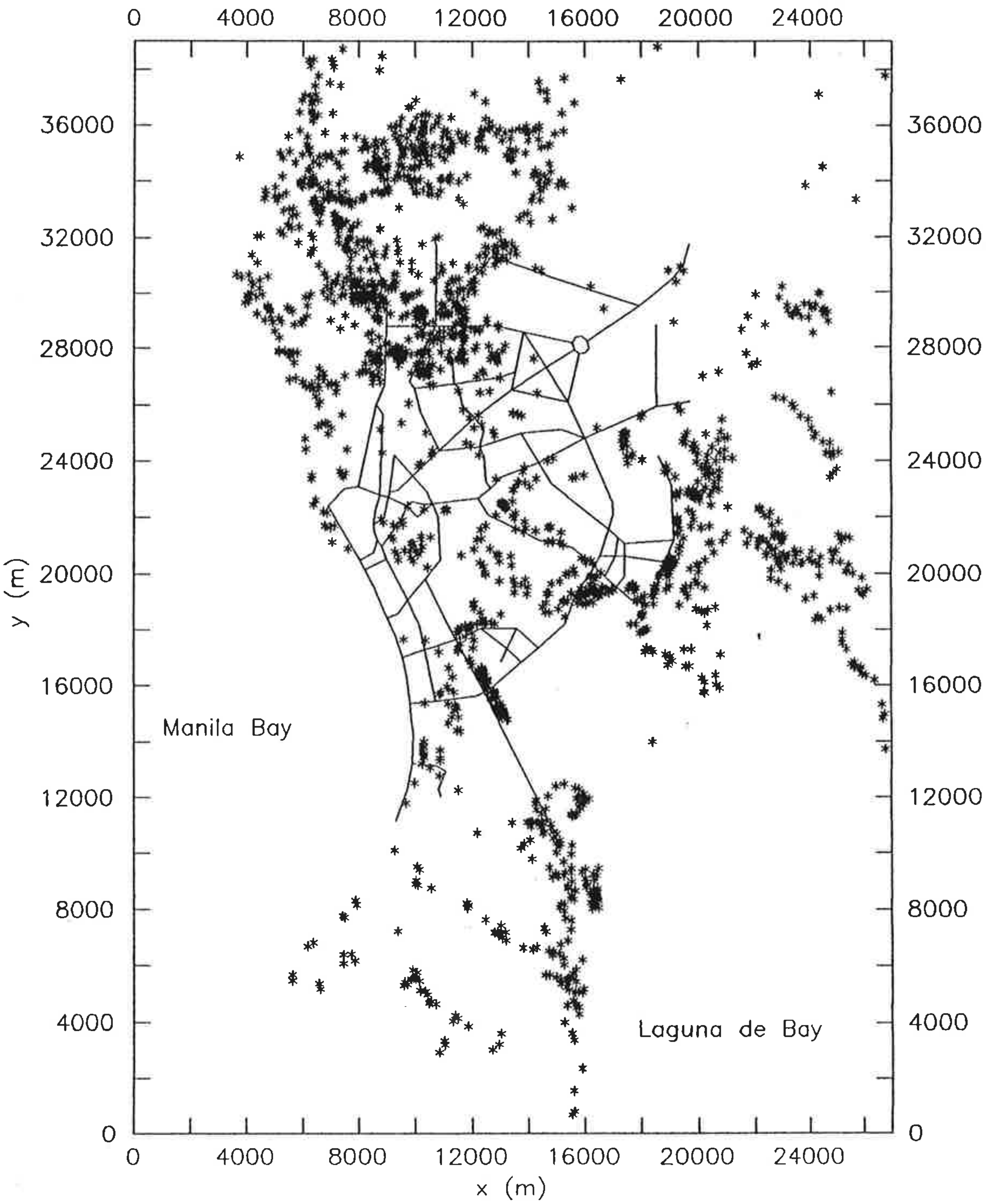


Figure 1.4: Locations of factories in Metro Manila (1987) (Ref.: E. Anglo, 1994)

annual amount of diesel oil for such purpose. The substantial consumption increase which is shown by the data from 1990 to 1992 may at least partially be explained by this.

2. Air quality assessment

The purpose of this chapter on Air Quality Assessment is to **estimate population exposure** to area air pollutants, and to quantify the contributions to this exposure from the various pollution sources.

This estimate is arrived at through the following analysis:

- Description of existing air pollution concentration measurements and their variation in time and space;
- Inventory of air pollution sources and their relative contributions;
- Description of the concentration distributions in the area, by means of dispersion modeling; and
- Calculating of the population exposure, by combining spatial distributions of population and concentrations, also incorporating exposure on roads and in industrial areas.

2.1 Air pollution concentrations

Overview of database

Metro Manila's air pollution measurement programmes reveal that Metro Manila has a substantial particle pollution problem. TSP and PM_{10} frequently exceed air quality guidelines. SO_2 is much less pronounced, although guidelines are exceeded at times. As the following analysis shows, SO_2 measurements in Manila need further evaluation. The SO_2 emission inventory indicates that SO_2 concentration level are significantly higher than the measurements indicate, as explained further later in this chapter.

In Appendix 1, the monitoring networks and results of measurements are described in greater detail. The monitoring networks which have provided the data on which our assessment are based, are the following:

- The DENR-NCR Air Quality Monitoring Network, consisting of 7 stations from which TSP and SO_2 data are reported regularly. 24 hour average samples are taken a few days per month, on a rotational basis. In periods of frequent brown-outs (1990-1993), 1 hour average samples have been taken instead of 24 hour samples. Some of these stations can be characterized as area-representative stations (Quezon City, Makati), others are located near streets with relatively heavy traffic (Ermita, Paranaque, Las Pinas), while others are located in industrial areas (Valenzuela, Pasig).

- The ADB/EMB monitoring network of 5 stations operated during parts of 1991/1992 (August to March) with NO_x, CO and SO_2 monitored continuously at 1 station, and 24 hour samples of TSP, PM_{10} and lead taken every 3rd and 6th day at some or all stations. Two of the stations had meteorological monitors. These stations were located on or near streets.

In the following, emphasis is put on summarizing the TSP, PM_{10}, lead and SO_2 measurements. The measurements of CO, NO_x, and particularly ozone, are, as described in Appendix 1, insufficient for concluding on prevalent levels in Metro Manila.

TSP

The Philippines has adopted the upper limit value of WHO air quality guidelines (AQG) as their National AQG (see Appendix 2). The WHO guidelines are as follows:

Long-term (annual) average :	60- 90 µg/m^3
Short-term (24 hour) average :	150-230 µg/m^3

These values are clearly exceeded at all DENR-NCR measurement stations in Manila, as shown in Figure 2.1. This figure gives annual averages for 1992 and the maximum values measured during 1990-1992. The annual averages for 1990 and 1991 do not differ much from those of 1992.

The highest annual average concentrations are measured at the Valenzuela station, situated in an industrial area (lumberyards and light steel industries). Otherwise, the highest concentration are in Manila (Ermita station), and diminish towards the outskirts. Annual TSP averages at the Ermita and Valenzuela sites are 2.5 to 3 times the AQG value.

Very high 24 hour average values are recorded at all stations. Except for one extreme value, 823 µg/m^3 at Makati (possibly due to some extraordinary industrial influence), the maximum values are 300-500 µg/m^3, or as much as 2 times the AQG value.

Figure 2.2 shows samples of time series of 24-hour TSP measurements at the Valenzuela and Ermita sites for 1992. These show, as is generally true in Metro Manila, an annual variation with relatively higher values in the late winter (dry season) than during the wet season (starting July/August).

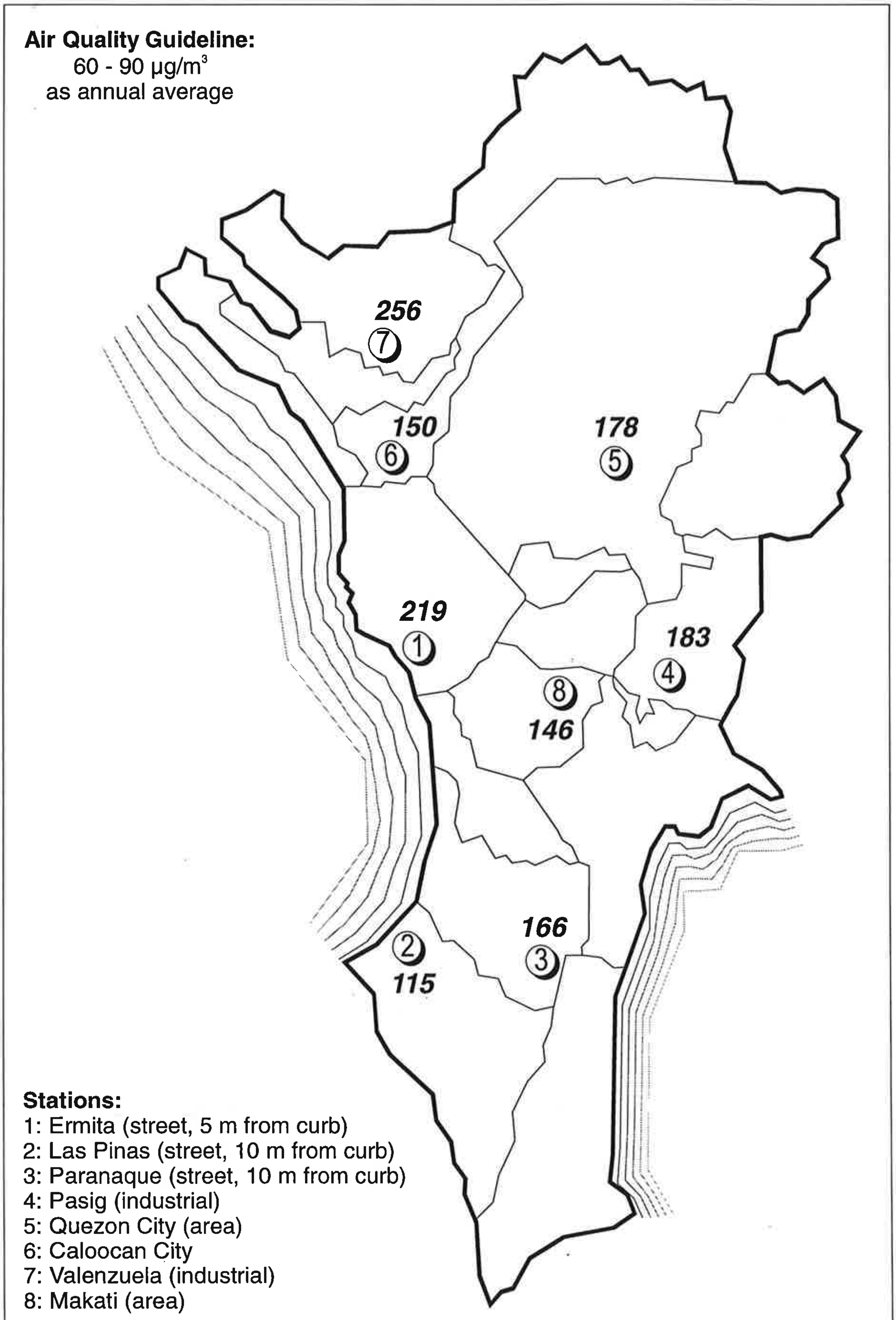


Figure 2.1a: Mean annual TSP concentrations for the year 1992 ($\mu g/m^3$)

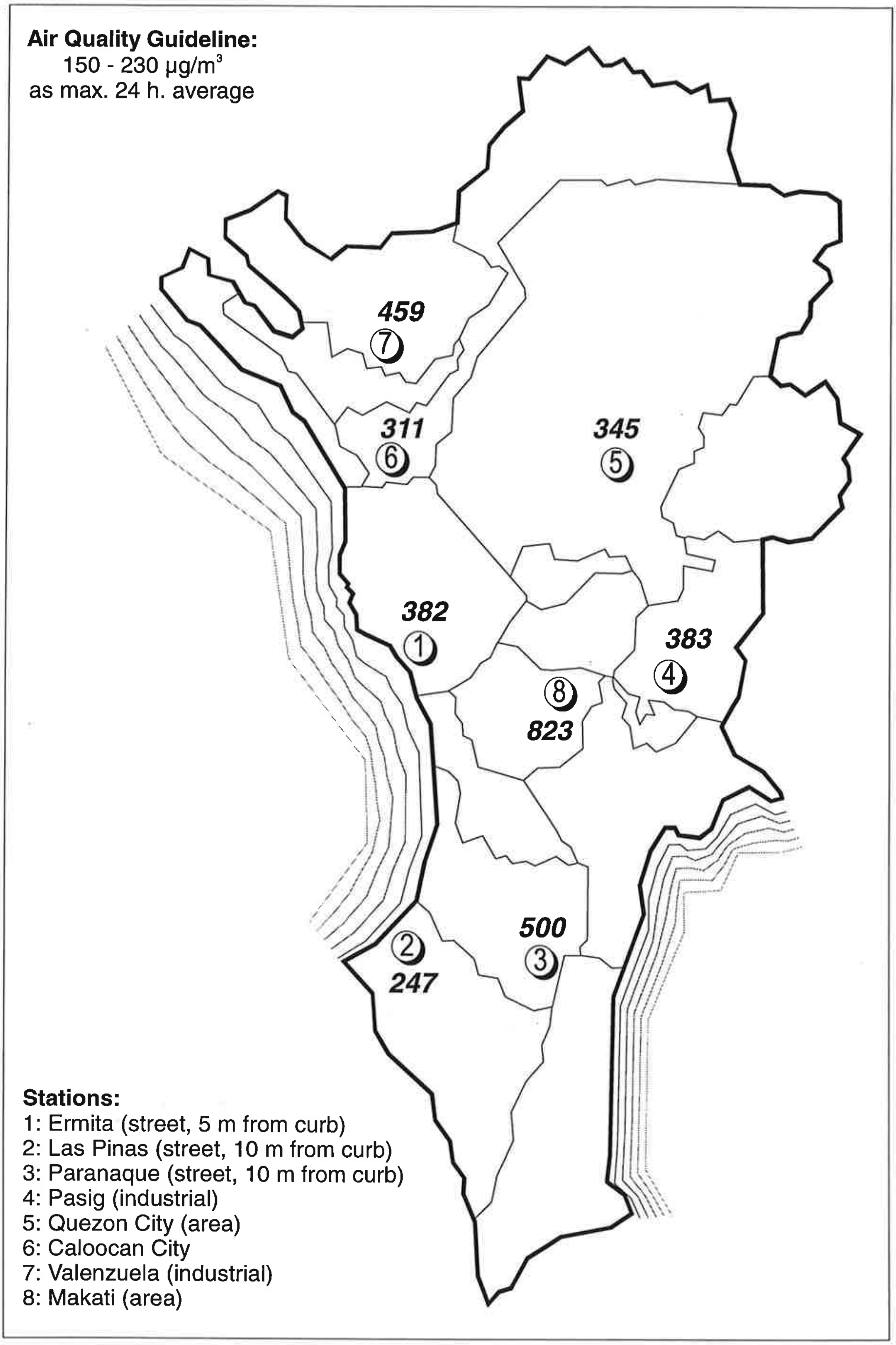
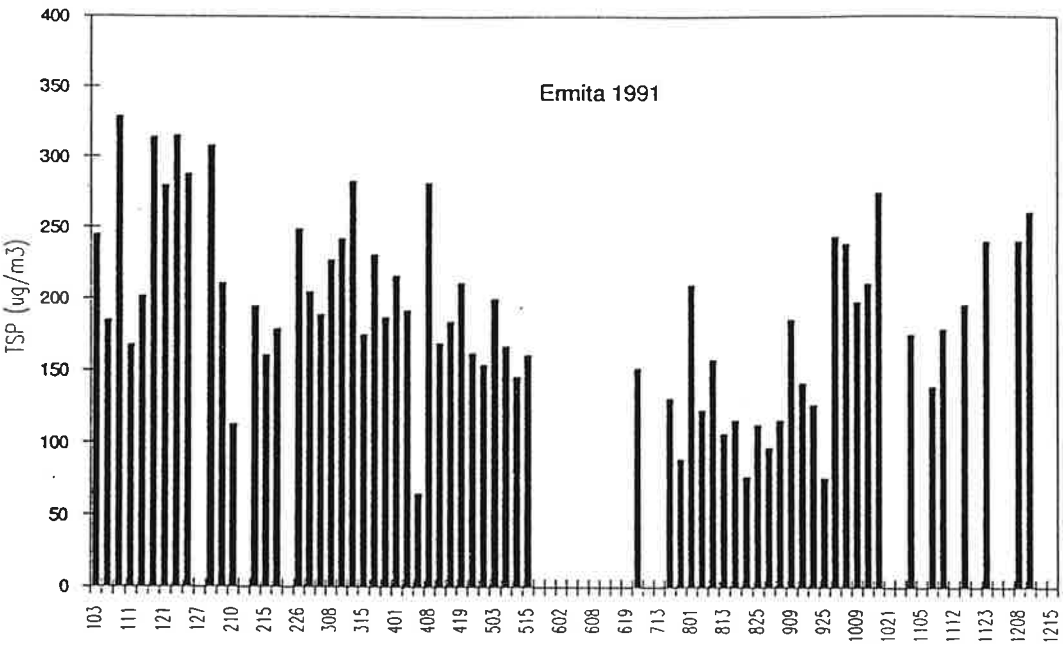


Figure 2.1b: Maximum 24 hours TSP concentrations during the years 1990-1992 (µg/m³)



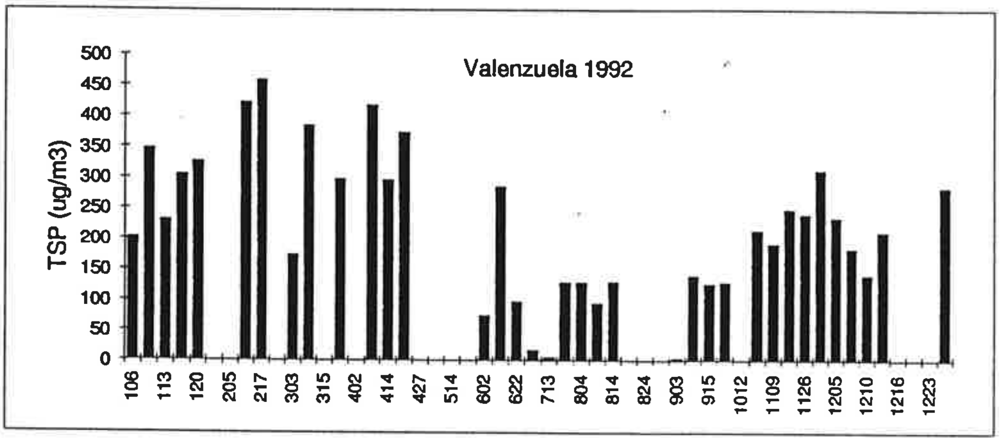


Figure 2.2: 24-hour TSP concentrations given by month and day for the Ermita and Valenzuela sites (µg/m³)

Dry season TSP could be as much as a factor of 2 higher than wet season TSP. This probably reflects one or more of the following effects:

- increased wind speed and turbulence, causing dispersion, during the monsoon;
- decreased resuspension from the ground during the monsoon; and
- increased washout of particles during the monsoon.

Some of thse stations are exposed to industrial source areas, or road traffic. Measurements at and near streets with heavy traffic were made in the ADB/EMB Vehicular Pollution Control project.

Table 2.1: TSP concentrations (μg/m³) measured on sites located on or near streets

Station	Street/AADT	TSP concentration Average	max. 24 h	Period 1991/1992	No. of observations
Ermita, Manila	Taft/	256	549	Aug.-Feb.	49
ADB, EDSA	EDSA/	497	843	Aug.-Feb.	47
Monumento	EDSA/	400	489	Feb. 92	5

On heavily exposed streets such as the EDSA, TSP concentrations are very high on average, and maximum 24 hour concentrations reach 850 μg/m³.

This summary points to TSP as a general air pollution problem in Metro Manila, in most parts of the city, especially near streets and industrial areas, and especially during the dry season.

PM_{10}

Inhalable particles (PM_{10}, particles with diameter less than 10 μm) is a better indicator than TSP of the possible health effects of airborne particles. The provisional Philippine National AQGs and the WHO AQG for PM_{10} are as follows (μg/m³):

	National	WHO
Long-term (annual) average	60	
Short-term (24 h) average	150	70

In Metro Manila, PM_{10} has been measured only at the traffic exposed stations of the ADB/EMB project along EDSA, Quezon City during August 1992-February 1993, the dry season.

Measured PM_{10} concentrations were rather high, indicating annual and-24 h PM_{10} averages of more than twice the national AQG. The maximum 24h averages are more than 4 times the WHO AQG.

PM_{10} concentrations at area-representative sites are probably lower than those at the street sites. An estimate of the PM_{10} concentrations at the DENR-NCR sites can be arrived at by means of the average PM_{10}/TSP ratio measured at the ADB stations. This ratio is about 0.5. Using this ratio gives annual average PM_{10} concentrations at the DENR-NCR stations which are within the range 60-130 μg/m³, considerably higher than the national AQG (60 μg/m³), and highest at the Ermita and Valenzuela stations. Maximum PM_{10} concentrations would be about 150-200 μg/m³, at or above the national AQG (150 μg/m³) and well above the WHO AQG (70 μg/m³).

This points to PM_{10} as a significant air pollution problem, especially at and near the main road network, but also throughout Manila.

Table 2.2: PM_{10} concentrations (µg/m³) measured on sites located on or near streets

Station	Street/AADT	PM_{10} concentration		Period 91/1992	No. of
		Average	Max. 24 h		obs.
Ermita, Manila	Taft/	144	258	Aug.-Feb.	62
ADB, EDSA	EDSA/	219	321	"	47
DENR-NCR	Quezon Ave/	227	321	Oct.-Feb.	26
San Lorenzo, Makati		179	206	Jan.-Feb.	10
Monumento	EDSA/	198	241	Feb. 92	5

Lead

Results from lead measurements at the Ermita, ADB and Monumento sites of the ADB/EMB study are shown in Table 2.3, together with TSP and PM_{10} results.

Table 2.3: Lead, TSP and PM_{10} results (µg/m³) from ADB/EMB study 1991/1992, Metro Manila (n, number of measurements).

	Pb		PM_{10}		TSP	
	Mean	(n)	Mean/Max	(n)	Mean/Max	(n)
Ermita	1.07	(36)	144/258	(62)	256/549	(49)
ADB	2.30	(34)	219/321	(47)	497/843	(47)
Monumento	1.00	(4)	198/241	(5)	400/489	(5)

In general, measured long-term lead levels exceed the Philippines' AQGs (1.0 µg/m³) and the WHO (0.5-1 µg/m³). 24-hour averages up to 5.5 µg/m³ were recorded at the ADB site in 1991/1992.

The lead content gasoline in the Philippines (national standard) is reported to be (Rolfe, 1992):

	Up to 1991	1992
Regular gasoline (RON 81 min)		0.4
Premium gasoline (RON 93 min)	0.84	0.6

Low lead gasoline (0.15 g/l) was introduced in July 1993, and after February 1994 unleaded gasoline is also available in key cities. After this time, the lead concentration in the air in Metro Manila has been reduced quite considerably, according to measurements (NEDA, 1994), see Table 2.4.

Table 2.4: Ambient concentration of lead: 1993 and 1994 (μ/m3) 24-hour sampling time.

Year/Month	Ermita	Las Pinas	Makati	Pasig	Quezon City	Valenzuela
1993						
January		0.4				0.7
February	1.28			0.45		0.48
March	1.06		1.18	0.45		
August	0.58		0.27	0.28	0.28	0.23
September	0.26		0.27	0.31	0.23	0.48
October	0.33		0.59	0.38	0.37	
November	0.56		0.49		0.33	0.49
December	0.57				0.28	0.66
1994						
January	0.33	0.23	0.37	0.63	0.26	0.45
February	0.4	0.24	0.29		0.29	0.87
March	0.42	0.17	0.39		0.42	0.85
April	0.21	0.14	0.29		0.18	
May	0.2	0.16	0.25		0.17	
June	0.29		0.35		0.17	
July	0.24		0.24		0.19	

Note: April to July 1993 n.a.
Source: Environmental Management Bureau

SO_2

The Philippine national, and WHO AQGs are given below:

	National AQG		WHO AQG
Long-term (annual) average	80 μg/m3	(0.03 ppm)	50 μg/m3
Short-term (24 hour) average	180 μg/m3	(0.07 ppm)	125 μg/m3

The summary of measurements in 1990/1992, shown in Figure 2.3a and b, indicate that the long-term average SO_2 concentration is low, less than one-half of the AQG, and that the maximum 24-hour values exceed the AQG, only occasionally. The TGS (Pararosaniline) colorimetric method is used to measure this.

SO_2 monitoring at the Ermita station during the ADB/EMB study gave, for a one-month period, 24 average values up to 0.035 ppm.

Considering the amount of high-sulfur fuel oil which, according to the available fuel consumption data, is used in Manila, this measured SO_2 concentration level seems suspiciously low.

Table 2.5 gives calculated emission data for SO_2 and TSP for various combinations of area-wide source categories, as well as the ratio between the SO_2 and TSP emissions (see Ch. 2.2). Also, the measured SO_2/TSP ratios at DENR-NCR sites are shown.

Power plant emissions are not included in this exercise, because their high stacks, do not affect ground level concentrations very much.

Table 2.5 Calculated SO_2 and TSP emissions in Metro Manila, 1992 and the ratios between them, and between measurements at DENR-NCR sites.

	Source(s) - 10^3 tonnes/a			Measured SO_2/TSP concentation ratios at DENR-NCR sites, averages, 1992[1]
	Traffic	Traffic + areawide fuel	Traffic + areawide fuel + resuspension + construction	
SO_2 emissions	17.0	258	258	
TSP emissions	8.9	25.9	60.9	
$\frac{SO_2}{TSP}$	1.9	10	4.2	0.08-0.14

1 An extra-urban background of 30 $\mu g/m^3$ has been subtracted from the TSP measured values.

The measured ratios are much lower than the ones from the emission survey. The discrepency may be explained by the following possible reasons:

- The TSP emission inventory is seriously lacking. Resuspension of dust is an important but only roughly estimated source, and no data are available for wood and coal consumption. Also, industrial process emissions may be significantly underestimated.

- The SO_2 emissions inventory is not sufficently precise, especially because the actual sulfur-content in BOF might be much lower than the maximum allowed 3.8%.

- The SO_2 measurements give suspiciously low concentrations.

All these factors may be necessary to explain the differences, and it seems fair to indicate that the SO_2 measurements are much lower than the actual concentrations.

SO_2 concentrations reported during 1977-1989 may be taken to support this, as summarized by UNEP/WHO (1993). Measurements with SO_2 monitors before 1983, gave SO_2 concentrations three times higher than the TGS bubbler method used after 1985.

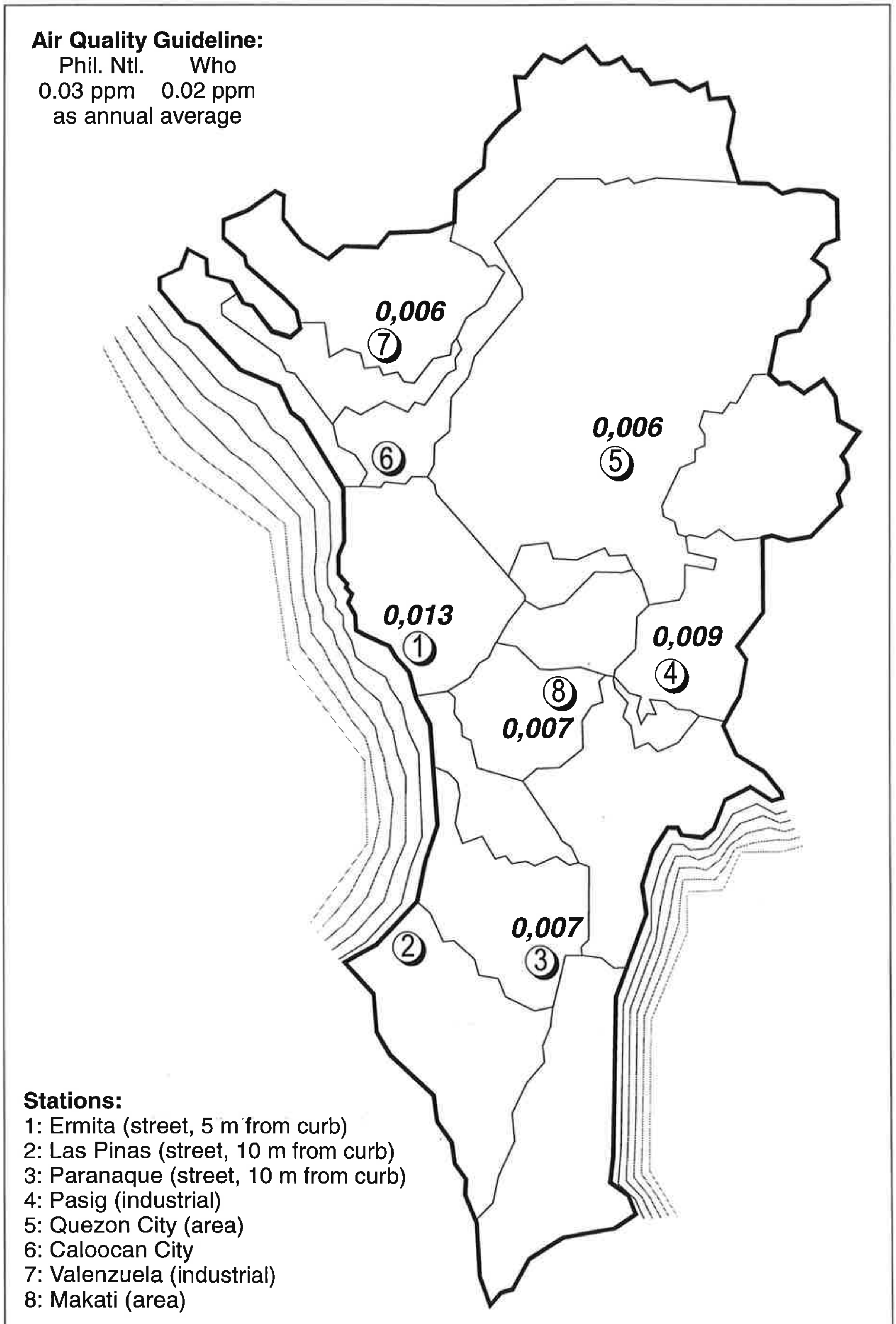


Figure 2.3a: Mean annual SO_2 concentrations for the year 1992 (ppm).

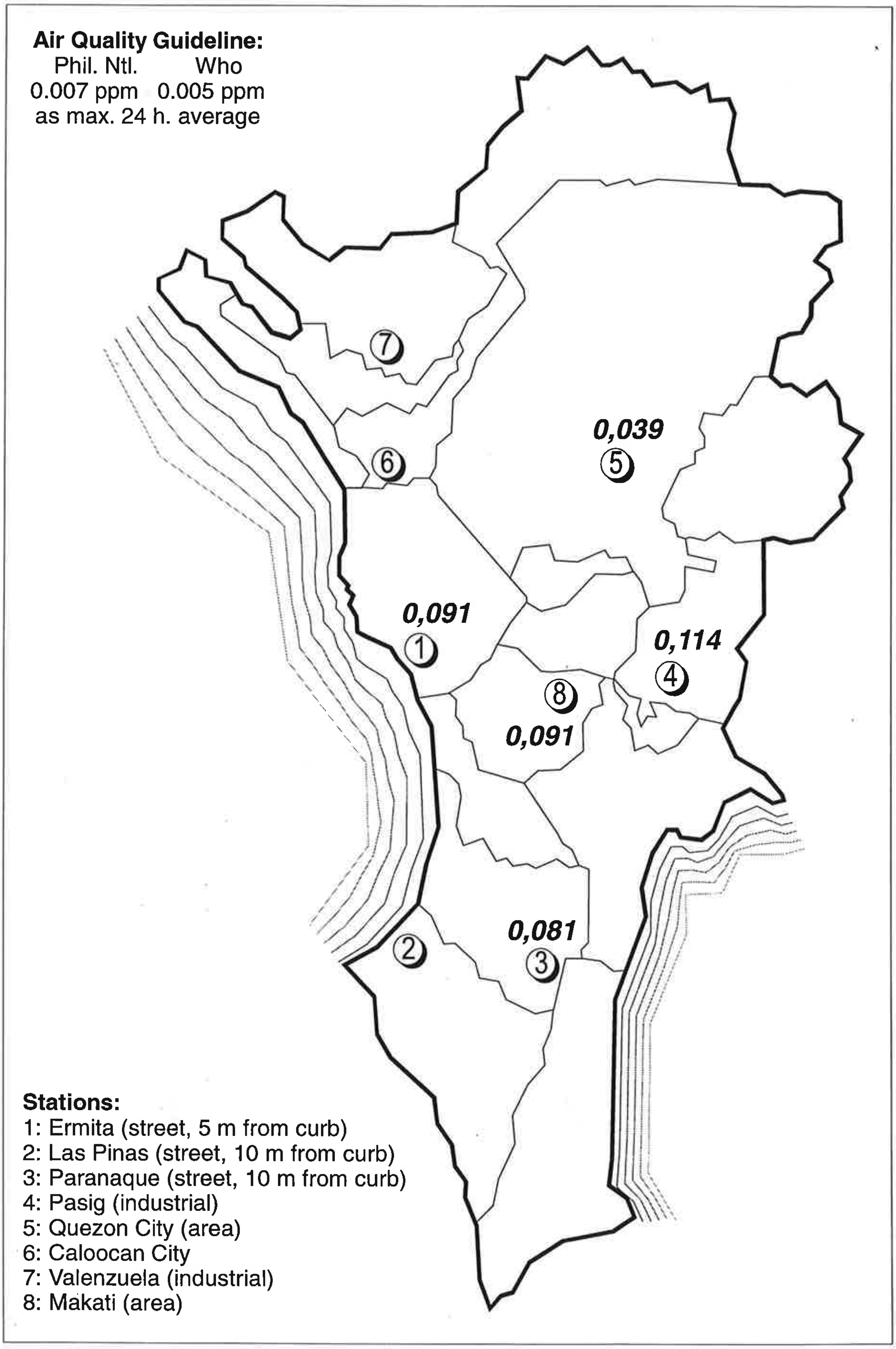


Figure 2.3b: Maximum 24-hour SO_2 concentrations during the years 1990-1992 (ppm).

2.2 Air pollutant emissions in Metro Manila

Total emissions

There has been various attempts to produce a total air pollutant emission survey for Metro Manila.

In 1991, Dr. Manins, as a visiting WHO consultant, develpoed a gridded emission inventory for SO_2 in connection with establishing a "model for air pollution planning" (Manins, 1991). In 1993, Ms Ayala, as a UNDP-TOKTEN consultant, worked out a total emission survey for CO, NO_x, SO_2, TSP, PM_{10} and TOG as well as the methodology for producing such a survey (EMB, 1993). This survey is not gridded, and the emissions are not distributed spatially over the city.

These surveys have suffered under various constraints especially the completeness of the input database. The most pronounced shortcoming is that emission data from industrial plants have not been available from the LLDA jurisdiction areas (Manila, Quezon City, Caloocan, Marikina, Pasig, Pateros, Pasay, Taguig, Muntinlupa). The results of their work are summarized in Appendix 4.

Based on the studies mentioned above, the work done within the ADB/EMB Vehicular Emission Control Project (VECP, 1991) and additional data on traffic and fuel consumption provided by Test Consultants Inc. in Manila (Lesaca, 1993), a modified total emission calculation was performed in this URBAIR study for TSP, PM_{10}, and SO_2.

The emission inventory is presented in Table 2.6, based on the emission factor data given in Table 2.7, and the fuel consumption and traffic activity data of Table 2.8. The traffic activity data are described in detail in Appendix 4. The fuel consumption data for 1992 were taken from official statistics (Lesaca, 1993).

The inventory covers the main source categories. The category "generator sets" is not separated out in the inventory, since data on the fuel consumed by these has not been available. Their fuel consumption is included under DOF.

The source contributions to TSP and PM_{10} are shown in Figure 2.5.

As described below and in Appendix 4, the accuracy of the emission inventory should not be overestimated. Some of the estimates are very rough, and based upon incomplete background information. We do not attempt at this stage to estimate the accuracy of the figures. Nevertheless, the presented inventory is considered sufficiently accurate for a first estimate of source contributions, and a suitable background for a first. stage cost-benefit analysis.

Table 2.6: Total annual TSP and SO_2 emissions in Metro Manila, 1992, according to source groups

Emission sources	Vehicle type/Industry	TSP tonnes/a	TSP %	PM_{10} tonnes/a	PM_{10} %	SO_2 10^3 tonnes/a
Transport Sector						
Exhaust						
Gasoline vehicles	Cars	580	0.8	580	1.4	
	UV	1 180	1.6	1 180	2.7	
	MC/TC	290	0.4	290	0.7	
	Bus/truck	150	0.2	150	0.4	
Diesel vehicles	Taxies	170	0.2	170	0.4	
	UV	1 160	1.5	1 160	2.7	17.0
	Jeepneys	1 580	2.1	1 580	3.8	
	Truck/bus	3 800	5.1	3 800	9.0	
Sum vehicle exhaust		8 910	11.9	8 910	21.1	
Resuspension from roads		25 000	33.4	6 250[6]	14.9	
Energy/industry sector						
Power plants		2 120[1]	2.8	2 010[2]	4.7	101.8
Other fuel combustion						
BOF (Bunker)	Industrial/commercial	14 380	19.2	12 220[3]	28.9	216.6
DOF (Diesel)	Industrial/domestic	2 550	3.4	1 280[4]	3.0	24.2
Kerosene		20	-	20	-	-
LPG		40	0.1	40	0.1	-
Wood		?	-			-
Coal		?	-			?
Sum, fuel combustion (excl. power plants)		16 990	22.6	13 570	32.0	
Industrial processes[7]		6 000	8.0	3 000[5]	7.1	?
Other						
Refuse burning[7]		(<)6 000	(<)8	(<)6 000	14.2	-
Construction[7]		10 000	13.3	2500[6]	5.9	-
Sum		(<)75 020	100	(<)42 240	100	359.6+

1 Emission control: Multicyclone
2 PM10 = 0.95 x TSP (Ref.: EPA AP42)
3 PM10 = 0.85 x TSP (Ref.: EPA AP42)
4 PM10 = 0.50 x TSP (Ref.: EPA AP42)
5 PM10 = 0.50 x TSP (Rough estimate)
6 PM10 = 0.25 x TSP (Rough estimate)
7 Rough estimates

Table 2.7: Emission factors for particles (TSP), used for Metro Manila. For references, see Appendix 3

Emission source	Vehicle type/ Industry	This work	Ayala ADB/EMB
Vehicles			
Gasoline	Cars	0.2 g/km	0.1
	UV	0.33 g/km	0.12
	MC/TC	0.5 g/km	2.0
Diesel	Taxies	0.6 g/km	0.6
	UV	0.9 g/km	0.9
	Jeepneys	0.9 g/km	0.9
	Truck/bus	2.0 g/km	1.5
Resuspension		2.0 g/km	~7
Fuel combustion			
Power plants		1.5 kg/m^3 1)	
BOF (Bunker)	Industrial/commercial	5.1 "	
DOF (Diesel)	Industrial/domestic	1.4 "	
Kerosene		0.06 kg/tonne	
LPG		0.06 kg/tonne	
Refuse burning	Residential	37 g/kg	

Table 2.8: Traffic activity and fuel consumption data, Metro Manila, 1992

Emission source	Vehicle type/Industry	10^3 m^3/a	10^9 vehicle km/a
Vehicles			
Gasoline	Cars	292	2.92
	UV	536	3.57
	MC/TC	28	0.57
	Bus/truck	66	0.22
Diesel	Taxies	29	0.29
	UV	262	1.75
	Jeepneys	194	1.29
	Truck/bus	571	1.90
Fuel consumption			
Power plants		1 410	
BOF (Bunker)	Industrial/commercial	2 830	
DOF (Diesel)	Industrial/commercial/domestic	1 820	
Kerosene		312	
LPG		682	
Wood		?	
Coal		?	

TSP

The industrial processes emission figure in Table 2.6 is a very rough estimate. It is based on the Ayala emission survey presenting total emissions from industries, by industrial branch. The present work estimates how much of the calculated TSP emissions are associated with fuel consumption, based on her corresponding SO_2 emissions The rest are presumed process emissions. The emission figure for construction is also taken from Ayala's work, which was based mainly of US EPA emission factors.

For refuse burning, a rough total emissions figure is given here. The estimate is based on 1 million households in Metro Manila each burning 0.5 kg of refuse per day. This is probably an overestimate. Even so, refuse burning is not a large source compared to other fuel combustion.

For road dust resuspension, a rough estimate is given here. Ayala's estimate is believed to be much too high for Metro Manila. She used a factor of 7 g/km, while the US EPA suggests the following emission factors (EPA, AP 42):

- local streets (AADT < 500): 15 g/km
- collector streets (AADT 500-10 000): 10 g/km
- Major streets (AADT 10 000-50 000): 4.4 g/km
- Freeways/expressways (AADT >50 000): 0.35 g/km

These factors are suggested for dry road conditions. Much of the traffic activity in Metro Manila takes place on roads with AADT >50 000. Assuming the traffic activity share of these road classes are 5%, 25%, 30%, 40% respectively, and that the roads are wet 50% of the time, EPA emission factors suggest an average factor of somewhat more than 2 g/km. Even this may be felt as an overestimate. However, 2 g/km was selected as an average resuspension emission factor for Metro Manila. TSP concentrations measured at the ADB study street stations support a resuspension factor of about this magnitude. Also, a recent evaluation of emission rates from roads, based on measurements, supports in general the EPA emission factors for paved roads, although the study concludes that more investigation is needed (Claiborn et al., 1995).

Emission estimates for power plants are based on an emission factor of 1.5 kg/m^3, assuming multi-cyclone emission control. If the multi-cyclones are out of order, which is sometimes the case, the emissions are about 4 times greater. Even so, power plants are not significant contributors to ground level particle concentrations, due to their tall stacks which disperse the emissions. SO_2 emissions will, however, in combination with other SO_2 emissions in the area, at times exceed AQGs in the area (1-4 km) near the plants (see Ch. 2.3.3).

Source contributions for TSP and PM_{10} are shown in Figure 2.5. The largest contributions are from BOF combustion, most probably in small to medium industrial and commercial installations, and from resuspension and construction activities. Vehicle exhaust contributes about 12% of total TSP emissions. The largest traffic contributors are diesel trucks and buses and diesel jeepneys, with 6.2% and 2.7% respectively.

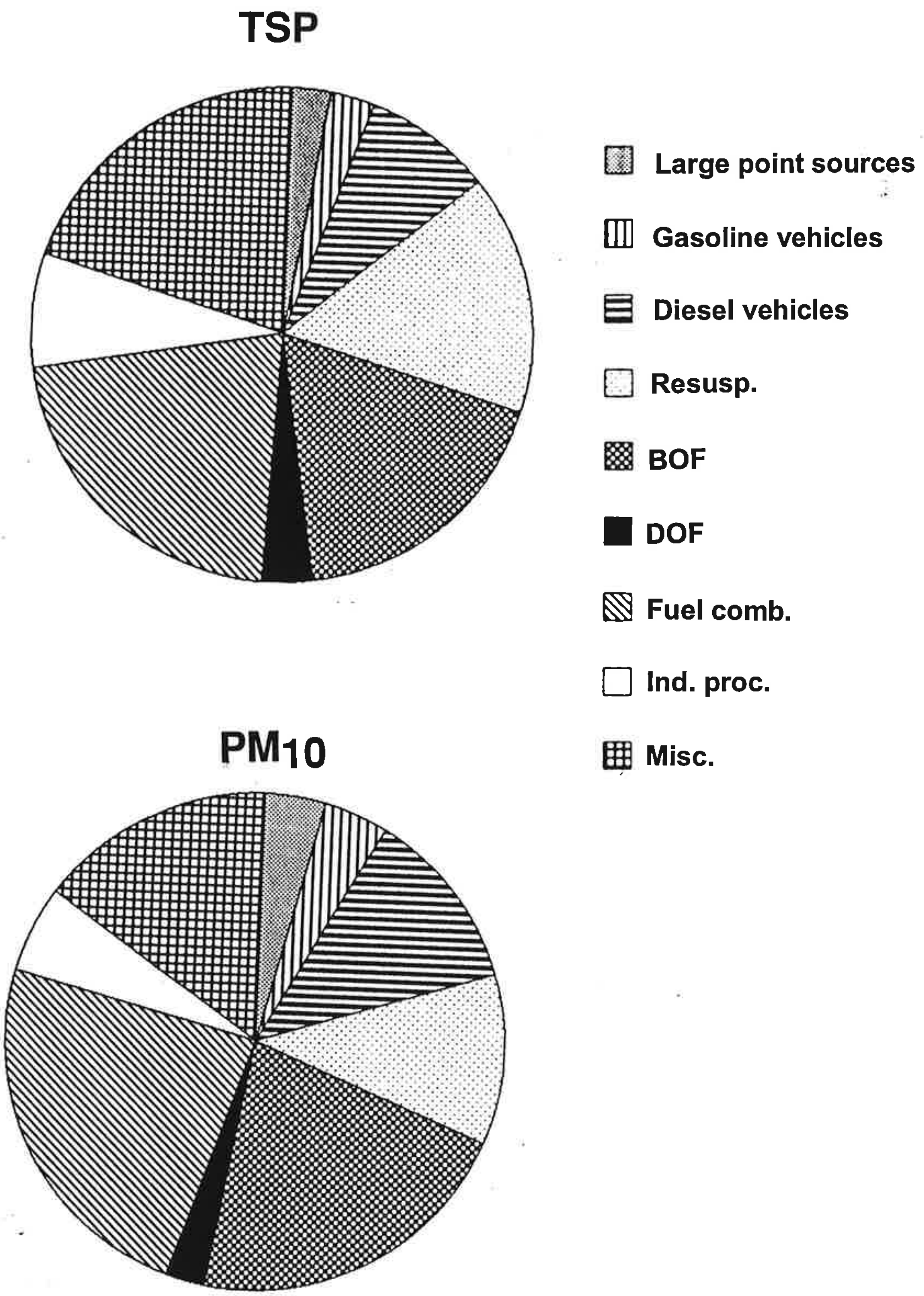


Figure 2.4: Source contributions to emissions of TSP and PM_{10}, Metro Manila, 1992.

PM_{10}

PM_{10} emission figures are based on the TSP emissions and PM_{10}/TSP rates (see Table 2.6 footnotes).

Total PM_{10} emissions, about 45 000 tonnes/a, is about 60% of total TSP emissions. Vehicle exhaust particles are more significant for PM_{10}, 20% of the total emissions, compared to 12% relative to total TSP emissions. The resuspension are mainly coarse particles and its estimated contribution is only 14% of PM_{10}, compared to 33% of TSP.

SO_2

SO_2 emissions from fuel combustion is based on the following sulfur contents of fuel (Lesaca, 1994):

BOF: 3.8%
DOF: 0.8%
Coal: 2.5%

Actual sulfur contents are assumed to be less than these maximum allowable levels. There is no complete information available on SO_2 emissions from industrial processes, or coal consumption.

Lead

The total content of lead in gasoline consumed in Metro Manila in 1992 is calculated below:

Premium gasoline	$1\,018 \cdot 10^6$ l @ 0.6 g Pb/l	gives	611 tonnes
Regular gasoline	$194 \cdot 10^6$ l @ 0.4 g Pb/l	gives	78 tonnes
Total			689 tonnes

Some of the lead is deposited in the exhaust system. Measurements show that during urban driving, about 35% of the gasoline lead is emitted immediately as particles in the PM_{10} fraction (Haugsbakk and Larssen, 1985). The exhaust system functions partly as a temporary, and partly as a permanent deposit. During accelerations, parts of the deposited lead is emitted as larger particles. It is generally assumed that about 25% of the gasoline lead is permanently deposited in the exhaust system. Thus, the annual emissions of lead to air in Metro Manila are, for 1992:

In the TSP fraction : 520 tonnes/a
Of this, in the PM_{10} fraction : 240 tonnes/a

Since low lead and unleaded gasoline have now been made available, these emissions will be reduced substantially.

Spatial emission distribution of vehicle exhaust particles

As a basis for a cost-benefit or cost-effectiveness analysis of abatement measures for Metro Manila, it was necessary for the URBAIR study to establish an air pollution exposure base-line. It was then necessary to establish the spatial concentration fields over the urban area. The main air pollution problem in Metro Manila is high particle concentrations, and to model the spatial distributions, a gridded particle emission survey was needed.

Only the road traffic source had sufficiently detailed data to produce a gridded emission inventory. Its background and methodology are in Appendix 2. A km^2 grid system of 18 x 30 grid squares was established, covering Malabon in the north to Las Pinas in the south, and from Manila in the east to Marikina in the west (see Figure 2.5). Valenzuela and the northern part of Quezon city were largely not covered by the model area, because the basis for the grid system and road network was the 1:25 000 scale "Map of Metro Manila", which does not include Valenzuela.

The population was distributed over the grid system based on the municipality populations, taking account of residential and non-residential areas apparent from the map (see Appendix 2). Figure 2.6 shows a classification of the calculated population density.

Figure 2.7 gives the gridded emission data for TSP (e.g. exhaust particles) from road traffic. There are large emissions in downtown Manila and in the grids along EDSA. The largest emission density was calculated for the grid (8.15), which include the intersection between EDSA and the South Diversion Rd. The emission density in this grid was 1.28 tonne/a of exhaust particles. High densities in downtown Manila are typically 1 tonne/a.

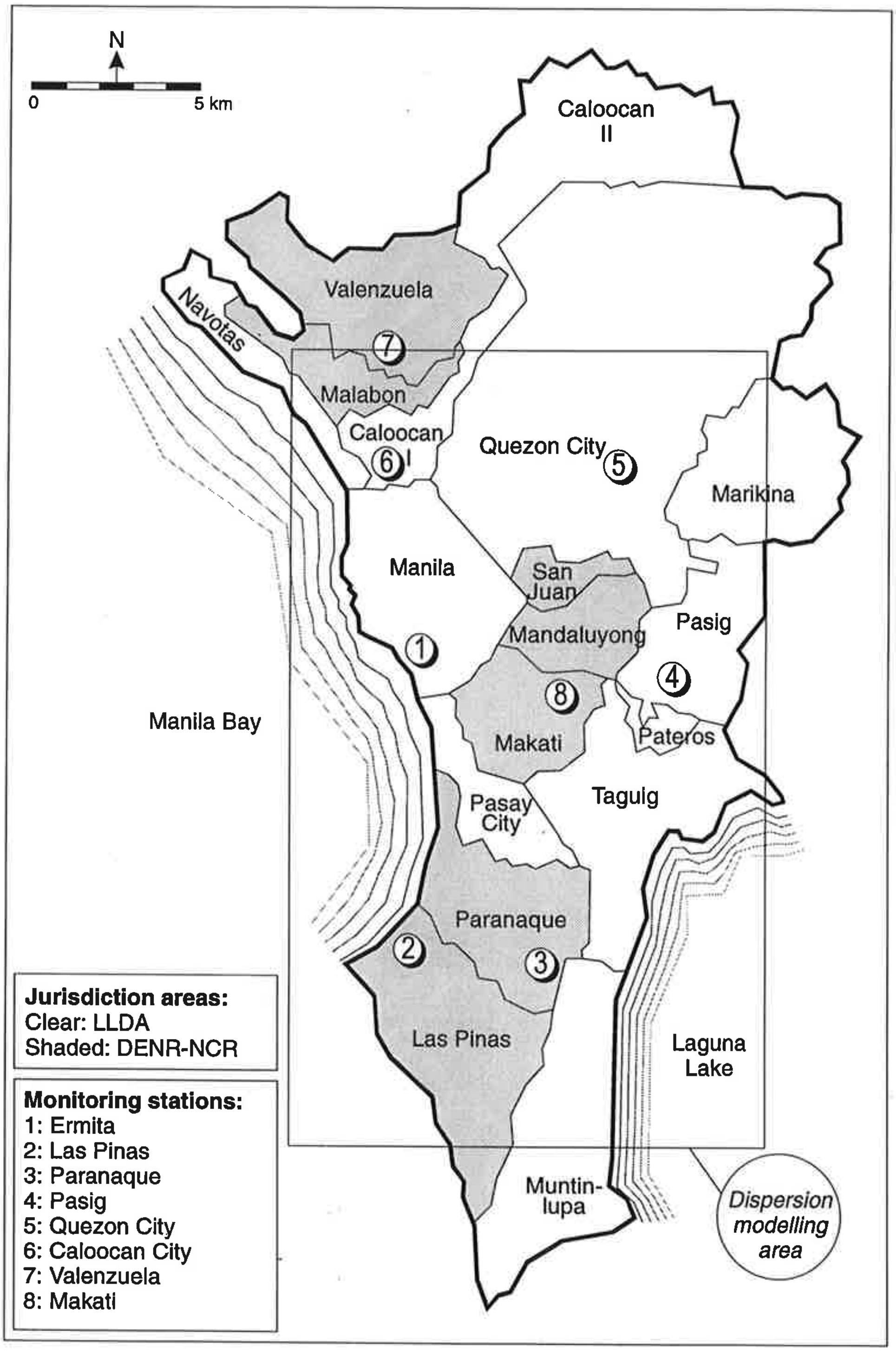


Figure 2.5: Dispersion modeling area, NCR.

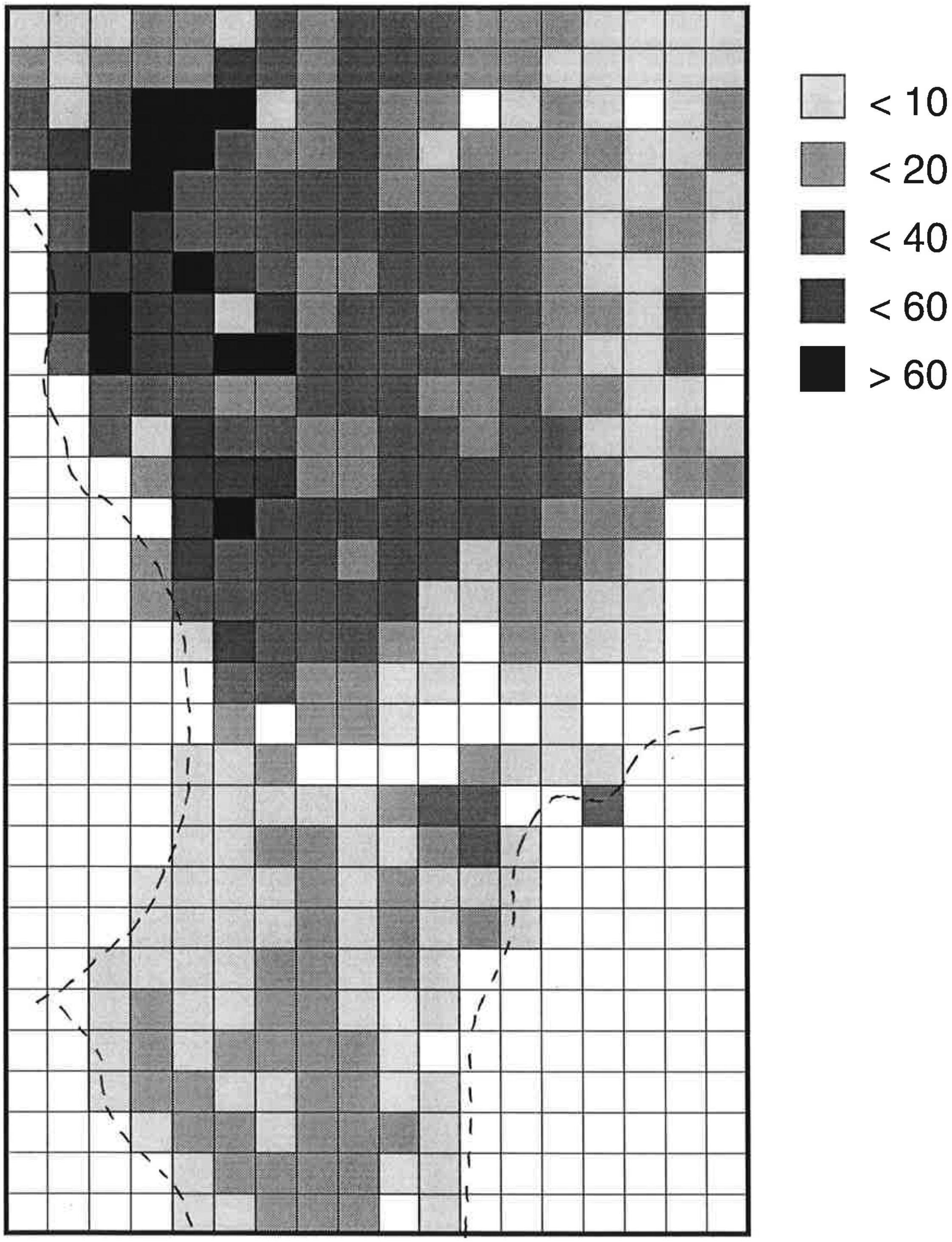


Figure 2.6: Calculated population distribution, NCR, 1992. (1000 people pr. km2). Area is shown in Figure 2.5.

MAP OF Part traf UNIT: Kg/h

MAX. VALUE IS 1.4602E+01, IN (8 , 15)
SUM= 1.40374E+03 SCALE: 1.0E-02

GRID SIZE 1000 METER

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
J=30	49.	70.	69.	185.	114.	147.	196.	260.	442.	442.	452.	338.	196.	196.	303.	192.	65.	82.
J=29	98.	33.	190.	115.	220.	539.	395.	265.	458.	392.	432.	358.	304.	272.	229.	65.	65.	114.
J=28	274.	94.	380.	687.	963.	901.	409.	515.	768.	494.	434.	32.	335.	422.	159.	.	16.	163.
J=27	306.	409.	219.	624.	865.	650.	262.	409.	638.	590.	435.	610.	348.	218.	224.	16.	49.	131.
J=26	5.	258.	654.	727.	518.	842.	535.	627.	803.	547.	545.	456.	409.	245.	147.	33.	131.	65.
J=25	.	354.	1029.	921.	526.	746.	541.	835.	694.	741.	978.	512.	648.	445.	157.	181.	181.	83.
J=24	.	663.	894.	1037.	1254.	948.	832.	512.	516.	663.	709.	939.	619.	327.	128.	184.	177.	67.
J=23	.	687.	1059.	1033.	1161.	428.	818.	405.	652.	804.	334.	834.	570.	358.	49.	109.	203.	.
J=22	.	542.	1018.	1028.	1283.	1181.	1116.	939.	717.	811.	938.	845.	513.	360.	82.	65.	139.	28.
J=21	.	19.	619.	914.	693.	461.	217.	595.	719.	604.	403.	405.	629.	262.	295.	91.	16.	53.
J=20	.	.	691.	807.	902.	724.	331.	287.	354.	665.	675.	654.	272.	245.	215.	209.	166.	160.
J=19	.	.	.	595.	1063.	1228.	854.	298.	327.	523.	737.	878.	221.	182.	162.	31.	49.	49.
J=18	.	.	.	193.	1119.	1289.	912.	717.	698.	576.	1199.	321.	357.	266.	160.	49.	.	.
J=17	.	.	.	49.	780.	594.	1057.	1003.	961.	1170.	902.	287.	333.	133.	82.	33.	.	.
J=16	.	.	.	56.	536.	288.	774.	1038.	1153.	763.	115.	181.	297.	199.	33.	16.	.	.
J=15	.	.	.	.	298.	409.	580.	1460.	672.	459.	224.	1.	275.	163.	33.	16.	.	.
J=14	.	.	.	.	269.	330.	290.	620.	529.	76.	74.	.	33.	84.	.	.	.	.
J=13	.	.	.	.	221.	296.	.	65.	437.	16.	.	.	.	58.	.	.	.	.
J=12	.	.	.	.	174.	366.	128.	.	174.	347.	.	65.	29.	58.	33.	.	.	.
J=11	.	.	.	.	192.	202.	16.	49.	82.	255.	147.	131.	26.	.	114.	.	.	.
J=10	.	.	.	34.	344.	58.	147.	147.	98.	445.	255.	163.	46.	.	.	.	.	.
J= 9	.	.	.	227.	191.	67.	33.	131.	126.	218.	410.	99.	54.	.	.	.	.	.
J= 8	.	69.	174.	63.	33.	320.	185.	131.	114.	147.	320.	49.	16.	.	.	.	.	.
J= 7	.	120.	91.	114.	98.	114.	266.	418.	217.	131.	288.	33.	.	.	.	.	.	.
J= 6	9.	18.	292.	163.	98.	33.	163.	147.	353.	250.	288.	.	.	.	.	.	.	.
J= 5	18.	.	217.	283.	386.	131.	131.	147.	163.	114.	407.	.	.	.	.	.	.	.
J= 4	9.	.	49.	163.	299.	386.	250.	147.	163.	49.	304.	.	.	.	.	.	.	.
J= 3	.	.	.	49.	163.	147.	201.	402.	250.	131.	304.	.	.	.	.	.	.	.
J= 2	.	.	.	.	98.	131.	131.	114.	369.	185.	304.	.	.	.	.	.	.	.
J= 1	.	.	.	.	16.	49.	147.	131.	98.	56.	552.	.	.	.	.	.	.	.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Figure 2.7: Gridded TSP (i.e. exhaust particles) emissions from road traffic, NCR, 1992.

2.3 Dispersion model calculations, NCR

2.3.1 Dispersion conditions

General description of topography/climate/dispersion

The Philippines are located in the subtropical climate zone and the climate has a very small annual variation. The air temperature averages between 26 and 27°C, and the seasonal variation is only 3-4°C. Regional climate differences are largely due to rainfall distribution.The western coast of Luzon has a marked dry season and rainy season. In the period June to December when the southwest monsoon dominates, there are heavy rains. The winter and spring seasons are dry because the coastline is sheltered from the north east trade winds. The eastern coast has a more even distribution of rain throughout the year. Most of it falls during the north east trade wind regimes. In the summer the southern monsoon wind brings the rain to the eastern coast. The average rainfall rate varies from under 1, 000 mm on the valley plains to 4, 500 mm in the mountains.

Manila is located on the mouth of the Pasig River in the Manila Bay on the western coast of the Luzon Island. The Manila plain is a densely populated agricultural area and is open to the sea (Manila Bay) on the west and to a freshwater lake to the east (Laguna Lake). Several mountain chains, 1, 000-1, 500 m high, stretches parallel with the main axis of the island. In the north the big mountain chain Cordillera Central is the main ridge of the Luzon island and consists of several parallel crests with an average height of 1 650 m. Along the north east coast runs the Sierra Madre with a length of about 560 km. The mountain chain is volcanic and slopes steeply down toward the ocean. The Cagayan valley, the main Philippines agricultural area, is located between these main mountain chains. The central plain is the Manila plain parallel with the Cagayan valley but west of Cordillera Central.

Near the coast the sea breeze dominates. The dominant wind directions in the Metro Manila region is the north/ north-eastern trade winds, and to a lesser extent the south/ south-western monsoon. The Philippines Atmospheric Geophysical and Astronomical Services Administration (PAGASA) collects hourly spot readings of speed and wind direction in the Metro Manila area at the Ninoy Aquino International Airport (NAIA), the Manila Port area (MCO) and at PAGASA in Quezon City (SCI). The Climate Data Section of PAGASA summarizes these as daily averages.

The PAGASA measurements consist of:

- wind speed;
- wind direction;
- air temperature;
- air stability; and
- rainfall.

Dispersion conditions

Dispersion of air pollution emissions is dominated by wind conditions and the vertical stability of the atmosphere.

An evaluation of the wind data from the three Metro Manila measurement sites reveals that the data from NAIA (Airport) and the Science Building in Quezon City (SCI) appear less trustworthy than those from the Port Area site, possibly because of local influences from nearby buildings, disturbing the wind flow (Anglo, 1994). Therefore, the URBAIR analysis, emphasizes the Port Area data.

Figure 2.8 shows wind roses for the three stations, for January, April and August 1992, from a database established as a part of the URBAIR work. There are similarities in wind direction distributions at the Port Area and Science Garden (near Quezon City) stations, but expected lower wind speed at Science Garden. The directional wind rose at the airport (NAIA) indicates a serious local effect on the sensor, possibly due to nearby buildings.

Figure 2.9 gives average wind roses for the months January, April and August as well as for the year, averaged over the period 1961-1980 (Anglo, 1994). These data were selected as a basis for the dispersion calculations in Metro Manila as part of the URBAIR project.

Data on the vertical stability of the Metro Manila atmosphere exist from the Manila (Tegen) station near the mouth of the Pasig River. Table 2.9 gives these data.

Table 2.9: Analysis of the Pasquill/Guifford stability classes based on data from Manila Tegen station. Total frequency of the unstable, neutral and stable conditions are given below.

	Stability classes					
Wind speed	A	B	C	D	E	F
0.4- 1.7 m/s	0	0	1.2	5.2	0.5	0
1.8- 3.5 m/s	0	0	0	6.0	8.8	0
3.6- 5.7 m/s	0	0.6	0	16.4	9.6	0
5.8- 8.4 m/s	0	1.6	3.5	17.0	4.3	0
8.5-10.6 m/s	1.2	3.2	3.5	8.2	1.2	0
>10.7 m/s	6	0.9	0	1.1	0	0

Stability classes: A: very unstable C: slightly unstable E: slightly stable
B: Moderately unstable D: Neutral F: moderately stable

From these data, a combined wind/stability matrix was constructed. Such a matrix representing the statistics of dispersion climatology can be used as input to dispersion models to calculate long-term average concentrations of pollutants. The combined matrix is given in Table 2.10.

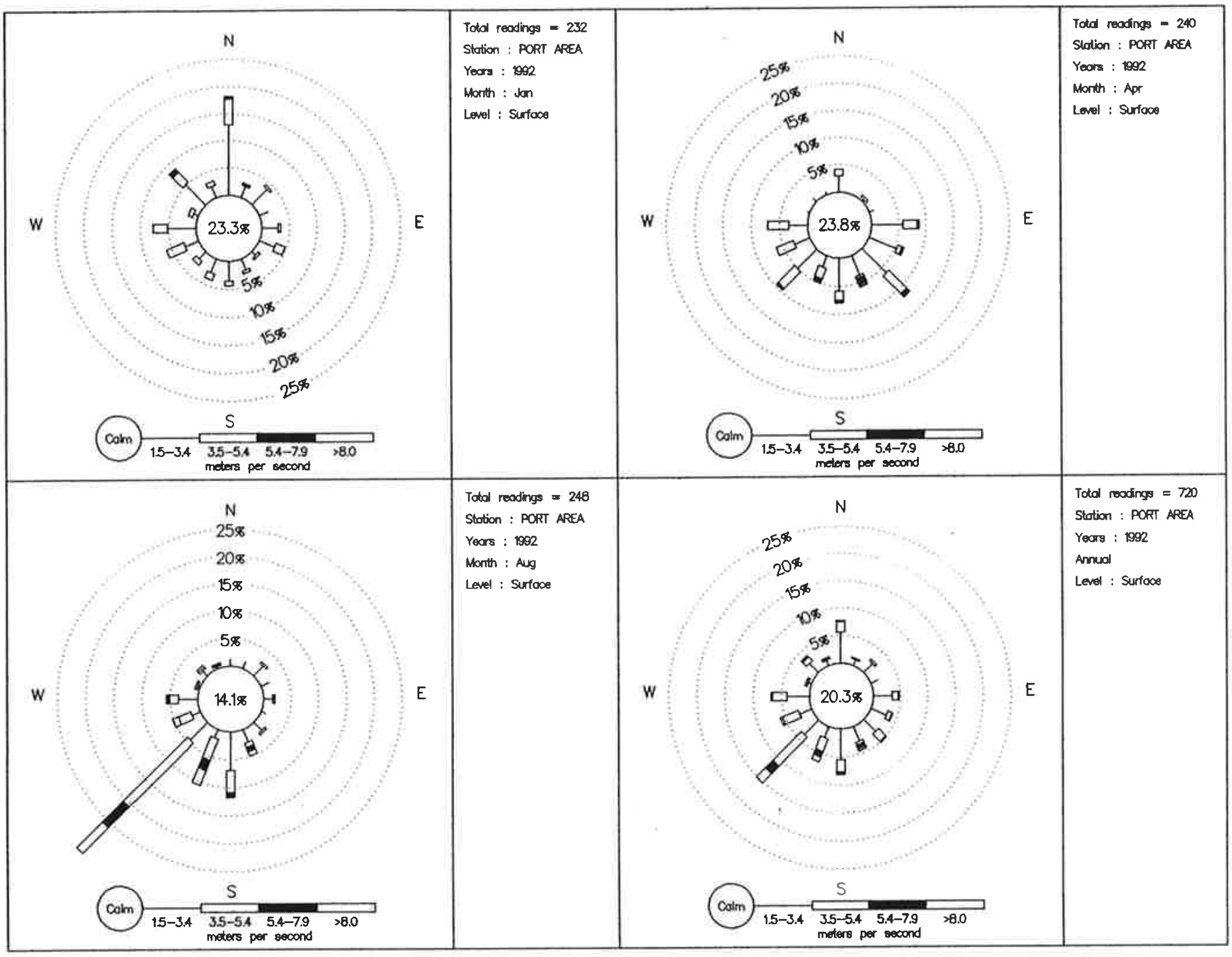


Figure 2.8: Wind roses for 1992, Metro Manila meteorological stations.

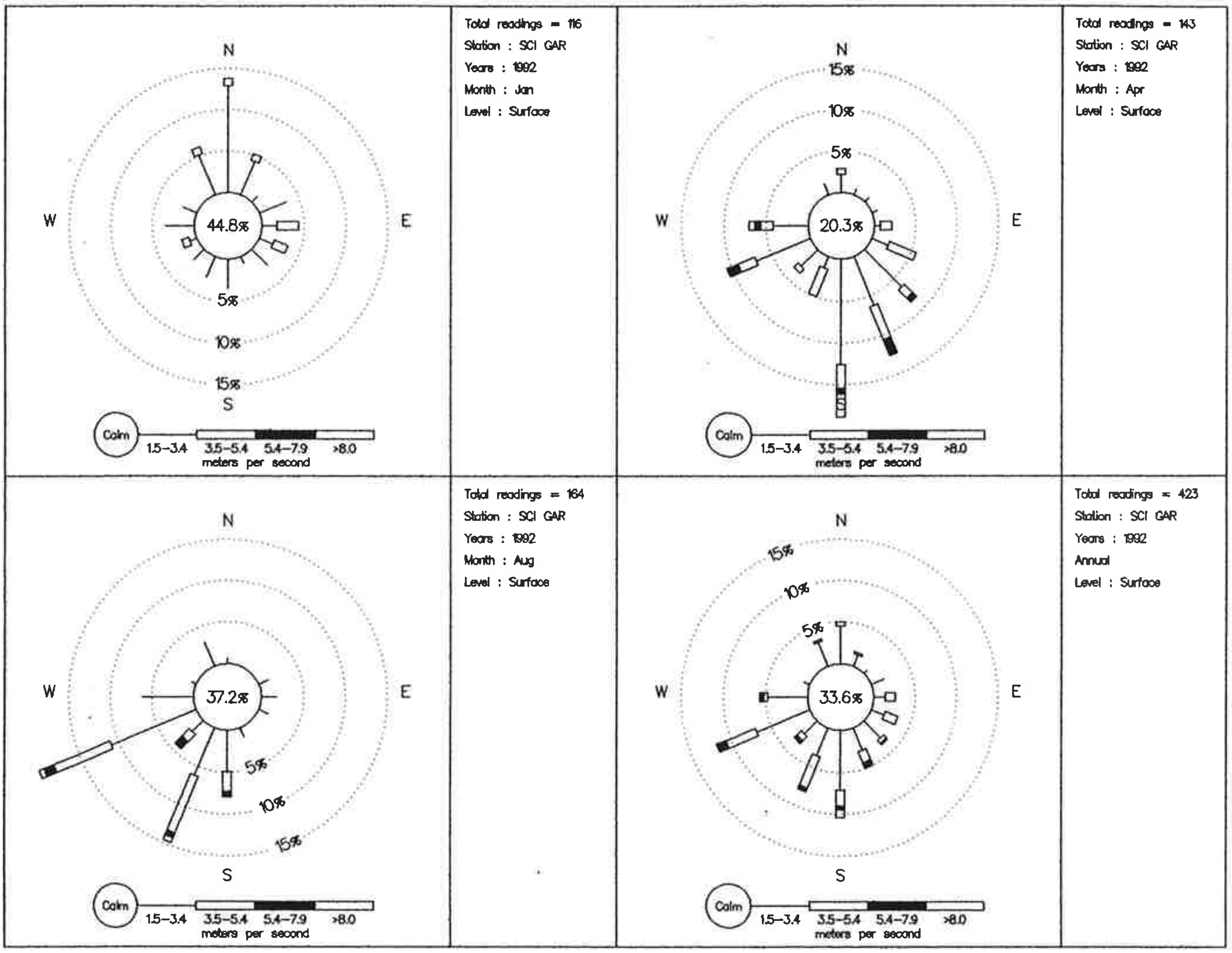


Figure 2.8: cont.

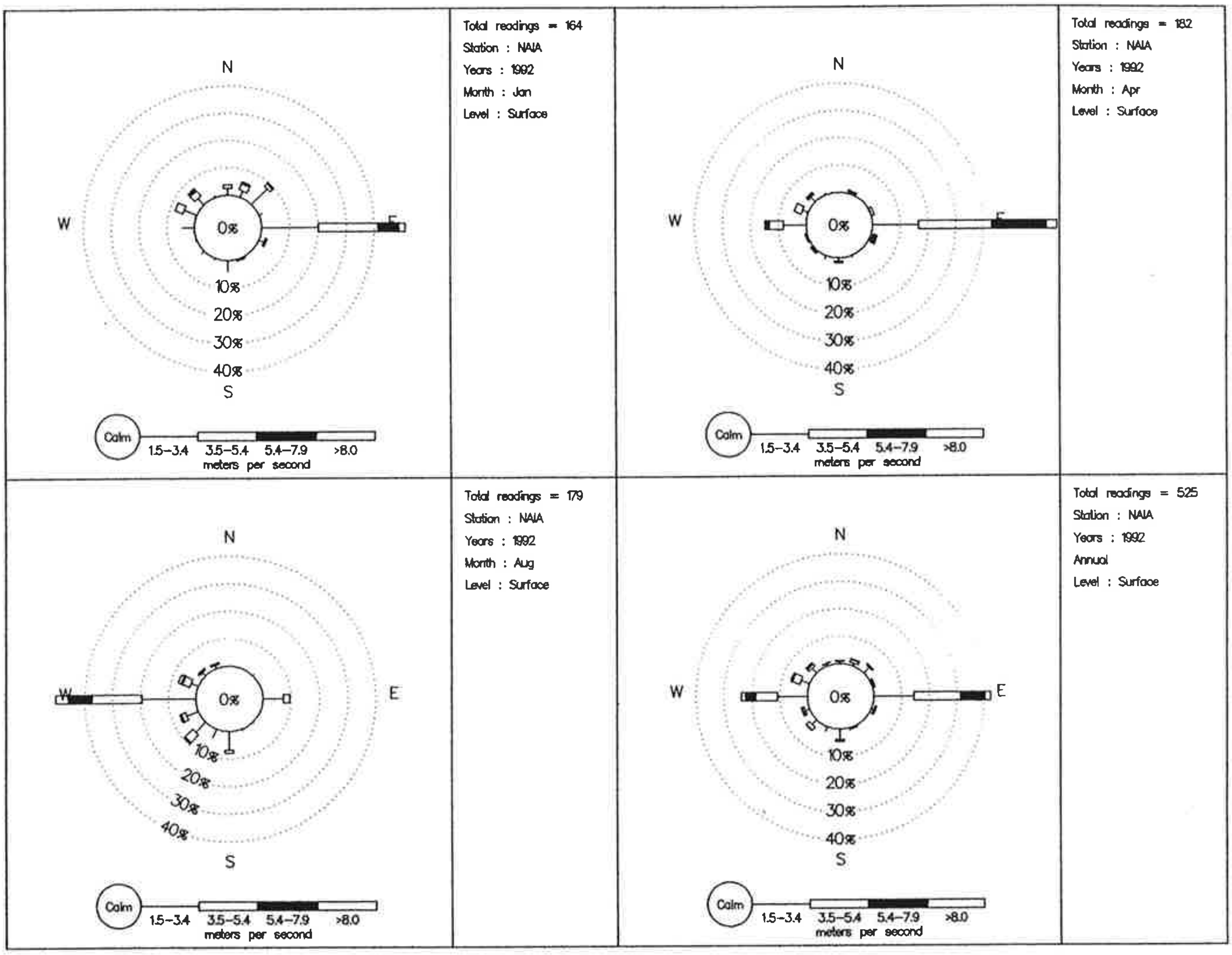


Figure 2.8: cont.

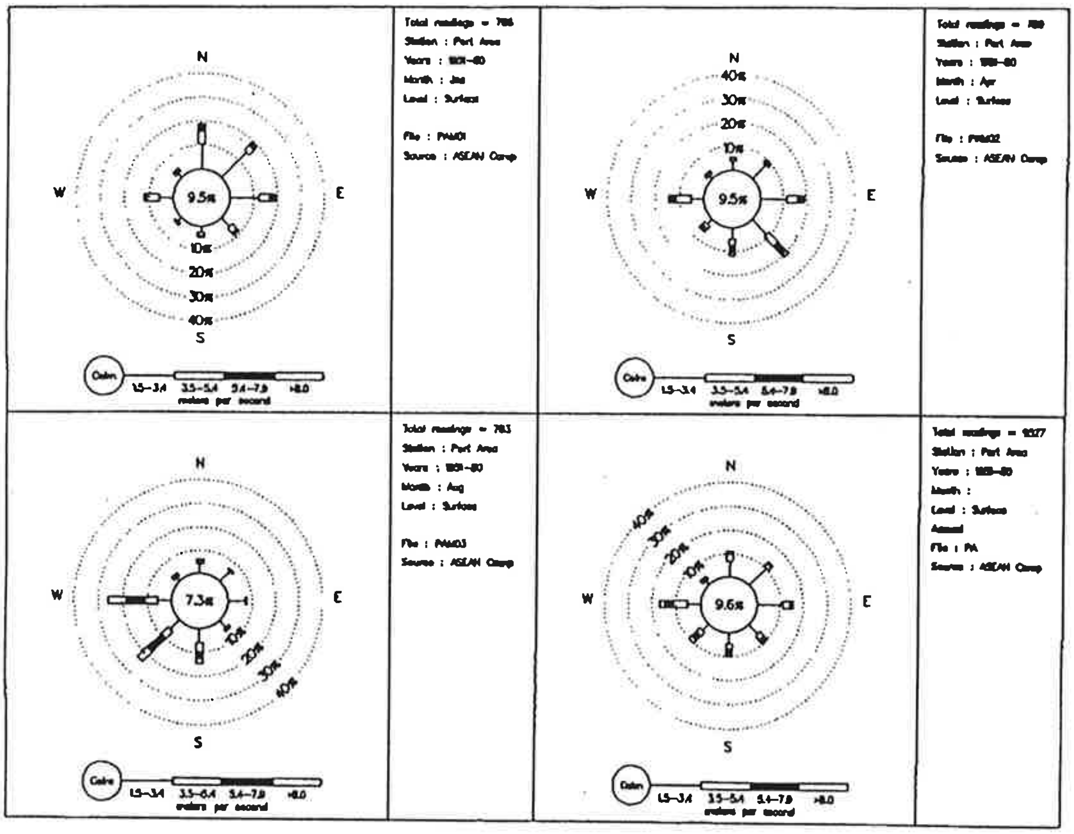


Figure 2.9: Wind roses, Manila Tegen station, average for the period 1961-1980.

Table 2.10: Wind/stability frequency matrix (annual), Metro Manila.

Sector	0-1.4 m/s				1.5-3.4 m/s			
degrees	U	N	L	S	U	N	L	S
45		2.0	0.2			1.0	9.0	
90		2.0	0.3			1.5	9.5	
135		0.9	0.1			1.0	4.0	
180	0.6	0.4			0.2	1.8	3.0	
225	0.4	0.2			0.1	2.8	0.2	
270	0.6	0.4			0.3	4.4	0.3	
315	0.1	0.3			0.1	1.8	0.1	
360	0.1	1.1	0.1		0.3	4.5	1.2	
Sum	1.8	7.3	0.7	0	1.0	18.8	27.3	0
	9.8				47.1			

Sector	3.5-5.4 m/s				>5.5 m/s				
degrees	U	N	L	S	U	N	L	S	Sum
45		0.6	1.1			1.2	0.3		15.4
90		0.8	2.2			1.3	0.7		18.3
135		0.6	2.0			1.4	1.2		11.2
180		0.6	1.2			2.4	0.4		10.6
225		0.6	0.9		1.8	3.1	0.1		10.2
270	0.3	5.2			2.5	3.5			17.5
315	0.1	2.3							4.8
360	0.1	2.9	0.5		0.2	1.0			12.0
Sum	0.5	13.6	7.9	0	4.5	13.9	2.7	0	
	22.0				21.1				100

U - unstable N - neutral L - light stable S - stable

Adverse dispersion conditions in Metro Manila

Weak and short-lived inversions are typical in a tropical city located on the coast. They break up as soon as the sun rises. One meteorological situation that may lead to high ground level concentrations occurs when the local land-sea breeze runs opposite the monsoon, at a speed than the monsoon. This happens during early mornings when the sky is clear and the inland airmass is cooled from below by the ground. The airmass tends to follow the topography towards the coast. In Metro Manila the airmass follows the rivers towards the Manila Bay.

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

2.3.2 Dispersion model calculations, city background

Model Description

The dispersion modeling work in this first phase of URBAIR concentrates mainly on the calculation of long term (annual) average concentrations representing the average within km^2 grids ("city background" concentrations). Contributions from nearby local sources in specific receptor points (e.g. street side, industrial hot spots) must be evaluated additionally.

The dispersion model used for URBAIR in the Metro Manila is a multisource Gaussian model treating area, point and volume sources separately.

Meteorological input to the model is represented by a joint wind speed/direction/stability matrix representing the annual frequency distributions of these parameters. The dispersion conditions are considered as spatially uniform over the model area. For point sources, account is taken of plume rise (Brigg's equations), effects of building turbulence, and plume downwash. For area sources, the total emissions in a km^2 grid is simulated by 100 ground level point sources equi-spaced over the km^2. The software package used is the KILDER model system developed at NILU (Gram and Bøhler, 1992).

Secondary particle formation, such as secondary sulfate and organic aerosol, are not taken into account by this modeling exercise, which treats only dispersion of primary emission compounds. Further modeling and particle analysis should be done to estimate the extent of secondary particle formation.

Suspended particles

Vehicle exhaust particles

As explained, the database for dispersion modeling is good enough only for the road vehicle source category.

Figure 2.10 shows the isolines of the concentration field, based on the calculated annual average concentrations in each km^2 grid. The emission distributions given in Figure 2.7 is modified by the differences in dispersion conditions caused by the differences in typical density and height of buildings in the various parts of the area.

The isolines show the highest concentrations in the same area where the emissions in general are largest in downtown Manila. The highest annual average concentration, 39 $\mu g/m^3$, was calculated for grid (4.23).

Total TSP and PM_{10} concentrations from area sources

Vehicle exhaust particles account for an estimated 12% of TSP emissions and 20% of PM_{10} emissions in Metro Manila (see Table 2.6).

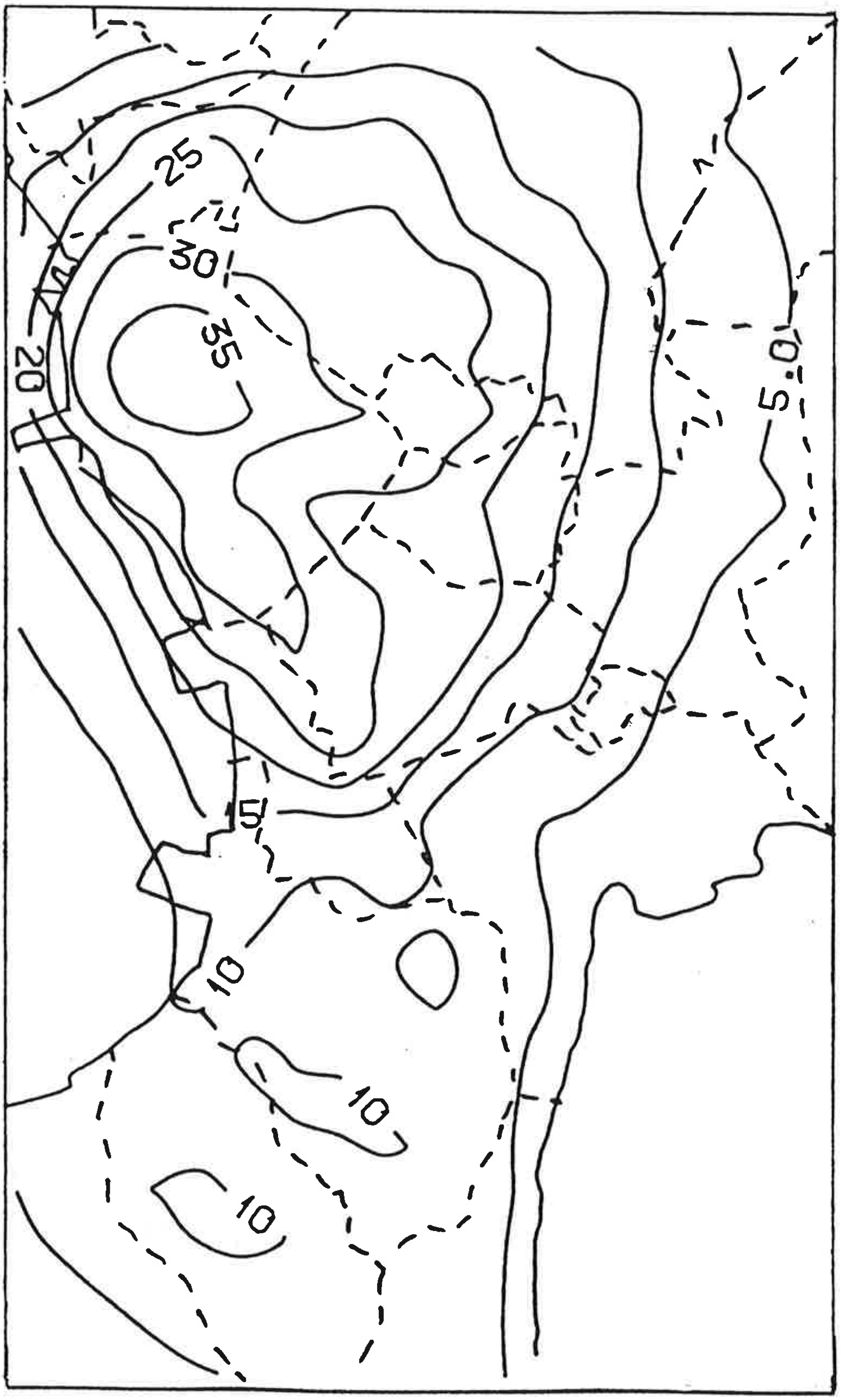


Figure 2.10: Road traffic exhaust particle concentration distribution (µg/m³), annual average 1992, Metro Manila.

The spatial distribution of emissions from the various source categories can be separated into two groups:

- Area sources, with spatial distribution determined to a large extent by population distribution and the road network: traffic, commercial/domestic fuel combustion, refuse burning, and construction.

- Point and industrial sources, concentrated in industrial areas: power plants, industrial process emissions, and industrial fuel consumption.

Vehicle exhaust emissions of particles account for an estimated 17% of total TSP emissions from the area distributed sources, and 37% of total area source PM_{10} emissions when these are defined as follows:

Total TSP and PM_{10} emissions from area distributed sources (tonnes/a):

	TSP	PM_{10}
Vehicle exhaust emissions	8 910	8 910
50% of DOF combustion	1 300	650
Refuse burning	(<)6 000	(<)6 000
Construction/Resuspension	35 000	8 500
Total	51 210	24 060

The remaining DOF and the BOF is probably used by industry.

From this it can be estimated that the maximum concentration calculated in downtown Manila, 35 µg/m³, corresponds to a total TSP concentration of about 235 µg/m³, and a total PM_{10} concentration of 105 µg/m³. when the contributions from the other area-distributed sources have been accounted for, and an additional 30 µg/m³ (15 µg/m³ for PM_{10}) as extra-urban background has been added:

TSP: $$\frac{35\ \mu g / m^3}{0.17} + 30\ \mu g / m^3 = 235\ \mu g / m^3$$

PM_{10}: $$\frac{35\ \mu g / m^3}{0.37\ \mu g} + 15\ \mu g / m^3 = 110\ \mu g / m^3$$

Table 2.11 shows the correspondence between calculated vehicle exhaust particle concentrations (C_V) and TSP concentrations (C_{TSP}), when an extra-urban background concentration (C_b) is also added:

$$\frac{C_V}{0.17} + C_b = C_{TSP} \qquad \frac{C_V}{0.37} + C_b = C_{PM_{10}}$$

Table 2.11: Corresponding concentrations of vehicle exhaust particles (C_V) and TSP and PM_{10} in Metro Manila, Base case (1990).

	C_b			
C_V	TSP	PM_{10}	C_{TSP}	C_{PM10}
35	30	15	235	110
20	30	15	145	70
10	30	15	90	40

Table 2.12 compars measured and calculated TSP. The calculated values represent the average concentrations in the grid squares where the sites are located. Local exposure from nearby roads and industries are indicated. Also, secondary particle formation is not accounted for in the calculations.

Table 2.12:1 Measured TSP concentrations at DENR-NCR sites, and calculated area-source average TSP concentrations in the grid squares where the sites are located.
Local exposure from nearby roads and industries are indicated.

	C_V Calc.	C_{TSP} Calc.	C_{TSP} Meas.	Local exposure from Roads	Industry
Ermita, Manila	30	195	219	+	?
Caloocan	15	113	150	?	+
Quezon City	20	140	178	(+)	(+)
Pasig	10	85	183	(+)	+
Makati	23	158	146	+	(+)
Las Pinas	11	91	115	+	+
Paranaque	10	85	166	+	+

At Makati, where local exposure seems small, there is fair agreement between measured and calculated annual average TSP. At all other sites, the calculated TSP values are lower than those measured. The discrepencies may be accounted for by additional local exposure from roads and industry. At Ermita, Las Pinas and Paranaque there is definite road exposure. At Pasig, Caloocan and Paranaque, there is industrial exposure. The "construction" source is significant, and its distribution over Manila is unknown. This may account for some of the noted discrepancies.

Measured TSP is represented fairly well by the dispersion calculations, considering the discrepencies noted above.

SO_2

The emission inventory of SO_2 (Ch. 2.2) was used as a basis for calculating a first approximation of the SO_2 distribution in Metro Manila. The emissions are distributed as follows:

- SO_2 emissions from diesel vehicles distributed according to the traffic activity pattern described in Appendix 2.

- SO_2 emissions from power plants calculated as point sources, with stack and fuel data as referenced by Manins (1993).

- SO_2 emissions from the industrial/commercial/residential use of DOF and BOF, a first approximation distributed according to the population distribution, since the actual spatial distribution of industries is not available.

Calculations of annual average SO_2 are shown in Figure 2.11 (the dispersion model as used for TSP). Contributions from the various sources and the total distribution are presented. The main contribution comes from BOF/DOF combustion, here considered as low level source. The total annual average SO_2 concentration is calculated to be 120-150 $\mu g/m^3$ in central Manila.

This should be considered a first estimate of the SO_2 concentration in Manila. SO_2 measurements at Ermita from the period 1977-1983 gave annual averages in the range 50-110 $\mu g/m^3$.

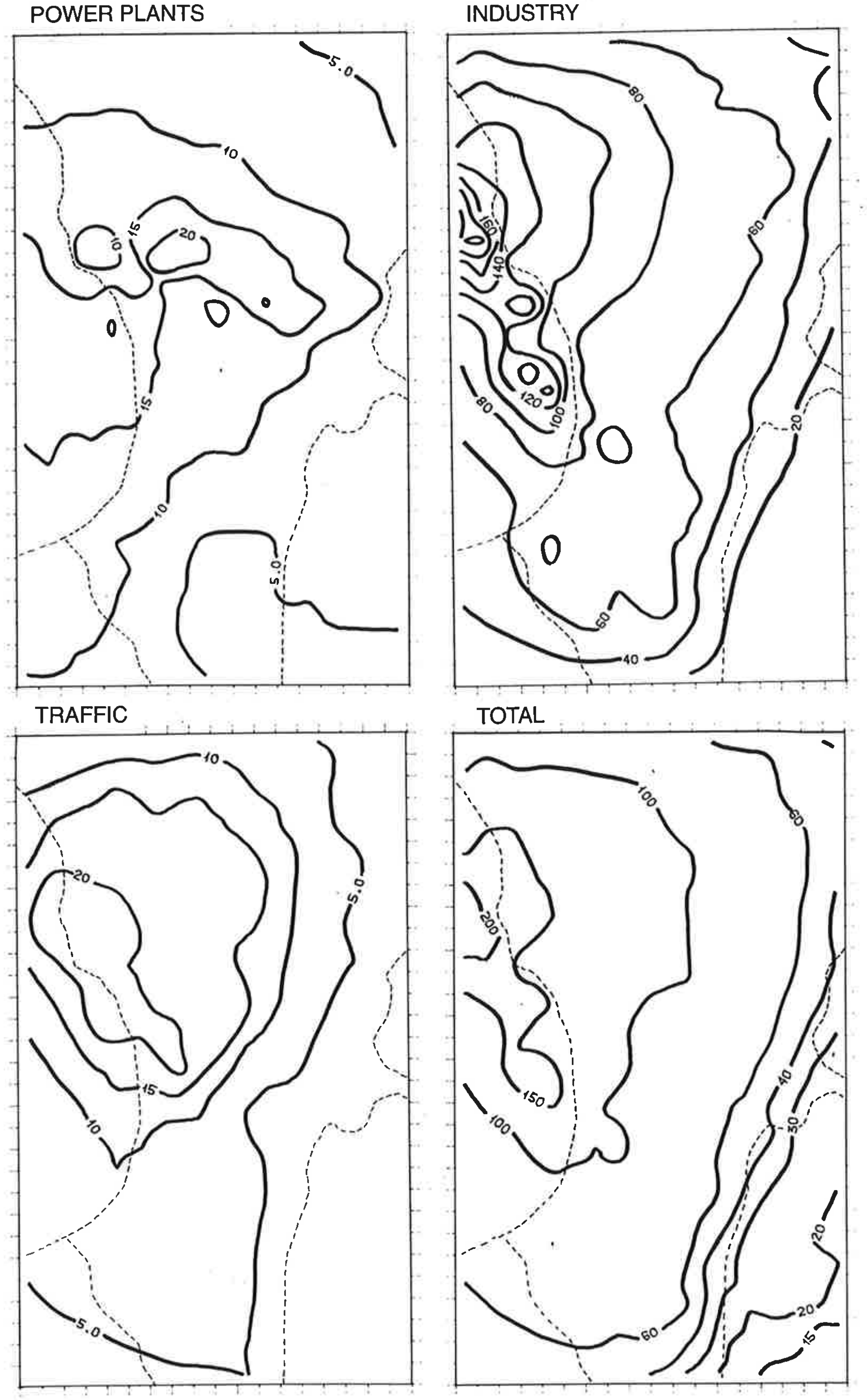


Figure 2.11: Calculated first estimate SO_2 concentration distributions (µg/m³, annual average), Metro Manila, 1992.
(Note the comments on the distribution of the emissions, on page 48).

2.3.3 Pollution hot spots

At pollution hot spots, significant pollution sources give large concentration contributions in their neighborhoods, adding to the general city background. Pollution hot spots are:

- along the main road system; and
- near industrial areas with significant emissions especially through low stacks.

Examples of hot spot pollution concentrations have been calculated by Emmanuel G. Anglo as part of the URBAIR work (Anglo, 1994).

SO_2 exposure near the Metro Manila Power Plant.

Anglo calculated SO_2 concentrations near this power plant (a 200 MW plant run on Bunker C fuel and 76 m stacks), within a 10 km radius from the plant, using an average emission rate of 760 g/s (corresponding to 24 000 tons/a) using statistical meteorological data for the Port Area meteorological station (Anglo, 1994). His results are given in Figure 2.12, showing isopleths for:

- monthly average SO_2 concentrations for January and August;
- maximum 1 hour concentrations for same months; and
- maximum 24 hour concentrations for August.

The calculations give maximum 1-hour concentrations up to about 250 $\mu g/m^3$. Concentrations above 200 $\mu g/m^3$ occur within 4 km from the plant both months. Maximum 24 -hour concentrations reach 140 $\mu g/m^3$ in August in the area northeast of the plant, at a distance of about 2 km. Monthly average concentrations reach up to 80 $\mu g/m^3$ in August, some 4 km to the northeast.

The exposure from this plant alone does not exceed National Air Quality Guidelines (NAQG), although WHO guidelines may be exceeded. These calculations show, however, that with city background SO_2 from DOF and BOF combustion and from diesel vehicles added, the 24-hour average NAQG's for SO_2 may be exceeded, particularly in the area northeast of the plant.

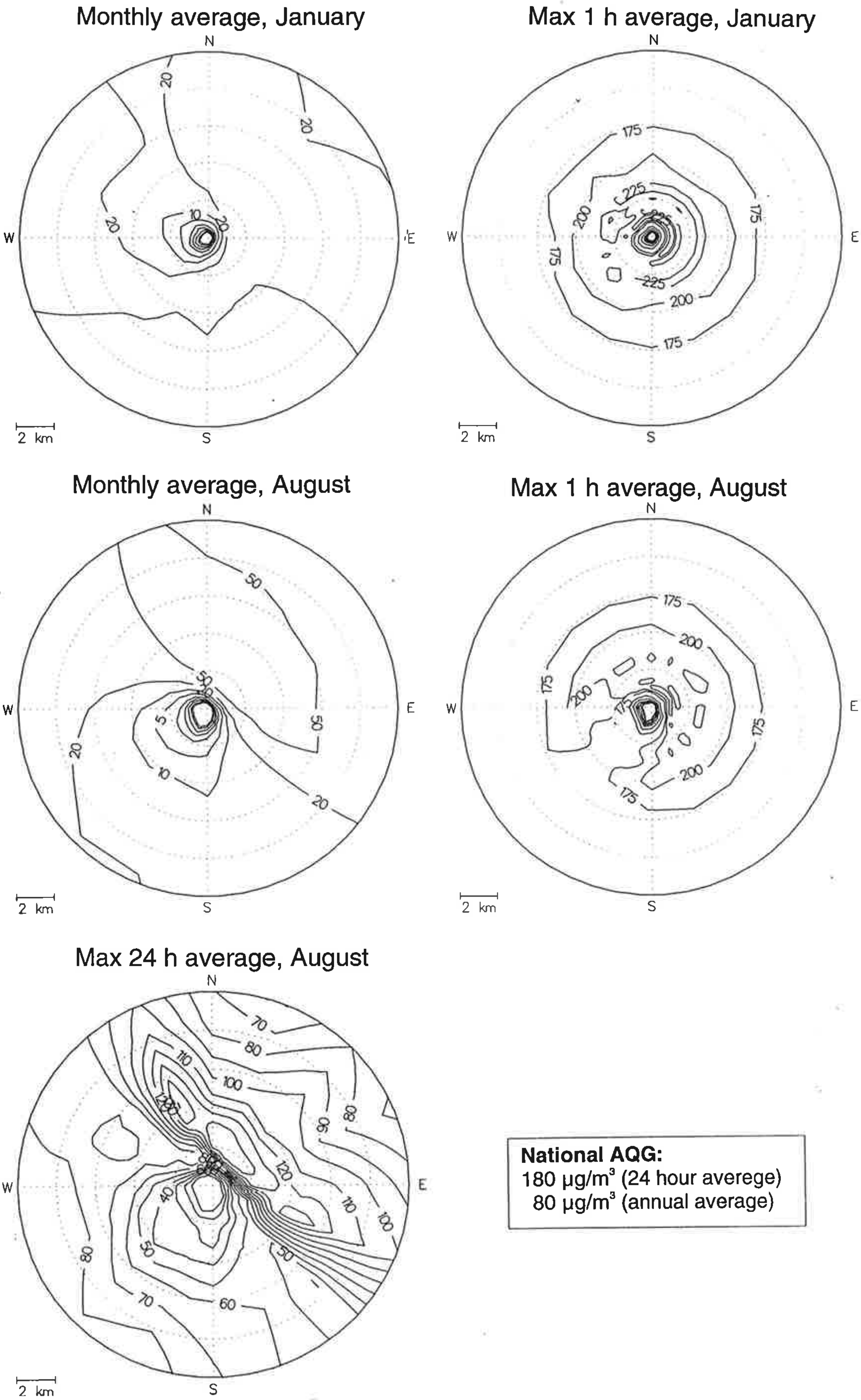


Figure 2.12: Isopleths of calculated SO_2 concentrations (µg/m³) around the Manila Power Plant. The plant emissions are in the centre of the circles. The figures give the calcuated concentrations as a function of direction and distance from the plant. (Ref.: E.G. Anglo, 1994.)

PM and SO_2 exposure near main roads

Anglo calculated typical hourly concentrations of exhaust particles (EP) and SO_2 near selected sections of the following roads, using meteorological statistics from the Port Area meteorological station:

- Taft Avenue, running NW-SE, with a large jeepney traffic
- EDSA, running NE-SW, dominated by car and bus traffic.

The input data to the calculations were the following:

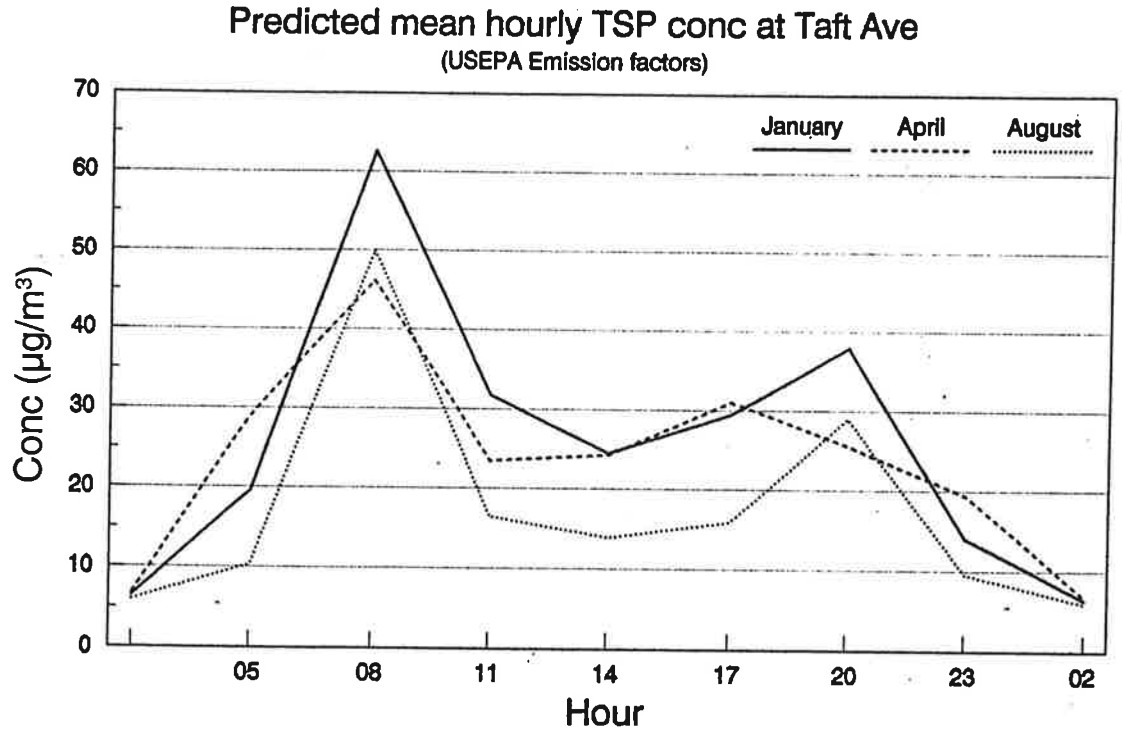
	Traffic data (AADT)		Emission factors (g/km)	
	Taft	EDSA	EP	SO_2
Cars	21 400	130 500	0.33	0.123
Taxis	1 050	6 500	0.45	0.634
Jeepneys	22 800	2 500	0.45	1.268
Trucks	4 450	3 700	0.93	3.38
Buses	250	15 150	0.93	2.54
Total	49 950	158 350		

The CALINE model was used. Results are shown in Figure 2.13.

Typical maximum EP concentrations at Taft were calculated to be about 65 $\mu g/m^3$ during morning rush hours, using US EPA emission factors. For jeepneys, trucks and buses, these emission factors should be almost doubled, to correspond with those selected for this study. Anglo's calculations would thus indicate typical rush hour concentrations of about 150 $\mu g/m^3$, and an estimated annual average EP concentration of 50-60 $\mu g/m^3$.

In addition to the EP concentration is contribution from resuspension, not calculated by Anglo. Using emission factors as selected in this study, this would at least double the particle concentration at Taft Avenue, resulting in a TSP contribution from Taft Avenue traffic of at least 100 $\mu g/m^3$. With a city background TSP contribution of about 150 $\mu g/m^3$, as calculated in Chapter 2.3.2, annual average TSP concentration at Taft would be about 250 $\mu g/m^3$. The average concentration measured at Ermita station near Taft was 219 $\mu g/m^3$ for 1992 (see Figure 2.1a), agreeing with the above.

SO_2 concentrations calculated for EDSA is about 120-170 $\mu g/m^3$ as typical rush-hour concentration, and about 40 $\mu g/m^3$ as annual average.



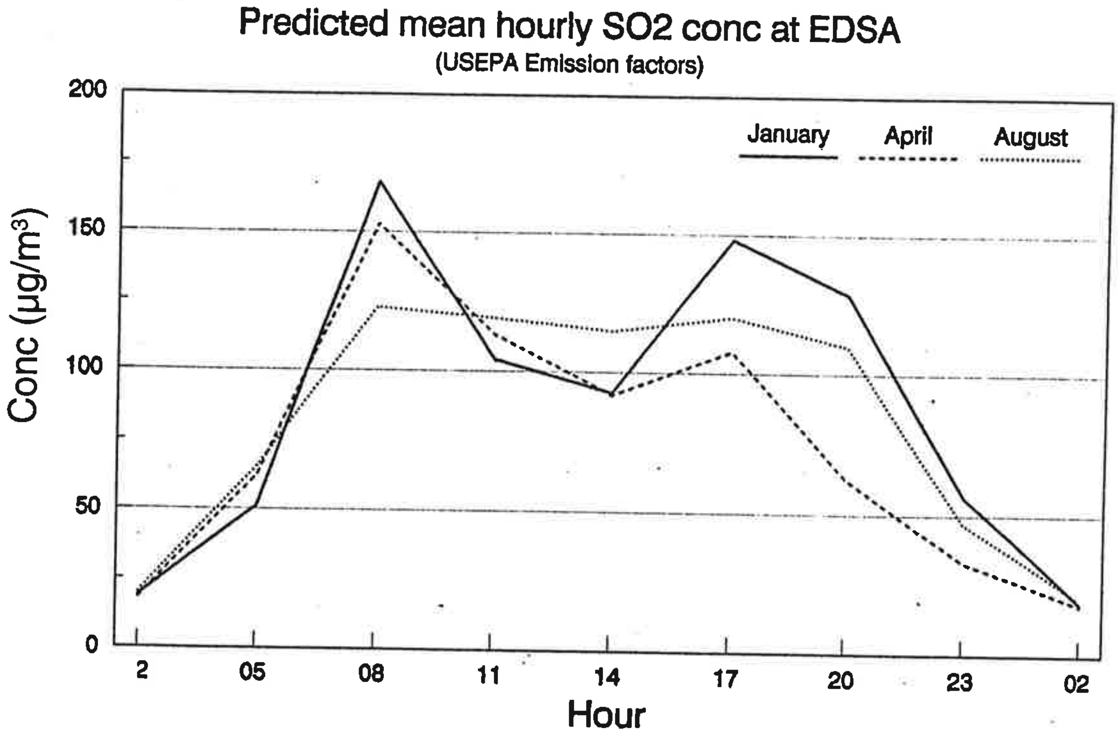


Figure 2.13: Calculated average daily variation of car exhaust concentrations (PM and SO_2) near selected roads in Metro Manila. (Ref.: Anglo 1994.)

2.4 Population exposure to air pollution in the NCR

The term "population exposure" is defined as:

- the number of inhabitants experiencing concentrations of pollution compounds within given concentration ranges.

The cumulative population exposure distribution gives the percentage of the total population exposed to concentrations above given values.

People are exposed to air pollutants at home, during commuting on roads, at work, and other places. The correct mapping of pollution exposure requires data on:

- Concentration distributions, and variation with time
  - at peoples residences (general city air pollution or "city background");
  - along the main road network; and
  - near other hot spots, such as near industrial areas.

- Population distribution (residences and workplace) and the number of commuters, and time-dependent travel habits.

The database for population exposure calculations are often incomplete. The methodology must be developed for each city based on the actual database.

The methodology used for Metro Manila is described in Appendix 4. It's features are:

- The concentration distribution of vehicle exhaust is calculated, per km^2 grid square.

- This distribution is adjusted upwards to account for all area-distributed sources.

- Residence exposure is calculated from this concentration distribution and the km^2 population distribution.

- Added exposure near industrial areas is calculated by giving 50% of the inhabitants an extra concentration value.

- Added exposure near roads is calculated for commuters, drivers, and roadside residents.

TSP

Population exposure has been calculated for **TSP**, the major air pollution problem in Metro Manila. The calculation has been done for **annual average** TSP, to serve as input to health damage analysis.

This is not to diminish the importance of exposure to high short-term concentrations of suspended particles and other pollution compounds, in hot spots such as on/near the main roads and near polluting industries. The calculation of such exposure requires, however, a more extensive database than has been available for Metro Manila under URBAIR. Also comprehensive dose-effect relationships regarding health has not yet been developed for short-term exposures, although air quality guidelines have been set.

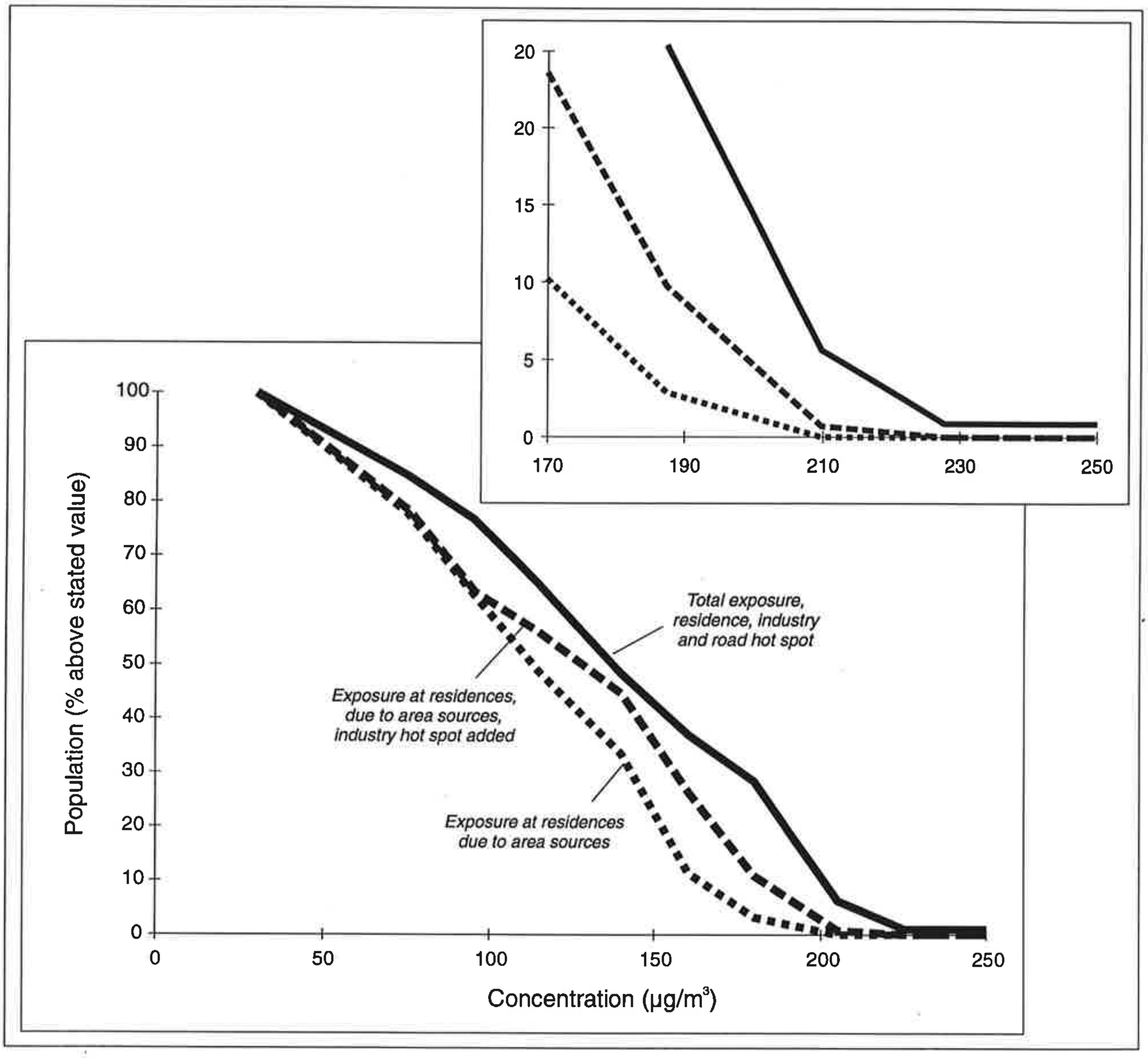
Annual average TSP population exposure calculations in Metro Manila (1992), are shown in Table 2.13. The calculations represent the dispersion modeling area, which includes 6,655,000 inhabitants but does not include much of Valenzuela and the northern parts of Quezon City, and.

Table 2.13: Calculated population exposure to TSP (annual average) in Metro Manila, (1992).

C traffic $\mu g/m^3$	C area sources[1] + background $\mu g/m^3$	Population exposure, area sources 10^3 inh.	Additional exposure, due to industry[2] 10^3 inh.	Population exposure, area sources + industry 10^3 inh.	Additional exposure due to roadside[3] 10^3 inh.	Resulting population exposure 10^3 inh.
	275				A = 65	65
>40	205-225		50	50	B = 300	350
35-40	180-205	210	140 370	670	C/3 = 800	1 470
30-35	160-180	550	370 250	1 030	-D	570
25-30	140-160	1 470	250 240	1 220	-D	760
20-25	115-140	1 010	240 250	750	C/3-D	1 090
15-20	95-115	940	250	460	C/3-D	800
10-15	75- 95	1 000		1 000	-D	540
<10	30- 75	1 470		1 470	-D	1 010
Sum		6 650		6 650		6 655

1. Area sources: Traffic + ind./comm. fuel combustion + refuse burning + construction.
   Traffic emissions = 23% of total area source emissions.
2. 25% of inhabitants in each km^2 is given an additional 20 $\mu g/m^3$.
   25% of inhabitants in each km^2 is given an additional 40 $\mu g/m^3$.
3. A: no. of roadside residents = 65 000, exposed to an estimated 275 $\mu g/m^3$
   B: no. of chauffeurs/policemen = 300 000, exposed to an estimated 220 $\mu g/m^3$
   C: no. of road commuters = 2 400 000, exposed to an estimated 185/135/100 $\mu g/m^3$
   (33% of the 2 400 000 in each of the three concentration levels).
   D: D = (A+B+C)/6
   The A, B, and C inhabitants are moved from the lower to the higher exposure classes.

Population TSP exposure distributions, annual average, and present conditions are shown in Figure 2.14.



o(z) Exposure at residences, due to area sources
o+q (z) As above, with exposure due to industry added
w (z) Total exposure, i.e. as above, with road exposure added

Figure 2.14: Calculated population exposure distribution, Metro Manila Modeling Area, TSP, annual average, present conditions (1992).

The present TSP exposure situation in Metro Manila can be summarized as follows:

- About 65% of the population lives in areas where the air quality guideline (90 $\mu g/m^3$) is exceeded.

- When industrial and road exposure is added, about 80% of the population is exposed above the AQG.

- Road and industrial exposure substantially increases the number of people exposed to high concentrations. Estimated exposure over 2xAQG is:
  - 3% of the population in their residences;
  - 11% of the population, when industrial exposure is added; and
  - 29% of the population, when road exposure is also added.

- The most severely exposed are roadside residents (estimated at 65 000 people, or 1% of the population), and public transport drivers, policemen, and other roadside workers (estimated at 300 000, or 4.5% of the population).

General exposure at residences are due to the following main sources:

For TSP: Resuspension from roads and construction, diesel vehicles, and refuse burning.
For PM_{10}: Diesel vehicles, refuse burning, and resuspension/construction.

Additional exposure in industrial areas is from BOF combustion and process emissions.

PM_{10}

Population exposure has also been estimated for PM_{10}. Long-term (annual) and maximum short-term (24-hour) exposure were considered. Table 2.14 gives averages of vehicle exhaust particles, TSP and PM_{10} (and lead), as well as estimated maximum 24-hour PM_{10} concentration, based on stated assumptions.

Table 2.14: Corresponding area (km²) concentrations of vehicle exhaust particles, TSP, PM_{10} and lead (µg/m³), Metro Manila, 1992.

Annual average concentration				Max. 24 hour concentration	
Traffic exhaust particles	TSP1	PM10 2	Lead3	PM10 (1)4	PM10 (2)5
40	205	100	1.5	155	200
35	180	90	1.3	135	175
30	160	75	1.1	115	155
25	140	65	0.95	100	130
20	115	55	0.75	80	105
15	95	40	0.55	65	80
10	75	30	0.35	45	60
<10	30- 75	5- 30	<0.35	10- 45	10- 60
National AQG	90	60		150	

1 Vehicle exh. particle emission = 23% of total area distributed TSP emissions.
2 Vehicle exh. particle emission = 42% of total area distributed PM_{10} emissions.
3 The ratio between vehicle PM_{10} lead and particle emissions = 0.33/8.9 = 0.037.
4 Max. 24-hour PM_{10} = 1.5 x annual average PM_{10}.
5 Max. 24-hour PM_{10} = 2.0 x annual average PM_{10}.

From the table it is clear that in Metro Manila, the long-term TSP AQG, (90 µg/m³), is exceeded to a larger extent than the corresponding PM_{10} guideline, 60 µg/m³. Thus, TSP is the limiting parameter for long-term exposure to particles.

Table 2.14 also shows, by comparing the calculated concentrations to the AQGs, that the Philippine short-term PM_{10} guideline, 150 µg/m³, is less restrictive in the Metro Manila than the long-term TSP guideline. The WHO short-term PM_{10} guideline, 70 µg/m³, is about as restrictive in the Metro Manila as the TSP long-term guideline.

2.5 Summary of the Air Quality Assessment

NCR Air Quality:

- For many years concentrations of TSP and SO_2 have been measured regularly at 8 fixed locations, for a few days per month. The locations are partly street-side, partly area-representative stations, and some in industrial areas.

- In addition to these measurements, a network of 5 street-side stations were introduced in 1991/1992. This program included NO_x, CO, PM_{10}, and lead, in addition to TSP and some SO_2 measurements.

- This database, which has limitations, shows:

  - TSP frequently exceeds WHO and Philippines National Air Quality Guidelines (AQG). Concentrations near the main roads are sometimes extremely high, exceeding the AQG by a factor as high as 5.

- Measurements in industrial areas (e.g. Valenzuela) indicate high TSP concentrations.

- TSP and PM_{10} are the most importantpollution parameters in the Metro Manila relative to their respective AQGs.

- SO_2 calculations indicate that AQGs are exceeded, although not as substantial as for particles. There is a large discrepancy between the results of those calculations and the results of SO_2 measurements.

Manila NCR's air quality monitoring system needs to be substantially improved (see Ch. 2.6).

Emission sources:

According to fuel consumption data, a large quantity of high sulfur Bunker C oil (BOF) is combusted in the Metro Manila annually. Road traffic is an important source, through exhaust emissions and resuspension of road dust. Little is known about industrial process emissions, and estimates of emissions from refuse burning, construction and resuspension are rough. There are no data on the use of wood and coal.

Estimated main contributions from sources are as follows:

TSP:	BOF combustion	22% incl. power plants 3%
	Resuspension of road dust	33% (rough estimate)
	Diesel vehicle exhaust	9%
	Refuse burning	8% (rough estimate)
	Industrial processes	8% (rough estimate)
PM_{10}:	BOF combustion	34% (incl. power plants, 5%)
	Diesel vehicle exhaust	16%
	Resuspension from roads	15%
	Refuse burning	14%
SO_2:	BOF combustion	≈88% (incl. power plants 28%)
	DOF combustion	≈ 5%
	Diesel vehicle exhaust	≈ 4%

An improved emission inventory is needed, especially regarding industrial emissions, refuse burning, resuspension, and construction (see Ch. 2.7).

Population exposure:

Calculation show that about 65% of the population live in areas where the AQG for annual average TSP concentration is exceeded. This is increased to 80%, when the estimates of exposure on roads and in industrial areas are added.

Estimated exposure in exceedance of 2xAQG (for annual average TSP) is:

- 3% of the population in their residences;
- 11% of the population, with estimated exposure in industrial areas; and
- 29% of the population, with roadside exposure also added.

General exposure at residences are due to the following main sources:

For TSP: Resuspension from roads and construction, diesel vehicles, and refuse burning
For PM_{10}: Diesel vehicles, refuse burning, and resuspension/construction.

Additional exposure in industrial areas is due mainly to BOF combustion.

Exposure to the highest concentrations are due to roadside concentrations, which affect drivers (estimated at 300, 000 people), commuters (estimated at 2.4 million people) and roadside residents (estimated at 65, 000).

Background for calculating of effects of abatements measures:

A simplified procedure for calculating emissions and population exposure has been programmed into spreadsheets, to calculatie first order estimates of the effects of various abatement measures on exposure distribution.

2.6 Needs for improvement of the Air Quality Assessment for the NCR

2.6.1 Shortcomings and data gaps

Air Quality

The present measurement system operated by DENR-NCR can be briefly characterized as follows:

- 24 hour samples of TSP and SO_2 collected rather infrequently (2-4 days per month).

- PM_{10}, lead, NO_2, CO, ozone and other compounds are not measured routinely.

- Many of the measurement sites are not clearly defined in terms of their representativity, as
  - city background stations (commercial, industrial, residential);
  - traffic exposed (street side) stations; or
  - industrial hot spot stations.

It is clear that the DENR-NCR group operates under considerable financial constraints, affecting methodological and manpower capacities. It is nevertheless important to improve air quality monitoring in Manila. It is anticipated that the improved monitoring system should include:

- a number (2-5) of city background sites;
- some (1-3) traffic exposed sites;

- some (1-5) industrial area/hot spot sites;
- monitors (continuous) for PM_{10}, CO, NO_x, SO_2, or O_3, depending upon the site; and
- on-line data retrieval system directly to lab database, via telephone/modem.

In particular, O_3 measurements should be carried out soon in Metro Manila to determine whether the area has a photochemical air pollution problem. Such measurements should be carried out continuously over a one-year period at sites inside and outside Metro Manila.

Emissions

The main shortcomings of the emission inventory:

- industrial emissions (use and combustion of fuel, process emissions);
- resuspension from roads;
- other coarse particle sources, such as construction; and
- domestic refuse burning.

Less important shortcomings include traffic distribution data which forms the background for car exhaust emission distribution, and the use and distribution of fuel in the commercial and domestic sector, including generators.

It is necessary to fill the inventory data gaps, and upgrade the inventory. In this regard, a comprehensive emission database should be developed, covering both the DENR-NCR and LLDA.

Population exposure

Determining the population exposure to air pollution in NCR, and contributions to this exposure from various sources, is based on a combination of dispersion modeling and air pollution monitoring.

A good quality population exposure distribution is important because it is the basis for:

- estimating health damage costs; and
- assessing the effects on health of various measures to reduce exposure, as part of a cost-benefit analysis.

To improve population exposure calculations beyond what has been developed as part of the first. phase of URBAIR, the following is needed:

- Improved data for distributing the population in km^2 grids. Barangay data exist already and should be used.

- Dispersion modeling expertise in Metro Manila should be identified and its use integrated into the control agencies' Air Quality Management work.

Dispersion modeling expertise and appropriate models for air pollution management and control strategies should rest with EMB and DENR-NCR.

2.6.2 Proposed Actions to improve the Air Quality Assessment

"Actions"	Time schedule
Air Quality Monitoring • Design and establish a modified/improved/extended ambient air monitoring system - evaluation of sites; number and locations - selection of parameters/ methods/monitors/operation schedule. - necessary upgrading of laboratory facilities, and man power capacities.	This activity should start immediately, and a proposed schedule is as follows: • By 30 June 1996: Finalized plan for an upgraded air quality monitoring system, including laboratory upgrading. • New modern monitoring stations have already been put in operation in 1994. Final upgrading is to be evaluated after this
• Design and establish a Quality Control/Quality Assurance System • Design and establish an Air Quality Information System, including - database - information to . control agencies . law makers . general public.	This activity should also start immediately, phased in with the establishment of the improved monitoring system, and the upgrading of the laboratory. This activity should be started as modern, on-line monitoring stations have been established. To be operative by the end of 1996.

Emissions • Improve emission inventory for NCR a) Produce inventory of industrial emissions (location, process, emissions, stack data) b) Improve inventory of road and traffic data c) Improve inventory of domestic emissions d) Study resuspension - from roads - from other surfaces • Develop an integrated and comprehensive emission inventory procedure, incl. emission factor review, update and QA procedures. Must cover both Metro Manila and LLDA areas. • Improve methods and capacity for emission measurements.	This activity should be started without delay, by establishing a unit which will have a long-term responsibility for emission inventory work in Metro Manila. • 1. priority: - industrial emissions inventory - study of resuspension from roads - start the development of an emission inventory procedure.
Population exposure Assess current modeling tools/methods, and establish appropriate models for control strategy in Metro Manila.	This activity should be started without delay by establishing a which will have a long-term responsibility for performing such modelling in Metro Manila.

3. Air quality in Metro Manila. The reference scenario 1991-2010

3.1 Introduction

This chapter forecasts Metro Manila's air quality, if only measures currently agreed are implemented. These expectations are based on:

- emissions in the various source categories in 1992 (see Table 2.6);
- forecasts of variables[2] influencing emissions, such as fuel consumption, vehicle mileages, or production values (see Ch. 3.1 below);
- technological developments relevant to emissions but independent of environmental policies;
- environmental measures already taken (see Ch. 5); and
- the number of people exposed to air pollutants.

The time horizon chosen is the year 2010. This choice is based on the assumption that it will take at least fifteen years to deploy an environmental policy. Futhermore a vehichles typical lifetime are 10-15 years, which implies that renewing the vehicle fleet will take 15 to 20 years (unless chosen for a forced development).

In Chapters 3.3-3.7, reference scenarios are described sector by sector along the methodology summarized above.

3.2 Projection for future growth

Projections on growth of population, GDP per capita and vehicle fleet are estimated by the ADB/EMB study "Vehicular Emissions Control Planning for Metro Manila". It's projections are given in Table 3.1, together with data from the last decade. Figure 3.1 shows past and projected growth, and growth rates.

The population has grown about 3% per year over the last decade. This growth is projected to be reduced to 2.0% p.a. GDP/capita growth is projected to increase from about 3% p.a. in 1985-1990, to 6.6% p.a. towards 2005.

[2] Emission = emission factor (Ef) * emission explanatory variable (eev).

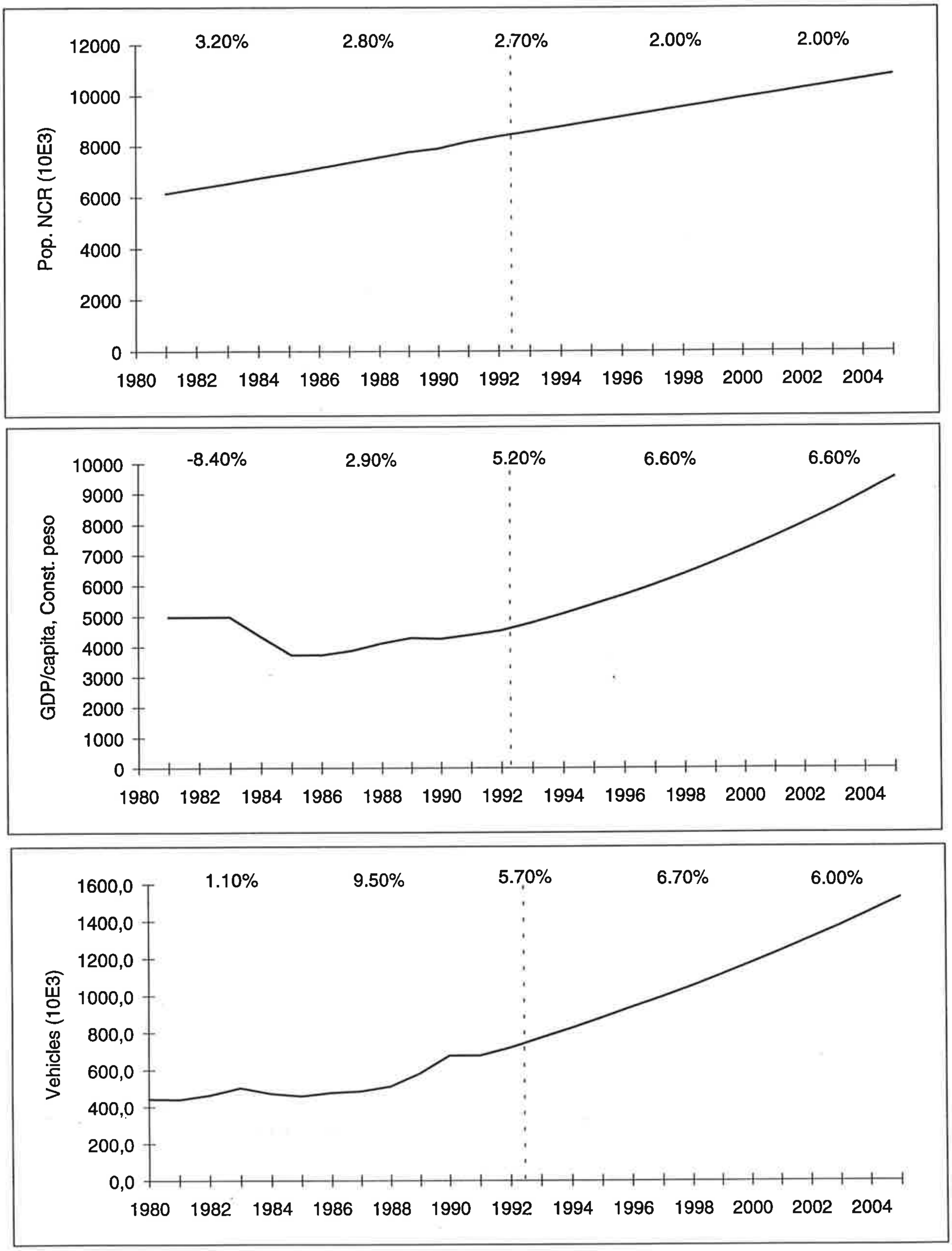


Figure 3.1: Growth and growth rates, Metro Manila, 1980-2005.

Future growth in the vehicle fleet is projected to follow closely this projected growth in GDP/capita. Projected growth in cars is about 5.5% p.a. and somewhat higher for UVs, trucks and MC/TC. The jeepney fleet is projected to grow about 1% p.a.

The Metro Manila Urban Transport Development Plan (1990-2000) in its EDSA Mass Transit Report gives the following projections for private vehicle ownership in Metro Manila (cars and utility vehicles):

Year	Cars/utilities per 1 000 people
1990	67
2000	87
2010	105
2020	121
2035	140

This projection is, for the period 1990-2000, essentially the same as in Table 3.1.

Table 3.1: Recent past and projected growth rates, NCR.

	Population		GDP/Capita		Vehicles, total		Cars + taxi	
Year	$x10^3$	AI	Const. Peso	AI	$x10^3$	AI	No.	AI
1981	6 160		4 970		445		206	
		3.2		-8.4		1.1		1.9
1985	6 940		3 720		464		222	
		2.8		2.9		9.5		7.7
1990	7 920		4 260		685		307	
		2.7		5.2		5.7		4.8
1995	8 970		5 370		880		380	
		2.0		6.6		6.7		5.8
2000	9 875		7 155		1 173		490	
		2.0		6.6		6.0		5.3
2005	10 840		9 530		1 524		621	
	Jeepney		UV		Trucks/buses		MC/TC	
	NO.	AI	No.	AI	No.	AI	No.	AI
1981			163		43		34	
				0.5				2.9
1985			166		38		38	
				10.4		11.6		1.5
1990			252		60		67	
				6.2		6.3		7.2
1995	52.6		277		79		91	
		1.0		8.2		6.3		8.1
2000	55.2		390		104		128	
		1.0		6.9		8.5		7.0
2005	58.0		525		148		173	

AI: Annual increase, %

3.3 Traffic

The evolution over time of emissions due to road traffic is the result of various developments:

- the size of the vehicle fleet;
- the vehicle technology (gasoline (four-stroke) mixed lubrication (2-stroke), diesel);
- the use of emission control techniques required by legislation; and
- the pattern of use (annual mileage, driving pattern).

A key factor is the development of the vehicle fleet. Table 3.2 projects its development, which the present study extrapolates to the year 2010.

Table 3.2: The Metro Manila vehicle fleet ('000) and growth rates (%) (Mehta et al, 1993; ADB, 1992)).

	Cars	UVs	MC/TC	Taxis	Jeepneys	UV(D)	Trucks	Buses
1991	289	136.6	65.1	14.5	50.5	63.2	53.1	5.2
2005	603	357.7	172.6	16.7	58.0	167.4	141.5	6.1
Rates	5.4	7.1	7.2	1.0	1.0	7.2	7.3	1.1

The numbers of vehicles are taken as the base for emission explanatory variables due to lack of projections of future transport activities (fleet mileages). We are aware of the uncertainties of this simple method for extrapolating emissions. It seems hardly possible that all this traffic can fit in Metro Manila. However, it can be assumed that road construction and traffic management will allow for traffic increase.

Nevertheless, it is assumed that traffic increase will extend outside the study area. Therefore, tentatively, growth rates have been lowered by 25%, the anticipated net effect of an increased vehicle fleet and expanded road network, inside and outside the NCR. Within the framework of this study, it is not possible to design a more extended refined reference scenario for future transport.

Current environmental policy. In order to assess emissions it is necessary to account for developments in environmental policy on top of the assumptions about future traffic activities. Current regulations on air pollution are described in Ch. 5 (more details in Appendix 3). Recently passed policies which will effect future air pollution are as follows:

Low lead/unleaded gasoline. On the 17th of March 1993 president Ramos and leaders of the Philippine petroleum industry agreed on a covenant to reduce the lead content of gasoline and eventually to phase out the use of lead. According to this agreement the lead content of both grades of gasoline (premium and regular) was to be reduced to 0.15 g/liter (the 1993 lead content of premium gasoline was 0.6 g/liter[2]). Low lead

[2] According to Mehta et al, (1993) (p.129) 0,45 gram/liter.

gasoline (0.15 g/l) was introduced in July 1993. An Executive Order is being considered which will call for a complete phase-out of lead in gasoline by 1998. Unleaded gasoline was made available in key cities by February 1994.

Reduction of the sulfur content of diesel fuel. The standard for sulfur is currently (July 1993) 0.7% (by weight). The current program calls for a reduction of sulfur from 0.7% to 0.5% by January 1, 1996.

Emissions. Figure 3.2 shows the developments of exhaust particle emissions from vehicles fueled by diesel and gasoline. This figure is based on the 1992 emissions presented in Table 2.5 and the growth rates presented in Table 3.2, modified as explained above. Other variables, such as the consumption patterns are assumed to be constant due to lack of proper information. The figure clearly demonstrates the environmental significance of the diesel part of the vehicle fleet.

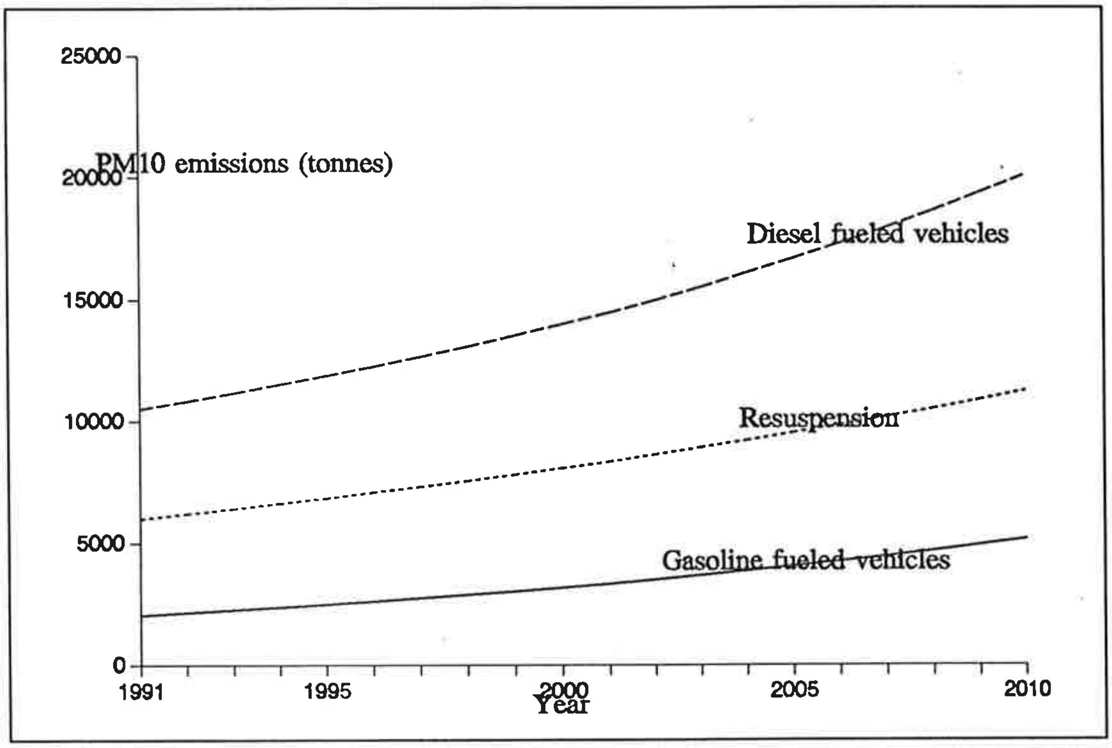


Figure 3.2: Reference scenario for the development of PM_{10} emissions from car exhaust.

Over a period of 15 years the PM_{10} emissions appear to double, people's would follow a similar path.

Unlike lead problems, which are being addressed with the shift to low lead, introduction of unleaded gasoline and the possible phase-out of lead by 1998, PM_{10} emissions from traffic will continue.

3.4 Power production

Power is provided by three oil-fired power plants with a total capacity of 1280 MW. The Sucat Power Plant is the largest, having a capacity of 800 MW. In addition to the public supply of power, many firms have their own equipment (gensets) to produce electricity, either continuously or as a reserve in case of a power outage. Outside Metro Manila power is produced both in coal-fired plants and geothermally.

It is expected that, nation-wide, power demand will increase 7% up to the year 2000 (Mehta et al, 1993). Coal and geothermal energy are expected to be used more in the future. It is expected that new plants will be built outsideMetro Manila. The scenario for Metro Manila is therefore that power production will not change. Old plants may be replaced, which could improve the environmental situation, but due to the long-range dispersion of power plant emissions this improvement within Metro Manila would be very small.

3.5 Fuel combustion (other than in power production)

Lacking detailed information the main indicator for developments in fuel combustion is the annual growth rate of industry. In the period 1986-1991 industry grew at an average rate of 3.7% per year. This rate is low compared to other countries in south-east Asia. It has been reported that the total Philippine economy (GDP) might grow at an annual rate of 5 to 6% between 1992 and 2000, provided certain economic constraints can be removed (Mehta et al, 1993, p.111). The actual growth in 1994 was 5.1%. Such growth will also occur in the NCR. The reference scenario is based on the assumption that fuel consumption will grow 5.5% per year in the period 1992 - 2010.

In Chapter 5 it is mentioned that by January 1996 the maximum allowable amount of sulfur in heavy fuel oil (BOF) will be reduced to 3.0% (by weight). The regulation for the amount of sulfur in light fuel oils (gasoil, industrial diesel, or DOF) will also be more strict. By January 1996 the maximum allowable content will be reduced from 0.7% to 0.5%.

Figure 3.3 shows the envisaged developments. It also depicts the use of heavy fuel oil as the main cause of TSP emissions. In fact, presumably it will be the main source of SO_2,.

It is noted that the annual growth rate in reacent years has been lower than the recent performances of other economies in the south-east Asia. Therefore, if the Philippine economy were to exhibit similar dynamics as the other economies, TSP emissions might rise even more steeply, other factors being constant.

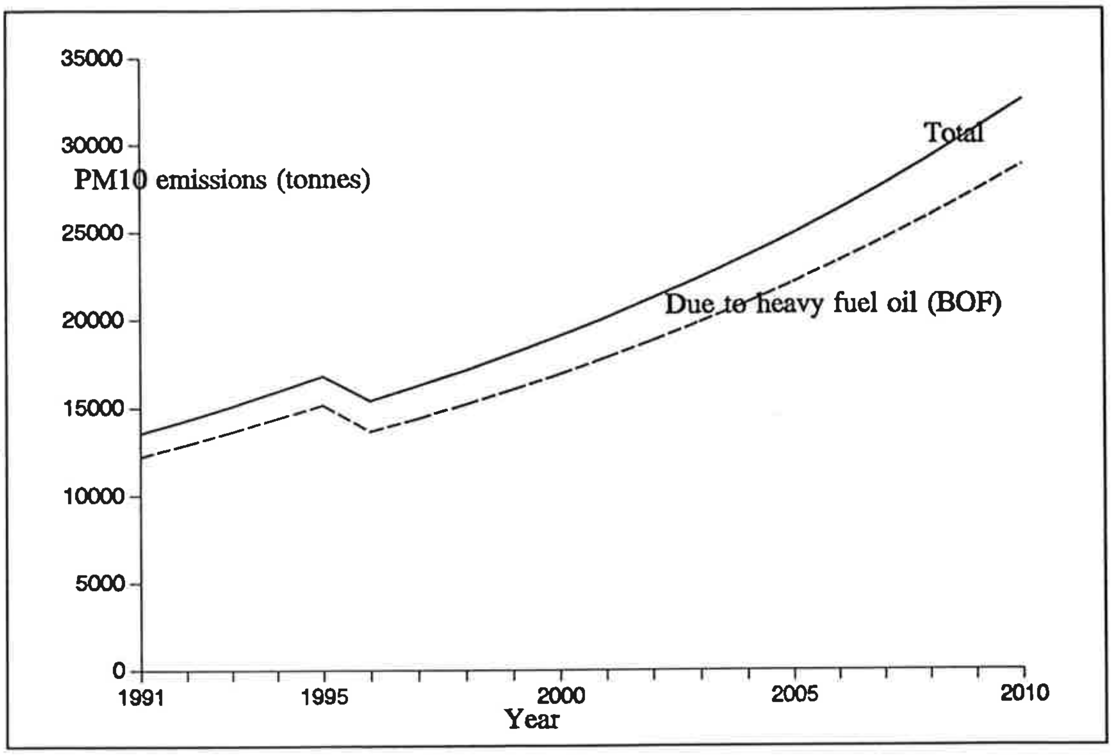


Figure 3.3: Reference scenario for PM_{10} emissions due to combustion of oil products.

3.6 Industrial processes (non-combustion sources)

The lack of data on process emissions, estimated at 3000 tonnes PM_{10}, in Metro-Manila does not allow for listing an appropriate set of measures. In the reference scenario these emissions are assumed not to change.

3.7 Refuse burning and construction

PM_{10} emissions due to construction are estimated at 2,500 tonnes, while the corresponding figure for refuse burning is less than 6,000 tonnes (see Table 2.5). The uncertainty of these figures is high, which makes validity doubtful. One might argue based on experience in industrialized countries that these emissions tend to grow with the growth of per capita GDP (which is projected at 6.6% in the period 1990 - 2005 (ADB, 1992)). On the other hand construction and, in particular refuse burning, are different from similar activities in industrialized countries. Lacking appropriate information, it has been arbitrarily decided to assume a 3% growth rate for construction and a 1% growth rate for the PM_{10} emissions from refuse burning.

3.8 Population at risk

The EDSA mass transport study (Department of Transportation and Communications, 1991) presents figures about the expected population growth in Metro Manila. Population increases from 7.92 million in 1990 to 8.97 million in 1995 (an average growth rate of 2.7%), while in the following decade an average growth of 2% annually is foreseen. It is assumed that 2% will also be the growth rate between 2005 and 2010.

3.9 Conclusions

This chapter presents as a reference scenario an assessment of the developments in emissions and the exposure of the Metro Manila population to PM_{10}. Figure 3.4, which contains basically the same data as Figure 2.14, but is now displayed as a frequency table, presents the 1992 population exposure to PM_{10}. The TSP concentrations of Figure 2.14 are converted to PM_{10} using the factor 0.55.

This information is processed from emission data using a dispersion model and population distribution (see chapter 2). Estimations of future exposure are similarly conducted. The basic assumption are summarized in Table 3.3 Figure 3.5 shows the resulting developments in emissions. Based on the assumptions, the combustion of fuel (DOF and BOF) will continue to be an important source of PM_{10} emissions.

The resulting future (2010) exposure is shown in Figure 3.6. The figure clearly shows a large increase in exposure. While in 1992 about 30% of the population was exposed to PM_{10} concentrations above 90 µg/m³ (as annual average, corresponding to 2 times the Air Quality Guideline for TSP), in 2010 in the reference scenario this increases to about 48%, and the highest exposure also increase correspondingly.

In Figure 3.7 the population distributions for 1992 and the reference scenarios (2010) are presented together, as cumulative distributions. The increased exposure of the reference scenarios is clearly shown.

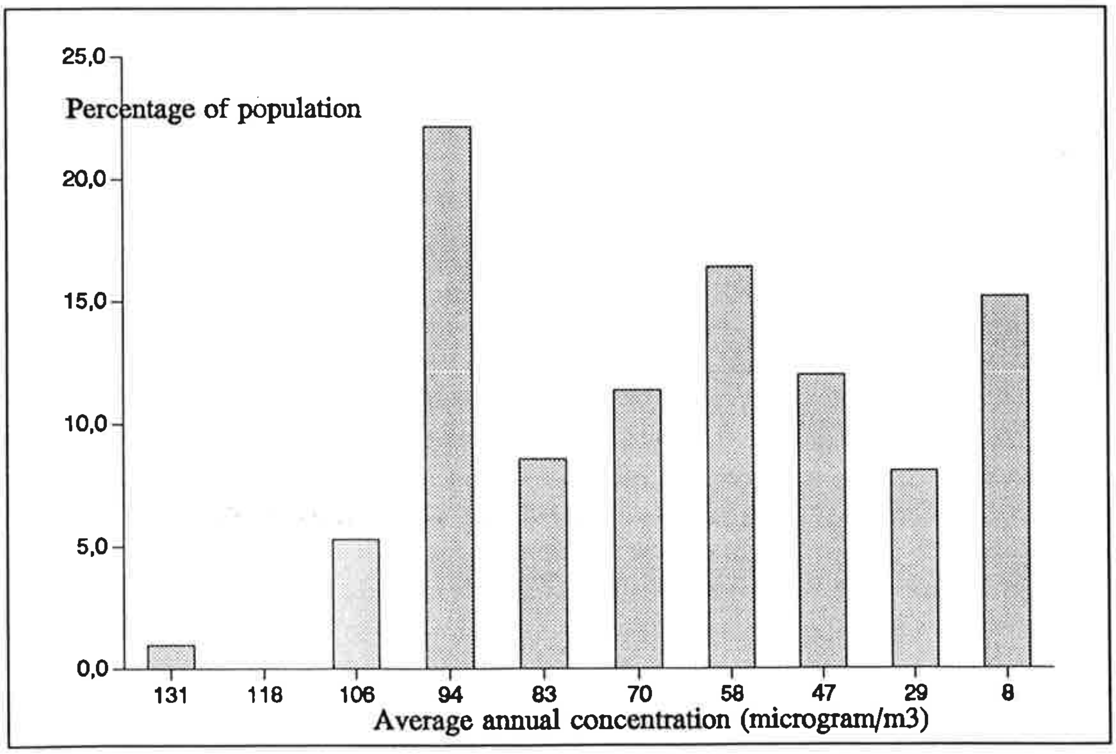


Figure 3.4: The 1992 exposure of the Metro Manila population to PM_{10}.

Table 3.3Summary of the assumptions of annual growth-rates of emission sources as used in the scenario calculations.

Mobile sources	Growth rates (%) (number of vehicles)*	Stationary sources Population	Growth rates (%)
Passenger cars (gasoline)	5.4	Power production	0
Gasoline Utility vehicles (gasoline)	7.1	Industrial fuel combustion	5.5
Motor cycles	7.2	Process emissions	0
Taxis (diesel)	1.0	Construction	3
Jeepneys (diesel)	1.0	Refuse burning	1
Utility vehicles (diesel)	7.2		
Trucks (diesel)	7.3	Population growth 1990-1995	2.7
Buses	1.1	Population growth 1995-2010	2

*In the calculations it is assumed that 75% of the associated traffic growth takes place in the area of study.

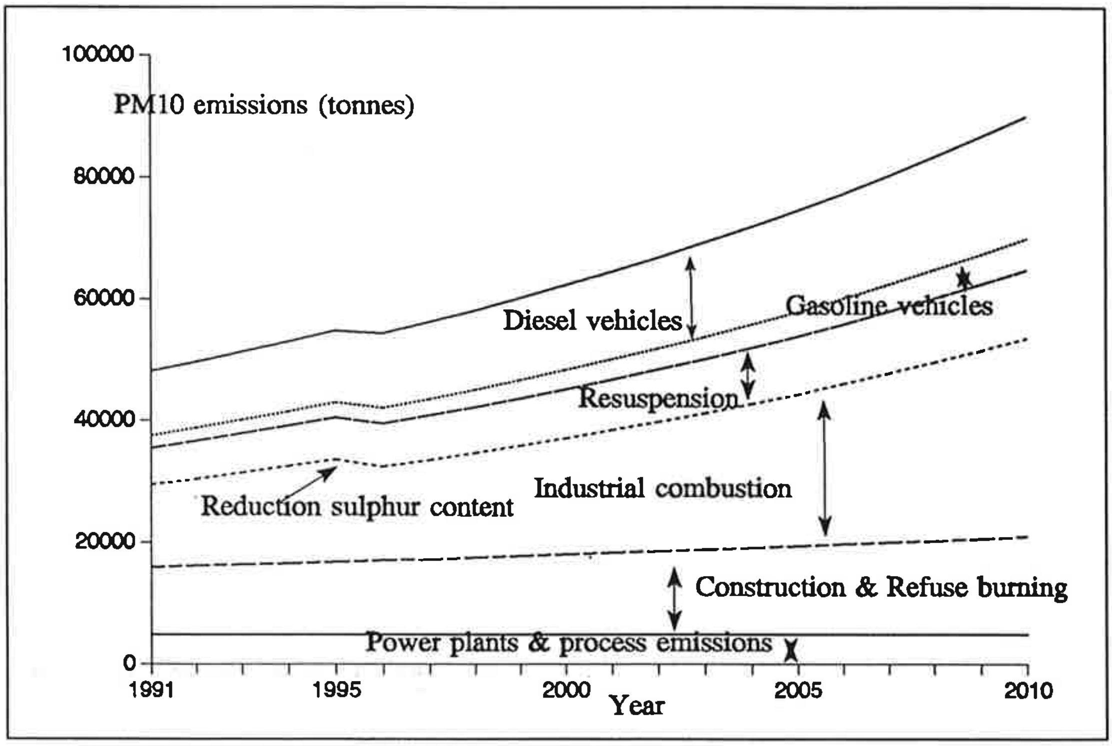


Figure 3.5: The reference scenario for the development of emissions of PM_{10} in the NCR.

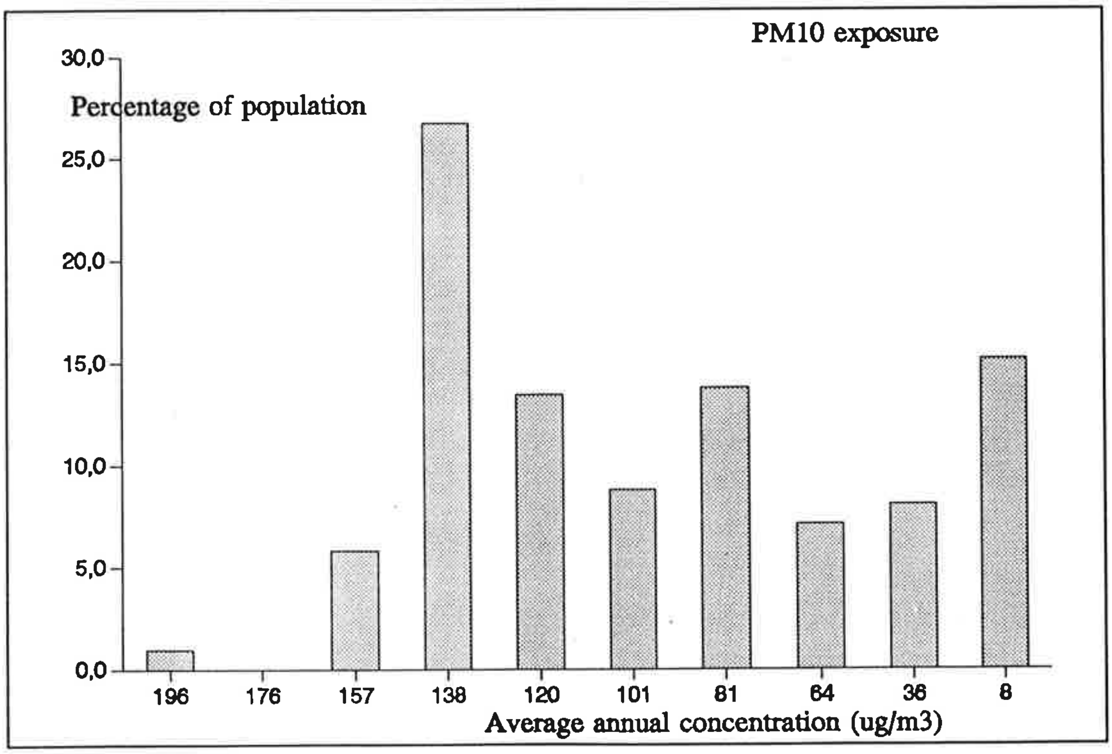


Figure 3.6: Population exposure to PM_{10} in the NCR, Reference scenario, 2010

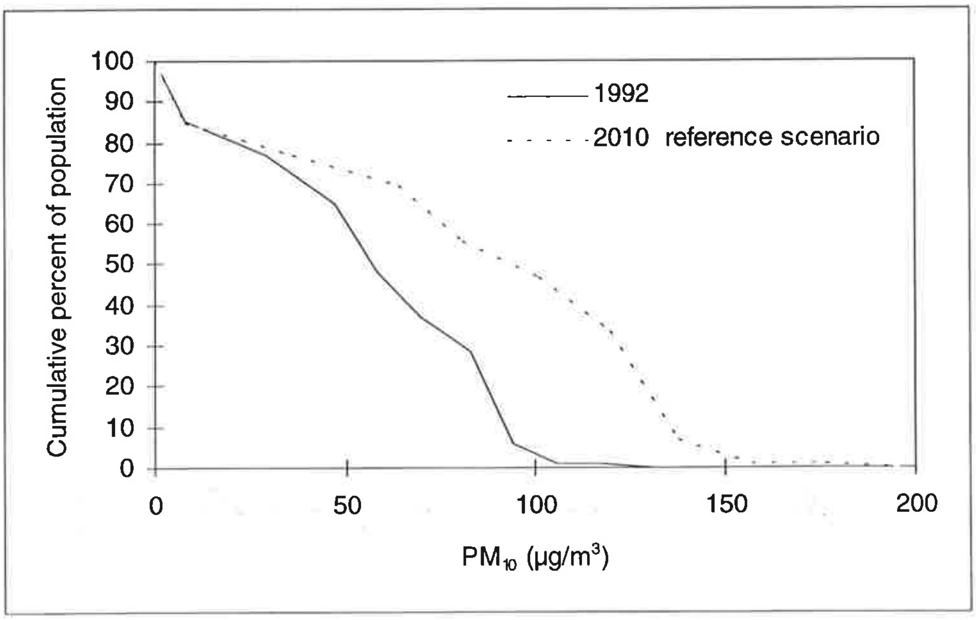


Figure 3.7: The PM_{10} exposure distributions presented as cumulative distributions.

4. The health impacts of air pollution in Metro Manila and their valuation

4.1 Introduction

With economic development and growth of large cities in Asia, air pollution problems have become endemic. This chapter presents an overview of major air pollution impacts in Metro Manila including an estimation of the monetary value on these damages.

Chapter 2 concluded that concern about air pollution is mainly due to high concentrations of suspended particles and lead, both exceeding health guidelines. SO_2, NO_x and ozone (photochemical air pollution) do not appear to be as serious. Therefore, this chapter concentrates on PM_{10} and lead.

Estimates of health impacts is mainly based on Ostro's work, described in the general URBAIR report (Ostro, 1994). The equations presented in the following text are based on this work. Guidelines for acceptable air concentration, a "no-damage" benchmark, have been proposed by the World Health Organization (WHO).

Health is not the only adverse impact of air pollution, but due to lack of appropriate data it was not possible to quantitatively assess different impacts such as reduction of capital goods, economic life, tourism, crops, and other intangible impacts.

A related problem is traffic congestion which is very severe in Metro Manila. It may be resonable to assume that 1/3 of the population (9 million persons in 1994) loses on average two hours per day during 300 days/year. At an hourly wage rate of 12P, this results in a damage of over 20 billion P.

Sections 4.2 and 4.3 deal with the impacts on death rates and health in Metro Manila. Section 4.4 presents a calculation of the costs which can be attributed to these impacts. The impact calculations are based on dose-effect relations, and on the population exposure estimates and methodology described in Ch. 2.4 and Appendix 6 and 7.

4.2 Death (mortality)

The impacts on health are divided into mortality (excess deaths) and morbidity (excess cases of illness). Mortality and morbidity are derived from air quality data using dose-effect relationships. In principle such relations are found by statistical comparison of death rates and morbidity in urban areas with different air quality. Ostro (1994) has estimated appropriate dose-effect relations. Admittedly, these dose-effect relations are derived from studies in countries different from the Philippines and it is somewhat speculative to apply them to Metro Manila. But until specific dose-effect relations tropical conditions are derived, Ostro's relations are the best available.

Although it is clear that indoor pollution, such as caused by cooking, can also damage health, we restrict the analysis to outdoor concentrations.

Mortality due to PM_{10}.

The relation between air quality and mortality used is:

Excess death = 0.00112 x ([PM10] - 41) x P x c

where	P:	number of people exposed to a specific concentration
	c:	crude rate mortality = 0.0061 in Metro Manila (Subida and Torres, 1994).)
	PM_{10}:	Annual average concentration ($\mu g/m^3$) of PM_{10} (particles with a size smaller than 10 μm)

The number 41 in the equation is the WHO-guideline for long-term annual average concentration (section 2.1) taking into account that PM_{10} concentrations typically are about 55% of TSP.

From this relation and the exposure data given in Chapters 2 and 3 it can be concluded that the mortality increases from about 1,300 in 1992 to about 2,500 in the year 2000 and 5,700 in 2010. This increase about 25% due to the increase of the exposed population from the expected growth of Metro Manila's inhabitants.

Mortality due to lead

In the dose-effect function of mortality caused by lead, diastolic blood pressure (DBP) plays a role. The relation between lead concentration and change in DBP is estimated as:

$$\Delta\, DBP = 2.74\ (\ln\ [Pb\ in\ blood]_{old} - \ln\ [Pb\ in\ blood]_{new}),$$

where [Pb in blood] indicates the concentration of lead in blood ($\mu g/dl$).

The relation between lead in blood and lead in the air is complex, but a good approximation is proportionality. In that case:

$$\Delta\, DBP = 2.74\ (\ln\ [PbA]_{old} - \ln\ [PbA]_{new}),$$

where [PbA] indicates the concentration of lead in the air ($\mu g/m^3$).

Evidence of a threshold level of [PbA] is scant, and the threshold might well be zero. Howevr, WHO guidelines, suggest a $[PbA]_{old}$ benchmark, of 0.5 μg. The change in DBP can now be derived. The change in the 12 year probability of death related to change in blood pressure due to lead is estimated as:

$$Pr\ (M) = (1+ \exp(-(-5.315 + 0.03516\ DBP_{old}))^{-1} - (1+ \exp(-(-5.315 + 0.03516\ DBP_{new}))^{-1}$$

As reference value, DBP_{old} can be 76, the average US value.

No reliable data on lead exposure could be derived. About 700,000 people live in areas where lead concentration is 1.2 $\mu g/m^3$ or higher. Moreover, some 1 million people along the roadside are exposed to that concentration. It was not possible to give a more precise distribution of people exposed to concentrations below 1.2 µ g/m³, to give distribution of people exposed to higher concentrations.

If for this 1,700,000 people lead concentration were be reduced to 0.5 µg/m³, mortality would decrease by 770 people yearly. This damage figure of 770 cases of excess yearly mortality is an underestimate, as the population exposed to concentrations between 0.5 and 2.1 µg/m³ is not included, and a part of the 1,700,000 people are exposed to concentrations above 1.2 µg/m³

It is expected that the lead will diminish in Metro Manila, with the lead content in gasoline decreases, by far the most important source of airborne lead pollution.

4.3 Illness (morbidity)

Particulates. The following effects can be attributed to particulates: chronic bronchitis (CrBr), restricted activity days (RAD), respiratory hospital diseases (RHD), emergency room visits (ERV), bronchitis (B), asthma attacks (A) and respiratory symptoms days (RSD).

The following dose-effect relationships are described in the general URBAIR Guidebook:

CrBr: the change in yearly cases of chronic bronchitis per 100,000 persons is estimated at 6.12 per µg/m³ PM_{10}. The total number of yearly cases of chronic bronchitis per 100,000 persons is than 6.12 x ([PM_{10}] - 41).

RAD: the change in restricted activity days per person per year per µg/m³ PM_{10} is estimated at 0.0575. If we use again the WHO standard, the change is 0.0575 x ([PM_{10}] - 41).

RHD: the change in respiratory hospital diseases per 100,000 persons is estimated at 1.2 per µg/m³ PM_{10}.
Using the WHO standards, the respiratory hospital diseases per 100,000 persons are estimated at 1.2 x {[PM_{10}] - 41).

ERV: the number of emergency room visits per 100,000 persons is estimated at 23.54 per µg/m³ PM_{10}, and the total number per 100,000 persons at 23.54 x ([PM_{10}] - 41).

B: the change in the annual risk of bronchitis in children below 18 years is estimated as 0.00169 x ([PM_{10}] - 41). The number of children below the age of 18 is estimated at 35% of the total poplulation.

A: Likewise, the change in daily asthma attacks per asthmatic person is estimated at 0.0326 x ([PM_{10}] - 41). What still is needed is the number of asthmatic persons.

RSD: the number of respiratory symptoms days per person per year is estimated at 0.183 x ([PM_{10}] - 41).

Table 4.1: Impact of PM_{10} air pollution on health in 1992, 2000 and 2010.

Type of impact	Number of cases (thousands)		
	1992	2000	2010
Chronic bronchitis (Ch Br)	12	21	48
Restricted activity days (RAD)	11,006	22,140	47,078
Emergency room visits (ERV)	45	88	185
Bronchities in children (B)	112	218	460
Asthma (A)	436	850	1,789
Respiratory symptom days (RSD)	35,028	68,130	143,500
Respiratory hospital admissions (RHD)	2	4	9

* Figures are presented in detail for reasons of consistency, not to suggest large reliability.

Mortality evidence on a threshold level is scant and be zero. However, for practical purposes the WHO standard could be used. The main effects of lead are hypertension, coronary heart disease and decreased intelligence in children. The relation between hypertension and a change in air quality is estimated as

$$\Delta H = \quad (1 + \exp - (- 2.744 + 0.793 \ln 2[PbA]_1))^{-1} - (1 + \exp - (- 2.744 + 0.793 \ln 2[PbA]_2))^{-1}$$

in which $[PbA]_2$ is the ambient lead concentration in the air. The WHO $[PbA]_1$ guideline of 0.5 μg/m3 can be used.

The dose-effect relationship with coronary heart disease (CHD, the increase in the 10 years probability of a case) is:

$$\Delta \Pr(CHD) = (1 + \exp - (- 4.996 + 0.030365\ DBP_1))^{-1} - (1 + \exp - (- 4.996 + 0.030365\ DBP_2))^{-1}$$

in which DBP can be treated as in Section 3.2.1.

The decrease in children IQ points is:

$$\Delta IQ = 0.975 \times ([PbA]_2 - [PbA]_1),$$

in which the WHO$[PbA_1]$, guideline can be used.

For the benchmark concentration we used the WHO guideline of 0.5 μg/m3. It can be argued that a no-effect level is lower, possibly 0, also because the lead intake from air adds to other intakes.

We calculate the damage as the effect of a change in the concentration from 0.5 to 1.2 μg/m3 for a group of the 1,700,000 people exposed to higher concentrations; this is an underestimate as part of the 1,700,000 people are exposed to concentrations above 1.2 µg/m³ and a probably larger group is exposed to concentrations between 0.5 and 2.1 µg/m³.

The results ar given in table 4.2.

Table 4.2: Health impact of lead air pollution (1992).

Coronary heart disease	762	cases
Hypertension	91,207	cases
IQ points loss	403,000	points

4.4 Valuation of health impacts, present and projected

Mortality

A monetary value for mortality is a debatable figure. Many argue that a valuation cannot be made on ethical grounds. However, deleting mortality damage would seriously underestimate total damage.

For the value of a case of mortality, two different approaches can be used; one is based on willingness to pay (WTP), the other on salaries. The WTP approach is described in the general URBAIR report. In the USA a value of about US $ 3 million per statistical life is often used. Although such a valuation is not readily transferable from one country to the other, an approximation can be derived by correcting the US figure by a factor of Philippines purchasing power parity, divided by the US purchasing power. This factor is 2, 110/21, 900=0.096 (Dikhanov, 1994). At an exchange rate of 1P=.03 US$, this suggests a value of P11 million per statistical life in the Philippines.

The other approach is based on lost income. The value of a statistical life is then estimated as the discounted value of expected future income at the average age. If the average age of population is 26 years, and life expectancy at birth is 65 years, the value is

$$V = \sum_{t=o}^{38} \frac{w}{(1+d)^t}$$

with w = average annual income (Shin et al., 1992). In this method, the value of people without a salary (e.g. housewifes) is the same as the value of people with a salary.

The minimum wage in Manila is P145 per day, but very often a lower wage is paid. A reasonable but low estimate is P100 per day, which corresponds to P20,000 per year. At a discount rate of d=5%, V=P.35 million.

Both approaches to the valuation of premature death from PM_{10} the cost figure of air pollution in 1992 ranges from P 0.5 billion to P14.3 billion.

Morbidity

The general URBAIR report presents an estimation of the costs of morbidity (medical treatment, lost earnings), based on US values for the various morbidity categories. In order to obtain city-specific figures the US figures were corrected with a factor .096 that reflects the difference in purchasing power parity between the USA and the Philippines (Dikhanov, 1994). These initial estimates are supplemented by estimates based on specific data for Manila (Subida, 1994). The data sets are presented in table 4.3.

Table 4.3: Valuation of health impacts (all figures in Pesos).

	Estimate from Manila	USA derived
Effects of PM_{10}		
Restricted activity day	160	190
Energency room visit	1,790	856
Bronchitis	1,840	1,069
Asthma attacks	1,190	328
Respiratory symptoms day	40	49
Hospital admission	11,900	92,378
Effects of lead		
Hypertension		722
Coronary heart disease		160,700
Loss of IQ points		15,000

The derivation of the USA figures is explained in the general URBAIR Guide-book.

Combining the results of Chapter 2 and Chapter 3 (as presented in figure 3.4 and 3.5) with the data presented in table 4.3 gives the cost figures presented in Table 4.4. In addition, Table 4.4 summarizes the present damage due to lead pollution.

For some of the effects the figures derived from the USA valuation are higher. This is explained by the high valuation (WTP method) of a statistical life (US$ 98,400) whereas in the Manila valuation the low valuation (loss of income) of a statistical life was used (US$ 11,124). In contrast, the valuation of illness in the Manila figures is higher than in the figures derived from USA.

Table 4.4: Costs (million Pesos) of health impacts of PM_{10} calculated from Manila data.

	1992	2000	2010
Mortality	14,5/0,5*	28,0/0,9*	59,0/1,9*
Restricted activity days	2118/1800	4067/3457	8565/7280
Emergency room visits	39/81	74/156	156/330
Bronchitis in children	122/210	233/403	491/848
Asthmatic attacks	145/526	279/1011	587/2129
Hospital admissions	1738/1518	3338/2907	703/6121
Respiratory symptom days	215/28	413/53	869/112
Total	18727/4594	35971/8824	75745/18582

* First US-derived figures, second Manila data.

For the valuation of health damage due to lead, no Manila data were available. We used morbidity cost figures derived from the USA and, for the valuation of a statistical life, the lower estimate.

Table 4.5: Costs (million Pesos) of health impacts of lead (1992).

Mortality	283
Coronary heart disease	40
Hypertension	23
IQ point loss	2,000
Total	2,300

The estimate of the lead damage is biased downward, as no good exposure figures are available for Metro Manila.

Morbidity and Mortality together. In a recent study, carried out for the URBAIR project (H.A. Francisco, Valuation of Air Pollution Damages in Metro Manila, 1994), the monetary value of damage to health due to air pollution was estimated using the Contingent Valuation Method (CVM), a survey method in which respondents are asked about their willingness to pay to reduce damage. The total estimate of damage to health amounted to P 300-450 million. This figure is low compared to the earlier estimates. This may partly be explained by the fact that the respondents were not aware of dose-response relationships. However, the estimate might also indicate that the value of statistical life as derived from the USA studies may not be applicable to Manila, even if corrected for differences purchasing power parity.

The estimate was based on the average willingness to pay to reduce general health damages. Therefore, it cannot be related to specific illnesses or to exposure to specific concentrations.

4.5 Valuation of non-health damages

Francisco's study (1994) also investigate material damage (housing repair and maintenance). Although no total figure for Metro Manila could be derived, there were indications that material damage could be substantial. Interviewed households reported perceived damage due to air pollution of P 3,233 to P 5,500 per year per house. Howevr, the interviewed home owners did not represent average households, which makes extrapolation to Metro Manila as a whole impossible.

As stated earlier, information on other damage categories is lacking. Only on soiling costs can a speculative estimate be made, using Freeman's estimate (mentioned in the general URBAIR report in section 5.4.4.1) of US$ 2.7 benefits per household due to a reduction of 1 $\mu g/m^3$. Corrected for differences in purchasing power parity, this figure amounts to US$ 0.26. If the average number of persons per household is 8, cleaning costs can be estimated at US$ 2 million or P 60 million.

As indicated in the introduction of this chapter, the order of magnitude of damage due to congestion could well be over P 20 billion.

4.6 Conclusions

The damage caused by air pollution includes harm to human health, materials, vegetation and crops, buildings and monuments, the ecosystems, and tourism. It is not possible to value all of them. However damage to human health can be estimated by using US dose-effect relationships. Damage to health consists of mortality and morbidity. Valuating loss of life is difficult and can only be estimated. If estimated by the human capital approach (lost earnings due to premature death), the value of a statistical life amounts to about P 35 million.

Morbidity costs (illness) are more reliable. They consist of foregone wages and costs of medical treatment. Estimates were made specifically for Manila, of costs of morbidity due to PM_{10}. This valuation of damage to human health contains a tendency to underestimation as suffering due to illness or premature death is not included.

Table 4.6 presents the result of a calculation aimed at attributing air-pollution (PM_{10}) impacts to source categories. The valuation is based on the Manila data.

Health damage due to lead is less reliable, as no good exposure figures are available. Costsfigures of illness were based on US figures, corrected for differences in per capita income differences in USA and Philippines. Both factors lead to serious underestimation. Our rough figures of health damage due to lead amounts to about US$ 70 million in 1992. Other health damage (e.g. due to ozone, NO_x, SO_2) could not be estimated for lack of exposure figures.

Table 4.6: Air pollution impacts attributed to source categories (1992).

Source category	Mortality	RSD millions	Costs (mill. pesos)
Gasoline cars	44	1.2	151
Motorcycles	22	0.6	75
Jeepneys	112	3	395
Utility vehicles (diesel & gasoline)	177	5	614
Trucks and buses (diesel & gasoline)	555	15	1,924
Combustion of heavy fuel oil (BOF)	200	5	695
Refuse burning	435	12	1,519

As is indicated elsewhere in this report, lead pollution is bound to decrease sharply as initiatives to reduce the lead content of gasoline take effect. In contrast, PM_{10} pollution stands to increase: if no environmental measures are taken the health situation will severely deteriorate, while associated costs will increase from about 4.9 billion pesos, a conservative estimate, to about 18.6 billion pesos in the year 2010. Clearly there is an economical justification for addressing Metro Manila's air quality in.

5. Existing institutions, regulations, and policy plans

5.1 Institutions

This chapter briefly mentions the Metro Manila's institutions specifically concerned with air pollution or which are otherwise relevant to environmental policy. A more extensive description is given in a recent World Bank report (Mehta et al. (1994)).

The main air pollution management institution is the Department of Environment and Natural Resources (DENR), a government agency responsible for environmental protection and management. Within DENR is the Environmental Management Bureau (EMB), responsible for developing environmental management strategies and programs. EMB's main tasks are: to recommend environmental management and pollution control, legislation, policies, programs, and projects; to formulate environmental quality standards; to recommend rules and regulations environmental impact assessment; and to provide technical assistance for implementating environmental education and information campaigns. DENR Regional Offices mainly implements laws, rules and regulations, policies, plans, programs, and projects at the local level.

In co-operation with EMB and the DENR Regional Offices, the Pollution Adjudication Board (PAB) adjudicates pollution cases referred to it.

The Laguna Lake Development Authority (LLDA) has a mandate to manage and control the resources of the Laguna de Bay and its region with due regard for environmental concerns. It has jurisdiction over 4 cities and 5 municipalities in Metro Manila. The division of responsibilities between DENR and LLDA is well defined.

The Local Government Units (LGUs) have local-scale responsibility to protect the environment and impose appropriate penalties for acts which endanger the environment. With the implementation of Local Government Code (1991), the environmental functions of the Metro Manila Authority (MMA), supposed to be the co-ordinating body for Metro Manila, became less clear and are being redefined.

The Land Transportation Office (LTO) inspects vehicles, including emission testing as a prerequisite to registration.

The Inter-Agency Committee on Environmental Health has a coordinating function, formulates programs and policies and promulgates guidelines for environmental health protection.

The Board of Investments of the Department of Trade and Industry identifies priority areas for investments and registers industries which qualify. They require companies to secure either an Environmental Clearance Certificate (ECC) or an exemption prior to registering these companies.

The National Economic and Development Authority (NEDA) has the task of integrating the concept of sustainable development in the country's economic development plans. The NEDA Director General is the chairman of the Philippine Council for Sustainable Development (PCSD) and the NEDA office serves as the secretariat of the PCSD, as well as all the Regional Development Councils (RDC).

The conceptual framework of the Philippine Strategy for Sustainable Development was accepted in 1989. It is a very general strategy with among its objectives the achievement and maintenance of acceptable air quality. In the proposed Clean Air Act of 1993, DENR tasks are defined. It states that DENR has jurisdiction over all aspects of air pollution. Presidential Decree (PD) 1181 of 1977 provided for the prevention, control, and abatement of air pollution from motor vehicles. PD 1586 of 1978 established the Environmental Impact Assessment System. The Philippine standards for ambient air concentrations are as shown in Table 5.1.

Table 5.1: National Ambient Air Quality Guidelines for Criteria Pollutants.

Pollutant	Short term (a)		Averaging	Long term (b)		Averaging
	µg/Ncm³	ppm	G Time	µg/Ncm³	ppm	Time
Suspended Particulate Matters (e)						
TSP 230 (f)	-	24 hrs.	90	-		1 yr. c
PM_{10}	150 (g)		24 hrs.	60	-	1 yr. c
Sulfur Dioxide (e)	180	0.07	24 hrs.	80	0.03	1 yr.
Nitrogen Dioxide	150	0.08	24 hrs.	-	-	-
Photochemical Oxidants	140	0.07	1 hr.	-	-	-
as Ozone	60	0.03	8 hrs.	-	-	-
Carbon Monoxide	35 mg/Ncm	30	1 hr.	-	-	-
	10 mg/Ncm	9	8 hrs.	-	-	-
Lead (d)	1.5	-	3 months	1.0	-	1 yr.

Notes:

a. Maximum limits represented by ninety eight percentile (98%) values not be exceeded more than once a year.

b. Arithmetic Mean.

c. Annual Geometric Mean.

d. Evaluation of this guideline is carried out for 24-hour averaging time and averaged over three moving calendar months. The monitored average value fr three months shall not exceed the guideline value.

e. SO2 and Suspended Particulates are sampled once every six days when using the manual methods. A minimum number of twelve sampling days per quarter or forty eight sampling days each year is required for these methods. Daily sampling may be done in the future once continuous analyzers are procured and available.

f. Limits for Total Suspended Particulates with mass median diameter less than 10 microns until sufficient monitoring data are gathered to the proper guideline.

Although the division of responsibilities between DENR and LLDA are well defined the existence of two separate jurisdiction areas may complicate the actual performance of regulatory work. There are overlapping responsibilities in testing motor vehicle emissions of between DENR and LTO. The institutions involved have very limited budgets for environmental management and protection, leading to a shortage of well-trained personnel. Equipment for measuring emissions and monitoring needs to be upgraded. Current fuel pricing and tariff policies stimulate the use of dirty fuels and inefficient engines.

The Oil Price Stabilization Fund (OPSF) plays a role in the price of oil and oil products, and the Energy Regulatory Board allocates costs across all refined products; neither take environmental considerations into account in their pricing policies.

5.2 Existing Air Pollution Laws and Regulations

A summary is given in Appendix 3 of this report. The National Air Quality Standards of the Philippines are described separately in Appendix 2, together with the WHO Guidelines.

A comprehensive set of air pollution laws and regulations has been enacted in the Philippines, which, when enforced, provides the necessary basis for improving the air quality of Metro Manila. A summary follows:

- The **Philippine Clean Air Act** was adopted in 1994, formulated as an umbrella law regulating the work of managing and improving air quality on the national scale.

- **Air Quality Standards** have been set for major pollutants in Metro Manila: TSP, PM_{10}, SO_2, NO_2, Photochemical Oxidants (as O_3), CO and Lead (DENR AO No. 14, 1993). Possible elevated concentrations of other toxic compounds may exist near specific sources.

  The standards are comparable to those given by the US EPA, but they are less stringent than the WHO Guidelines.

- The **emission standards for stationary sources** are comprehensive, also requiring monitoring activities (both of emissions and the ambient air near the plant), and sets requirements for good practices in operating process and control equipment (DENR AO No. 14, 1993). Permissible particle emission levels have recently been made more stringent (1993), while the permissible SO_2 emission will be more stringent by 1996.

- **Fuel specifications**, for sulfur and lead, still quite high, are under consideration. The table below gives presently allowable contents, and the strategy for reductions.

	Present (1994)	Strategy
Sulfur (%, by weight)		
(Ref.: DENR AO 14, 1993)		
- Fuel oil (BOF)	3.5	3.0 (by Jan. 1996)
- Industrial diesel (DOF)	0.7	0.5 (by Jan. 1996)
- Motor diesel		0.5 (by Jan. 1995)
		0.3 (by Jan 1997)
		0.05 (by Jan. 2000)
- Coal	2.5	1.0 (by Jan. 1996)
Lead (g Pb/l fuel)		
- premium gasoline	0.8	0.15 (by July 1995)
- regular gasoline	0.4	0.15 (by July 1995)
- unleaded gasoline		25% (by July 1994)
(market share)		50% (by Jan. 1995)
		100% (by Jan. 2000)

Reducing sulfur and lead in fuels were in 1994 the subject of voluntary agreements involving industries, DENR, and the Congress.

- An **Environmental Impact Assessment System** is in place (PD No. 1586, with last revised implementing rules of 1992).

  This system requires that all planned projects within the country that are environmentally critical or located in an Environmentally Critical Area must obtain an Environmental Complience Certificate before undertaking actual construction. For all projects falling within the scope of Environmentally Critical Projects, a complete environmental impact assessment must be made, while projects to be located in environmentally critical areas need only to submit a Project Description (PD). An outline/guideline for preparing an EIA on a PD has been prepared by EMB.

  The EIA must include a full description of the project's effects on **local air pollution**.

- **Motor Vehicle emission standards** have been set (PD 1182, with implementing rules of 1980).

  The standards set in these rules correspond to standards enforced in Europe during 1975-1979. After this time, the regulations of European and other countries have become considerably stricter. However, a DENR Standard Review Committee is currently revising the 1980 standards.

  The 1980 Philippine standard only covers CO and HC emissions during idling from gasoline-powered vehicles, and smoke opacity during a free acceleration test for diesel-powered vehicles. Modern vehicle emission standards should cover emission limits during driving, according to a standard test cycle, and should cover CO, NO_x, HC and particles.

- **Prohibitive regulations** regarding miscellaneous air polluting activities are in place, such as:
  - activities causing fugitive particle emissions;
  - handling of volatile organic components;
  - open burning; and
  - operating miscellaneous equipment such as furnaces, smoke ovens, bake ovens, coffee heaters, and paint booths.

- **Traffic regulations** have been set with the aim to improve the flow of traffic on Metro Manila's main roads, reducing congestion and air pollution emissions per vehicle, such as
  - bus/PUJ lanes ("yellow lanes);
  - truck ban during rush hours on main thoroughfares;
  - towing illegally parked vehicles obstructing traffic;
  - prohibiting pedicabs/tricycles on main roads; and
  - clearing obstructions on sidewalks and roads.

This set of rules and regulations is considered sufficient, judicially, to form a basis for improving Metro Manila's air quality, if adequately implemented.

The most aggressive enforcment campaign is the Anti-Smoke Belching Campaign, which has been active since 1977. Up to 18, 000 smoke-belchers have been apprehended per year, which means about 1 out every 20 vehicles, if all UVs and trucks/buses are counted. The actual effect of this effort on average smoke emissions from these vehicles has not been evaluated.

With the DENR AO 14 and EIA system, there is a basis for expecting improvement in air quality from stationary sources in Metro Manila. However, improvement will be small and slow, and easily off-set by the present rate of development in population and activities.

The same is true for motor vehicle-related air pollution. Lowering and removing lead and sulfur from gasoline is the only decisive regulatory action which must be followed up strongly to be successful,. Present vehicular emission regulations are lax, compared to present state-of-the-art emission control, and are inadequate to curb emissions, although the Anti-Smoke Belching Campaign is being carried out rigorously. Rapid technical improvement of the diesel vehicle fleet, in particular, is necessary.

5.3 Policy plans

Under Presidential Decree 1181 the "OPLAN Clean Air Metro Manila" has been formulated with the aim to improve the quality of the air within five years, starting January 1993. It contains the following strategies:

- An intensive information, education ad communication campaign.
- Networking with all national government agencies, NGOs and other organizations which can play a role in this campaign.
- Enforcement in two phases: a 'benign' phase in the first six months in which everyone is given the chance to maintain their vehicles in good operating condition and only excessive smoke-belchers will be apprehended; and a "malevolent" phase in the second six months in which all smoke-belchers will be punished.
- Cleaner fuels.
- An inspection and maintenance programme requiring emissions testing of all public utility vehicles, with initial focus on buses and trucks.
- Review of the pricing mechanism for petroleum products, in particular the subsidy for diesel fuel and low tariffs and duties on importing second-hand engines.
- Finalizing of a Clean Air 2000 Action Plan for Metro Manila.

The preliminary Clean Air 2000 Action Plan for Metro Manila formulated strategies along three lines: policy reforms, institutional linkages, and networking, and public information, education, and communication. The policy reforms address five fields:

1. reducing lead in gasoline and sulfur in diesel;
2. mandatory inspection and maintenance program of all vehicles;
3. clean jeepneys;
4. adopting clean vehicle emission standards and phase-out of two-stroke motorcycle engines; and
5. traffic management.

EMB's Air Quality Management Master Plan will be finalized in 1994. It's ten major measures are:

1. remove the price subsidy on diesel;
2. introduce unleaded gasoline;
3. encourage or mandate use of unleaded gasoline;
4. improve the quality of diesel;
5. introduce a strengthened air pollution control licensing system;

6. require all new gasoline vehicles to use unleaded gasoline;
7. encourage replacing diesel engines with gasoline engines;
8. require all new motor vehicles to meet emission standards in country of design origin;
9. mandatory inspection and maintenance program for all vehicles; and
10. introduce advanced emission control systems for new diesel engines.

In DENR's Anti-Smoke Belching Program, a continuing information, education and communication program plays an important role, in order to encourage people's active participation. A number of policies are mentioned that need to be developed, especially incentives to drivers to behave in a less-polluting way; these incentives largely coincide with those mentioned in other plans.

MEIP's Environment Management Strategy contains an Air Quality Management Strategy with the aim to reduce pollution below the proposed EMB air quality guidelines. The strategy contains policies aimed at phasing out lead in gasoline and sulfur in bunker fuels; a program for making vehicles comply with emission standards, coupled with an information campaign of the advantages of proper vehicle maintenance; a ban on large scale importation of used engines which do not meet the standards; strengthening monitoring capabilities; and monitoring so that a more specific industrial emission control strategy can be developed.

The Asian Development Bank carried out a study on vehicular emission control in Metro Manila. The strategy contains six measures:

1. reducing lead in gasoline;
2. low sulfur diesel fuel;
3. inspection and maintenance program;
4. clean vehicle emission standards;
5. clean jeepneys; and
6. public information, education and communication.

ADB is now developing a US$ 50 million investment project on vehicular emissions control

6. Abatement measures: Effectiveness and costs

6.1 Introduction

This chapter presents information about measures which are appropriate for reducing air pollution in Metro Manila. This information can be used to draft an action plan. The chapter is organized according to source categories: traffic; power plants; fuel combustion other than in power plants; non-combustion sources; construction; and refuse burning.

For the main sources, brief characteristics of appropriate measures are presented, including information about:

- their effectiveness in terms of both emissions reduction and reduced exposure impacts in the year 1995 (according to the methodology used in Chapter 4). The reference data are: mortality of 1700, and 50 million respiratory symptom days (RSD) in 1995 (all figures rounded off);

- their costs;

- the benefits (reduced excess deaths (mortality), reduced number RSD, and the economic benefits, based on Manila data (see chapter 4)

- policy instruments which might be used to implement the measures, implemented, and institutions which might be involved in implementing the measure; and

- the term in which the measure can result in emission reduction (short term 2 years, mid-term 2 - 5 years, long term > 5 years).

In the following text, all figures for emissions, costs and benefits represent **annual** figures for 1995, unless otherwise stated.

The list of measures is derived from the information presented by the local working groups, from the URBAIR guidebook, and from earlier plans (see Chapter 2) addressing parts of the problems in Metro Manila. In case of source categories such as industrial process emissions, construction and refuse burning it was not possible to present measures due to lack of information about the specific situation in Metro Manila.

Section 6.6 summarizes and concludes.

6.2 Traffic

In Chapter 3.2 it was shown that emissions are expected to double over the coming 15 years if no environmental measures are taken. This section describes the effectiveness (abated emissions) and, to the extent possible, the benefits of various measures such as:

- enhancing effectiveness of the anti-smoke belching program;
- improving diesel fuel quality;
- implementation of a scheme for inspection and maintenance;
- fuel switches (diesel toand gasoline) in the transportation sector induced by price-shifts;
- adoption of clean vehicle emission standards; and
- other measures.

6.2.1 Reinforcing the anti-smoke belching program

According to rough estimates about 25% of the jeepneys, utility vehicles and other diesel-engine powered vehicles are smoke belchers. The anti-smoke belching program specifically targets these vehicles. It is estimated that a 100% successful campaign would reduce overall emissions of all diesel-engine vehicles by 50% (2, 000 tonnes of PM_{10}avoided).

The costs of a more strict enforcement of regulations addressing smoking vehicles are difficult to assess, possibly including a scheme mandatoring improvement of engine controls (fuel injection/timing). Section 6.2.3 very briefly summarizes a proposal (Baker et al, 1993) for an inspection and maintenance scheme for Metro Manila. This scheme addresses all Manila's vehicles; the anti-smoke belching programme could be integrated into such an inspection and maintenance scheme. It is estimated that the costs of once-per-year-inspection would be about P 200. In addition to these costs, jeepney owners may face increased maintenance costs. The latter costs are expected to be partly compensated by improved energy efficiency.

Summary: Reinforcing the anti-smoke belching program.

Effectiveness:	2 000 tonnes PM_{10} avoided
Costs	Costs of annual inspection per jeepney/utility vehicle P 200 (at the expense of the vehicle owner). Total costs: P 2.5 million
Benefits	Mortality: 158, RSD: 4 million, Benefits 550 million Pesos
Instrument/institution	Enforcement authorities
Term	1 year
Target groups	Vehicle owners/drivers

6.2.2 Improving diesel quality

Ignition and combustion properties of diesel are important parameters in explaining PM_{10} emissions by diesel engines (Hutcheson and van Paassen, 1990, Tharby et al, 1992). It's volatility (boiling range) and viscosity (and its cetane number, an indicator of the ignition properties) are major characteristics which determine these properties, and, consequently, the PM_{10} emissions.

A proposal has been made (Mehta et al, 1993) to set quality requirements, including a further reduction of the sulfur content, shown in Table 6.1. Another requirement may be to add detergents and dispersants: these additives keep injection systems clean and have discernible efficiency effects (Parkes, 1988). Effects on Metro Manila emissions of PM_{10} may be significant.

Table 6.1: Current and proposed quality standards for diesel fuel (Mehta et al, 1993).

Fuel characteristic	Current	Proposed
Distillation 20 vol. % min. °C	none	210
90 vol. % max. °C	357	338
Viscosity (@ 40 °C) centistokes	1.9-5.0	1.8-4.1
Sulfur (weight percent)	0.7	0.20

Improving the quality, given the current refineries product mix, requires either importing low-sulfur diesel fuel or adjusting the refineries to produce lighter distillates and increase hydrodesulfurization capacity. However, this potential is initially limited; a major reason for the "bad" quality of diesel fuel is the structure of demand for fuels (LPG, gasoline, diesel, kerosene, fuel oil). The demand for diesel is relatively high, whereas there tends to be an oversupply of gasoline.

Table 6.2: Product mix of Philippine refineries (Mehta, 1993)

Type of fuel	Output (MTOE)	Share (%)
Gasoline	1 363	14
Kerosene	1 027	10
Diesel	3 972	40
Fuel oil	2 821	29
Other (e.g. LPG, Aviation fuel)	549	7

Effectiveness. Reduction of the **sulfur** content leads to a proportional decrease of sulfur dioxide emissions (about 17 000 tonnes in 1992). In , PM_{10} emissions decrease somewhat since a part of the particulates is sulfur from the fuel.

It is assumed that improvingdiesel's properties, as expressed in an increase of the cetane number[4] and adding detergents, results in a decrease of 10% (a rough estimate) of PM_{10} emissions.

[4] The physico-chemical properties - as expressed in the **cetane number** - of diesel fuel influence the magnitude of the emissions of exhaust particles (EP) from diesel powered vehicles. The relation between these properties (such as volatility and viscosity) and the production of EP in a diesel motor is not straightforward; the characteristics of the diesel motor, its load and its injection timing plan are other important parameters. In Manila it is expected that the cetane number and volatility is of limited significance for EP emissions in comparison with wear, lack of maintenance, and poor of motor settings.

Costs of reducing sulfur content of diesel fuel are due to more extensive desulfurization activity at the refinery. The costs per liter for reduction from 0.7% to 0.2% are in the order of magnitude of 1 cent ($US) or 0.3 P per liter. Sulfur in diesel fuel leads during combustion to the formation of corrosive sulfuric acid. Therefore, reducing the sulfur content has a financial benefit due to a reduction of vehicle maintenance and repair costs.

Currently the output-mix (different products from crude oil, Table 5.3) of the refineries does not match the demand structure: demand for diesel fuel is too high compared to the demand for gasoline. If, by changing the price build-up of transportation fuels demand ratio could be improved, it might be easier to improve diesel quality. Total required investments in refinery adjustments are P 11.5 billion, of which P 1 billion goes to hydrodesulfurization equipment.

The total consumption of diesel compares to gasoline consumption according to our estimation (Table 2.7). Expenditures for diesel fuel, other factors not changing, might increase to P 300 million, as an order of magnitude. These costs might be at the expense of the Oil Price Stabilization Fund, or, may be shifted to the vehicle's owner.

Policy instruments and target groups.

Quality requirements are set by the Energy Regulatory Board. Implementating quality improvement requires action from the petroleum industry.

The system of diesel-fuel subsidies, managed by the Oil Prize Stabilization Fund, provides an opportunity to tie in implementating and enforcing quality standards with the subsidy scheme. If subsidies can be made dependent on fuel quality, introducting clean fuel can be done in a market oriented way.

Term. Improved diesel can be widely available in two to five years. It is estimated that extending the refineries can be implemented in about 3 years (Mehta et al, 1993).

Summary. Improving diesel fuel quality	
Effectiveness:	1,200 tons PM_{10} (1995)
Costs	P 300 million
Benefits	Mortality : 94, RSD : 2.5 million, Benefits 350 million Pesos. Reduction of SO_2 emissions
Instruments/institution	Energy Regulatory Board, Oil Price Stabilization Fund
Term	two-five years
Target groups	Petroleum industry

No detailed data on the cetane number of Manila diesel fuel is available, so far. However, the typical cetane number of diesel fuel in Southeast Asia is 47, whereas in Europe the corresponding number is 50.

6.2.3 Implementing a inspection and maintenance scheme

It has been observed (Baker et al, 1992,1993) that the poor state of vehicles maintenance is a major cause of emissions. Implementing a scheme for inspection and maintenance addresses emissions due to poor maintenance and maladjusted engine controls. A scheme of this nature proposed by ADB (Baker et al, 1993), includes annual inspection for all vehicles, whereas high-mileage vehicles are inspected twice a year. The scheme, to be implemented during 1993-2002, should result in privatecontractor 17 inspection and maintenance stations in Metro Manila. The scheme might be supplemented with roadside spot-checks.

Effectiveness.
Next to the traffic safety threat and unnecessary fuel waste, a major problem of poor maintenance are the large emissions associated with maladjusted fuel injection or carburetor systems and worn-out motor parts. Introducting a scheme requiring semi-annual inspection and maintenance, will probably result in a substantial reduction of emissions of $\mathbf{PM_{10}}$, **VOC,** and **CO**. An accurate assessment of the emission reduction associated with the implementating an inspection and maintenance scheme requires statistical data about emission characteristics of the Manila vehicle fleet relative to its state-of-maintenance, such information is not available. From a survey of emission characteristics of the Bangkok vehicle fleet (McGregor & Weaver, 1992) it can be inferred that diesel-powered jeepneys and pickup trucks tend to fail smoke tests more than other vehicles.

It is assumed that through the proposed inspection and maintenance scheme emissions of $\mathbf{PM_{10}}$, **VOC, and CO** would decrease by 35% in line with the World Bank estimate (Mehta, 1993). The **benefits** associated with a 35% reduction of PM_{10} emissions are an avoided mortality of 316 persons and a reduction RSD of 8 million. The associated economic benefits are US$41 (calculated with USA data - see chapter 4) or US$ 33 million (Manila data).

Costs of an inspection and maintenance scheme.

Estimates have been made in the ADB study (Baker et al, 1993). Total investments (investment costs) total US$ 63 million.

Costs per test (operating costs and depreciation expenses) increase from an initial P 181 to P 233. The costs will be covered by the vehicle's owner. The average test fee declines from P 215 initially to P 194 in 2002. Repair costs resulting from failing to pass the test are expected to be fully compensated by reduced fuel costs as a result of the repair.

If this scheme can be linked with the extending the current roadworthiness inspection scheme, not yet fully developed, increased road safety would constitute a second benefit. The ADB study (Baker et al, 1993) elaborate a scheme in which inspection and maintenance is carried out by the private sector at no cost to the government. A lack of initial financial resources is an obstacle.

Policy instruments and target groups. Currently the Land Transportation Office is responsible for inspecting vehicles for roadworthiness. However, due to lack of financial means and personnel, inspection is not fully implemented. Current legislation (Presidential Decree 1181) allows spot-check environmental inspections of vehicles by the *DENR-NCR* authorities. It has been proposed (Baker et al, 1993) to set up an inspection and maintenance scheme by the private sector, to overcome financial difficulties.

Term. An inspection and maintenance scheme can be implemented within 5 years.

Summary. Implementation of an inspection and maintenance scheme	
Effectiveness:	4 000 ton PM_{10} (1995) avoided annually
Costs	US$ 5.5 million for vehicle owners - inspection costs. Maintenance costs are expected to be set off by improved fuel efficiency
Benefits	Mortality : 316, RSD : 8 million, Benefits 1.1 billion Pesos. Reduction of CO, VOC emissions, improvement of road safety (if roadworthiness is included in the scheme)
Instruments/institution	Land Transportation Office, DENR-NCR authorities
Term	two-five years
Target groups	The scheme could be carried out by the private sector.

6.2.4 Fuel switching in the transportation sector

From diesel to gasoline. Diesel-engine jeepneys and utility vehicles are a major mobile source of PM_{10}. The popularity of diesel is due to the low market price of diesel fuel, as compared to gasoline. Fuel prices are regulated by the Philippine Government. The build up of the price at-the-pump is presented in Table 6.3 showing how the price of diesel fuel is kept low through the Oil Price Stabilization Fund.

Table 6.3: Transportation fuels price (Pesos per liter) build-up in Metro Manila (Mehta et al, 1993) effective 1 July 1992

Fuel	Direct Co. Recovery	Specific tax	Oil Price stabiliz. fund	Other	Pump price
Premium gasoline	5.52	2.52	1.39	1.57	11.00
Regular gasoline	4.97	2.28	1.70	1.55	10.50
Diesel oil	5.58	0.45	-0.58	1.55	7.00

By a change in the tax and subsidy structure, the gasoline/diesel price ratio could be reduced, which could constitute an incentive to change to gasoline as the preferred automotive fuel. It is conceivable that such change could be cost-neutral for the government.

The change in the subsidy regime could be made gradually, over a period of 5 years. A transitional period would allow for adjustments by all parties involved: refineries and other fuel suppliers, the gasoline distribution system, jeepney owners, and mechanical shops (engine replacement).

A primary obstacle might be that jeepney owners lack the funds to invest in gasoline engines. It is estimated that replacement costs are P 15,000 (Baker/ADB, 1992). The lower maintenance costs of gasoline engines (P 6,000 versus P 12,000) (Baker/ADB, 1992) constitute an extra incentive to change to gasoline. However, the fact that an investment must be made may constitute a barrier. Therefore, a change in fuel pricing would have to be complemented by an additional measure, such as a budget neutral scheme for subsidies or loans for engine replacement. A scheme feasible in Manila must be elaborated.

LPG (Liquid Petroleum Gas) can be used as a clean alternative for both gasoline and diesel. PM_{10} emissions from LPG are very low. Where LPG is plentiful, it is widely used as an alternative for gasoline even though vehicle manufactures do not market cars dedicated to the use of LPG. Adapting gasoline cars to LPG requires some investments (LPG-fuel tank and adaptation of the carburetor) by the vehicle owner, while marketing LPG also requires investmenthy fuel retailers. Participating countries, make LPG attractive by taxes and excises lower than those on gasoline.

LPG can also be used as a fuel in diesel engines, but the investments for adaptation are higher. Several European cities have started using LPG in city buses. The environmental benefits - PM_{10}emissions virtually eliminated, no Polycyclic Aromatic Hydrocarbons (PAH) or sulfur, low NO_x emissions, nuisances from smell justify the higher investments (about US$ 40,000 or P 1.2 million per bus).

Effectiveness

PM_{10} emissions from **gasoline** powered UVs (Utility Vehicles, which are, from a technical point of view similar to diesel-powered jeepney) are about a third of PM_{10} emissions from similar diesel-powered vehicles. When all jeepneys and UVs are equipped with gasoline engines, PM_{10} emissions will be reduced by 60%. The associated health **benefits** are mortality reduction by 100 and a reduction by 2.5 million of the number of RSD. However, these figures underestimate the health benefits as the PAH (carcinogenic) content of PM_{10} from diesel fuel tends to be larger than that of particulates originated from gasoline.

Changing over to gasoline, however, has environmental drawbacks: emissions of VOCs and CO will increase, unless legislation requires state-of-the-art emission abatement.

A further shift towards using **LPG** in these vehicles would virtually eliminate PM_{10} problems. In addition, SO_2 emissions will be eliminated, and NO_x emissions from LPG fueled vehicles are about 50% lower than equivalent gasoline-powered vehicles.

The **benefits** of a large-scale introduction of LPG (50% reduction of PM_{10} emissions of both gasoline and diesel vehicles) would be mortality reduction of 567 and 15 million fewer RSD.

The associated economic benefit, from improved health, ranges from P 1.9 billion (Manila specific data) to P 7.5 billion (based on US-derived data, see Chapter 4).

Costs

Government costs: By properly adjusting the fuel tax and subsidy scheme, the changeover could be budget-neutral. A subsidy or loan scheme could also be financed by the fuel taxes.

Costs for jeepney owners and operators: These costs depend on the design of the transition period and, whether subsidies or loans are offered. Eventually jeepney owners would benefit from the scheme, depending on the final gasoline market price. The initial costs (replacing the engine and higher costs of diesel fuel before engine replacement) are compensated by lower maintenance and fuel costs.

It must be noted that any information about availability of LPG for automotive purposes is lacking and its market costs and feasibility might be low.

Policy instruments and target groups

The tax and subsidy scheme is operated by the Energy Regulatory Board. The groups involved are government agencies, the petroleum industry (supplying gasoline or eventually LPG), the jeepney owners, service stations and mechanical shops (engine replacement), and jeepney passengers. The last group is a major stakeholder. Therefore, any scheme must not increase jeepney fares substantially.

The possibilities of using LPG are strongly dependent on local supply and availability of LPG and fiscal policies.

Term. 5 - 10 years, providing there is a strong and determined political will.

Summary. Shift from diesel towards the use of gasoline or LPG (Liquefied Petroleum gas)

Effectiveness:	Jeepneys/UV using gasoline avoid 2,000 tonnes PM_{10} annually, by introduction of LPG
Costs	Inconclusive, because of regulated fuel market, but negative costs in terms of world prices, as gasoline is cheaper. Availability of LPG not known at the present
Benefits	Mortality : up to 600, RSD : up to 15 million, Benefits P 550 million. Reduction of SO_2 emissions
Instruments/institution	Energy Regulatory Board, Oil Price Stabilization Fund
Term	Five-ten years, or even longer (LPG).
Target groups	Petroleum industry, Fiscal Authorities

6.2.5 Clean vehicle emission standards

Several countries with severe air pollution problems from vehicles have adopted standards for allowable vehicles emissions. Modern standards require vehicles with four-stroke gasoline engines to be equipped with exhaust gas control devices based on three-way catalysts (closed loop systems). A few countries have also set standards for motorcycle emissions, requiring two-stroke engine powered vehicles to be equipped with open-loop catalysts. The latter devices control emissions of VOCs (PM_{10}) and CO, but not NO_x.

Catalyst technology prohibits the use of leaded gasoline and sulfur content should be at a low level (<500 PPM). Therefore, introducting such requires a structure for producting and distributing unleaded gasoline[5].

In Metro Manila two-stroke engines (motorcycles are not yet as common as in other Southeast-Asian cities such as Bangkok, Jakarta,or Taipei). Therefore, the problems may not be so pressing. However, from the experience in these other cities it is very likely that economic growth in Manila will be accompanied by a strong growth in motorcycles (see Table 5.1).

Diesel-powered vehicles are also subject to regulations. Emission requirements are met by adjusting the motor management plan, and the design of motors. Tailpipe emission treatment is also envisaged, as well as retrofits (installing abatement equipment in existing buses). In that case the requirements on the diesel fuel quality are made stronger (such as sulfur content below 0.02%, which is a severe condition). This type of standard is now (1994) being introduced in some parts of the world, such as the US.

Effectiveness

Closed-loop catalytic treatment of exhaust gases (three-way catalysts) in gasoline-engine vehicles. All exhaust emissions, NO_x, CO, and VOC, are reduced by about 85%. In addition, lead emissions are reduced 100% unleaded fuel is a prerequisite for these standards.

Open-loop catalytic treatment of exhaust gases of two-stroke motorcycles reduces CO, VOC and PM_{10} (oil mist) emissions (two-stroke engines being a major source) about 90%. Successful use of these catalysts also requires unleaded gasoline.

In case of diesel-engine powered vehicles, "clean vehicle" standards are currently enforced in relation to Europe, Japan, and the US. This implies the availability of "clean" diesel fuel as discussed above in combination with improved maintenance. Overall effectiveness is estimated at 35% compared to current emissions. **Oxidation filters** may be used to remove more particulates from diesel engines exhaust gases. Low-sulfur diesel (S content < 0.02%) is required for such devices.

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[5] To maintain the operation of the catalyst it is absolutely necessary that leaded fuel not be used. A single gram of lead will contaminate the catalyst and render it useless. In addition, lead destroys the oxygen sensor of the fuel injection system.

Emission reductions are 80%. However, as these devices are not yet common technology, they may bring a part of solution only later.

If in 1995 all vehicles were "clean " mortality would be 895 less and RSD would be reduced by 24 million. In addition, air borne lead would be dramatically reduced. Associated health benefits from eliminating lead are of the order of magnitude of P 2 billion (Chapter 2).

Catalytic converters require unleaded gasoline. Removing lead from gasoline requires reformulation of gasoline to maintain ignition. This can be done by increasing the content of aromatics in gasoline or adding oxygenated compounds such as MTBE (methyl-tertial-butyl-ether) to gasoline. Aromatics, however, include benzene, a carcinogenic compound. This would result in an environmental concern, both from benzene exposure due to evaporation of gasoline (during production, storage, and handling) and from the expectation that benzene in exhaust may increase (Tims et al, 1981; Tims, 1983). A limit for benzene content in gasoline may be necessary. A decision would require current air quality data on benzene. Experience in other countries indicates that this can be resolved. It should be noted that catalytic converters do destroy benzene in exhaust, which leads to the expectation that the net result, fewer benzene emissions from "clean" cars and a possible increase of the exhaust emissions of dirty cars using unleaded gasoline, is small.

Unleaded gasoline with a high RON-number is usually produced by adding MTBE, the preferred lead substitute. MTBE must be imported in the Philippines.

Costs

Due to methodological difficulties (definition of the reference situation and costs to whom) it is not possible to calculate costs for Metro Manila of a possible introduction of standards. However, costs can be estimated on a vehicle-by-vehicle basis.

The costs of **closed-loop catalytic treatments of exhaust gases** is mainly related to the extra purchasing costs of vehicles: ranging from US$ 300 to 500, on the average about US$ 400 (Wang et al, 1993) in the USA. The use of these devices does have a minor adverse effect on fuel economy. However, associated costs are compensated by decreased costs of maintenance, due to the increased lifetime of replacement parts, such as the exhaust system.

The costs of **open-loop catalytic treatment of exhaust gases** of two-stroke motor cycles are related to increased purchasing costs of the equipment and to decreased fuel costs due to improved engine operation. Taiwan adopted standards requiring the use of open loop catalytic devices which resulted in increased costs of US$ 60-80, offset by fuel savings (Binnie & Partners).

Other costs are related to the higher cost of unleaded gasoline due to increased production cost and modifying pump nozzles. A very rough estimate of the costs, only for the purpose of obtaining a perspective, is US$ 100 or P 3,000 annually per car (P 1,500 depreciation the of control system and P 1,500 increased fuel costs, depending on the possible subsidies or levies on gasoline).

Policy instruments and target groups

A regulation may be included in the revision of implementing rules and regulations under Presidential Decree 1181 (PD 1181), which is now under review by the DENR/EMB Standards Committee.

In order not to discourage the use of unleaded gasoline, and prevent misfueling, it is important that it is less expensive at the pump than the leaded gasoline. Taxes must be used to ensure this.

The groups involved in the introduction of "clean" vehicles are:

- firms which import vehicles;
- service garages (which must be able to maintain clean vehicles);
- the petroleum industry and gasoline retailers who must supply unleaded gasoline); and
- vehicle ownerswho will pay the price.

Term. In practice, standards can be set only for new cars; it is too expensive to equip existing vehicles with the necessary devices. The effect of these standards will be shown gradually, reflecting the rate of replacement of existing vehicles.

Summary. Adoption of clean vehicle standards catalysts in case of gasoline engines, best practical means for diesel engines

Effectiveness:	80% effectiveness per vehicle for gasoline and 35% for diesel
Costs	P 3,000 per car (including costs of unleaded fuel)- order of magnitude! In total P 1.3 billion.
Benefits	Mortality : 485, RSD : 13 million, Benefits 1.75 billion Pesos. Additional benefit due to virtual elimination of the lead pollution Reduction of emissions of CO, NO_x and VOC, in fact the main justification of introduction of these systems in other countries.
Instruments/institution	DENR/ National Capital Region. Oil Price Stabilization Fund, possibly.
Term	Two-five years. The result of such measures turns up with the renewal of the car fleet.
Target groups	Petroleum industry - the first move is to have unleaded fuel available, car importers

6.2.6 Other technical measures

The measures discussed above can be regarded as the state-of-the art measures or Best Practical Technical (BPT) measures. Some measures are discussed below, which are considered but not yet widely used.

Fuels.

Fuel switch. CNG (Compressed Natural Gas). The use of CNG as a fuel for diesel engines is technically feasible. However, CNG is not yet widely. It is contemplated for use in buses in down-town areas, in particular to address PM_{10} emissions. A major issue hampering the introduction of CNG is the required supply structure. The use of CNG is now feasible only in those areas where a system for natural gas for industrial, commercial and domestic use already exists.

CNG does well with respect to PM_{10}, NO_x, and SO_2 emissions. However, methane, a major component of natural gas, is a greenhouse gas. Using it for automotive purposes will increase methane emissions. More analysis is needed on the possibility of introducing CNG.

LPG, an alternative with comparable environmental improvements, is probably easier to introduce as an automotive fuel. Here also, more analysis is needed.

Fuel switch. Alcofuels and other agrofuels

In various parts of the world fuels made from agricultural products, such as ethanol and vegetable oils, are used, have been used or are being studied. Their use is advocated for different reasons:

- energy policy (in order to be less dependent on import of fossil fuels);
- agricultural policy (to use otherwise useless agricultural resources); and
- environmental reasons, mainly to prevent emissions of greenhouse gasses.

These fuels perform not particularly well with respect to emissions of NO_x, CO, and particulates. One advantage is that they do not contain PAHs or sulfur.

Improvement abatement/other propulsion techniques

In the USA and Europe (European Union) further tightening of standards is being discussed. Possibilities are:

- improving current techniques for abatement;
- improving inspection and maintenance, as a small number of maladjusted or worn-out cars cause disproportionally large emissions; and
- enforcing the use of "zero-pollution" vehicles, such as electric vehicles in downtown areas.

A bottleneck in decreasing automotive air pollution is diesel engines, since exhaust gas treatment similar to gasoline cars is not availiable. However diesel engines produce less CO_2.

6.2.7 Resuspension emission

Resuspension is a high priority issue in Manila. Unfortunately, quantitative information about measures appropriate to Metro Manila has not been found. Resuspension is still an important matter for further analysis in order to propose viable measures.

6.2.8 Improving traffic management

Traffic management includes a variety of measures, ranging from traffic control by policemen or traffic lights to one-way streets, building new roads, and road-pricing systems. Traffic management is usually carried out for a variety of reasons; solving congestion problems is a major one. On the curb-side level, traffic management may improve air quality[6], but, on a city level it may increase air pollution, since traffic management usually results in an increased use of the transport system. In terms of exposure, traffic management can be beneficial as downtown air quality improves and "road-exposure" declines, but, in terms of total exposure, the net result may be small.

It is noted that improved traffic management may have other environmental benefits such as less noise and congestion. More detailed analysis is needed, but traffic management seems to be a cost-effective policy.

6.2.9 Constructing mass-transit systems

Mass-transit systems, such as light-rail transport, may constitute a part of the solution of environmental problems due to traffic as well as a means to increase transport capacity. Building such a system is a long-term process and requires large investments, but can have large benefits in terms of reducing pollution and congestion.

A methodology to assess costs and effectiveness of a measure "construction of mass-transit systems" involves elaborating issues such as:

- describing a future system appropriate for Metro Manila;
- assessing the performance of such system - (passenger*km);
- assessing the construction costs;
- descripting the baseline (future situation without such system);
- estimating avoided emissions;
- assessing non-environmental benefits; and
- designing a scheme to identify costs and benefits to impute to the environmental aspects.

The costs of mass-transit systems are high and projects may not be justified from only an air-pollution point of view. Below, as an example of a calculation, is presented a "typical" environmental benefit of a mass-transit system. It can be concluded that the mass-transit systems have an effect on air quality, but it is low compared to the other measures mentioned above. However, mass-transit systems have a wide variety of other benefits, including reducing congestion[7].

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6 Accelerating vehicles, a feature of congested traffic, emit disproportionally large amounts of pollutants.

7 The current LRT (light-rail system) in Manila carries 300,000 passenger-km daily. This might correspond to 30, 000 vehicle-km of bus and jeepney traffic, assuming an average bus and jeepney occupancy of 10 persons. Using a PM_{10} emission factor of 2 g/km (exhaust particles + resuspension, see Ch. 2.2), the LRT line takes away some 20 tonnes of particles annually, a very

6.3 Power production

6.3.1 Cleaner fuels in existing plants

The three Metro Manila power plants are fired with heavy fuel oil (Bunker C fuel oil (grade 6)). The small Manila power plant is equipped with multicyclones to abate PM_{10} emissions. The first, technically very feasible, measure to consider is to switch to low sulfur fuel, as the SO_2 emissions are essentially proportional to the sulfur content of the fuel.

In addition, a reduction of the sulfur content of this type of fuel leads to a decrease in PM_{10} particles[8]. Another fuel-switch option is to use less heavy fuel oil, for instance grade 5 or grade 4 oil, with lower PM_{10} emission factors.

Effectiveness

Reducing the sulfur content of Bunker C fuel oil from 3.12 to 2% will reduce the emissions from power plants by 40%. Reverting to lighter types of fuel oils will be more effective, according to the emission factors given above; in case of the use of grade 5 fuel oil the reduction is by 70%, and in case of using grade 4 fuel oil about 80%.

Due to their high stacks, power plants' contribution to Manila air quality is low, as are the benefits.

Costs

Unless cleaner fuel oil is imported it must be produced at Philippine refineries. This would require either changing to low-sulfur crudes as feedstocks or extending the equipment for desulfurization and perhaps other secondary treatments, such as visbreaking. The precise costs are, however, unknown. An estimate of the eventual costs are derived from the sulfur premium, the increase of the world market price of fuel oil with decreasing sulfur content. The sulfur premium is US$ 5-10 per ton per percentage sulfur. Fuel consumption in power plants was about 1400 ktonnes. Buying similar oil with a sulfur content of 2% instead of 3% would involve a cost of US$ 10 million annually. Of course, SO_2 emissions would also decrease.

Policy instruments and target groups

The available instrument is legislation, either concerning the fuel quality or the allowable emissions.

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small amount compared to the total emissions. The LRT line does, however, take the 300 000 passengers away from road exposure, which corresponds to 12% of the 2.4 million daily commuters

[8] The emission factor for TSP is proportional to the sulfur content of Bunker-C fuel oil (grade 6), according to EF_{TSP} ($kg.m^{-3}$) = 1.25 * S (%w) + 0.36 (EPA 42). Two other factors are for Grade 5 fuel oil: EF_{TSP} ($kg.m^{-3}$) = 1.25 and in case of Grade 4 fuel oil: EF_{TSP} ($kg.m^{-3}$) = 0.88.

Target groups other than environmental institutions are the National Power Corporation, the Philippine National Oil Company and the energy policy authorities engaged.

Term From a technical point of view low-sulfur fuels can be implemented within a year.

Summary. Use of 2% sulfur fuel oil in power plants	
Effectiveness:	500 ton PM_{10} (1995)
Costs	US$ 10 million
Benefits	Only minor avoided health effects Reduction of SO_2 emissions
Instruments/institution	DENR, Energy Regulatory Board
Term	Immediately
Target groups	National Power Corporation, Philippine National Oil Company

6.3.2 Treatment of flue gases

The contribution of the power plants to air pollution in Metro Manila is low (see chapter 2), therefore measures to reduce emissions of these plants will have little effect. Consequently, these measures are low priority. However, for the sake of comprehensiveness these measures are adressed, although only briefly.
Treatment of flue gases aims at removing PM_{10}, SO_2 and NO_x from flue gases[9].

Table 6.4: Common techniques for cleaning of flue gases.

Pollutant	Flue-gas cleaning technique
PM_{10}	Electrostatic precipitators (ESP), fabric filters, (multi)cyclones
SO_2	Wet scrubbers, flue gas desulfurization FGD, dry sorbent injection techniques (DSI)
NO_x	Selective Catalytic Reduction (SCR)

Removing SO_2 from flue gases results in waste material, such as gypsum. Wet scrubbers do also partially remove PM_{10} from flue gases.

Effectiveness. The performance of these techniques varies from 80-85% (SCR, DSI,), 90-95% (FGD), to (95-99%) (ESP, fabric filters). Multicyclones are less effective in capturing particles from fuel oil combustion. About 50% of these are

[9] Methods to remove CO_2 (greenhouse gas) are being discussed but not used. Air pollution due to CO_2 is not a urban pollution problem and is therefore outside the scope of this study.

removed, in particular large particles. Small - harmful - particulates (< 5 micron) are hardly separated.

Costs. Preliminary rough estimates of costs are:

Electrostatic Precipitators	Investments US$ 10 million, annual costs US$ 3-5 million (own estimates).
SO_2 removal	Reduction of the 80,000 ton emission with 90% (FGD) would require about US$ 100 million annually.

Policy instruments and target groups

Possible policy instruments are:

Legislation concerning either allowable emissions or prescriptions to use a specific flue gas treatment.

The target group other than the environmental institutions is the National Power Corporation.

6.4 Fuel combustion other than for power production

6.4.1 Cleaner fuels

"Cleaner fuels" comprise a number of measures, ranging from lowering the sulfur content of fuel oil (BOF) to switching to natural gas (very little PM_{10} emissions). The measures are summarized in Table 6.5.

Table 6.5: Cost-effectiveness of clean fuel and fuel shifts.

Characteristic	Effectiveness	Costs
Reduction of S content of heavy fuel oil to 2%	40%	US$ 10-20 per ton fuel
Switching to natural gas	99%	Unknown

Data are lacking about the structure (number of plants factured by annual fuel consumption), therefore, our estimates of the effectiveness and costs of abatement are only preliminary:

- reduced emissions: 5000 tonnes (1995);
- reduced mortality: 100; and
- reduced RSD: 2.5 million.

Industry's total consumption of HFO is, according to our estimations, about twice that of power plants. It might be inferred that **costs** of firing clean fuel (HFO with 2% sulfur) is in the order of magnitude of US$ 10-20 annually.

Policy instruments and target groups

Reducing the sulfur content can be arranged by adaptating standards. The petroleum industry, including importers of oil products, must supply the clean fuels.

Switching to natural gas might be a long-term possibility, although this implies a radical change in the energy supply structure. Such change will require the use of energy-policy instruments.

Term. Low-sulfur fuels can, from a technical point of view, be implemented in the short term.

Summary. Reduction of the maximum sulfur content of heavy fuel oil (BOF) to 2% (weigth)	
Effectiveness:	5000 ton PM_{10} (1995)
Costs	US$ 10 - 20 million for industry
Benefits	Mortality : 100, RSD : 2.5 million. Benefits:327 million Pesos. Reduction of SO_2 emissions
Instruments/institution	DENR, Energy Regulatory Board
Term	short term
Target groups	Petroleum industry, Industry in general

6.4.2 Flue gas treatment

The options for reduction are similar as already treated above in the section on power plants. Multicyclones are a cheap and reliable devices to abate emissions of PM_{10}, however they are only effective in case of large (> 5 micron) particles. Considering the particle-size distribution of SPM from HFO- firing their effectiveness is about 50%, while the small - more harmful - particulates are not held back.

6.5 Industrial processes (non-combustion sources)

The lack of data about process emissions, estimated at 3,000 tons of PM_{10}, in Metro Manila, does not allow for listing an appropriate set of measures. In the reference scenario these emissions are assumed not to change.

6.6 Refuse burning and construction

Refuse burning results in PM_{10} emissions estimated at 6,000 tonnes. Measures to address these emission require more information about the characteristics of this source.

PM_{10} emission due to construction is estimated at 3500 tonnes. Part of this comes from demolition activities. Various means for controlling these emissions are envisaged, such as screens alongside demolition works, the use of chutes to remove rubble, and others.

However, details about these emissions are lacking; it is not possible to elaborate a proposal for measures to be elaborated. Emissions are assumed to grow at 1% annually in the reference scenario. From the environmental point of view, lack of data is probably not a serious failure because the environmental threat from the type of PM_{10} involved is less than fuel-originated PM_{10}. It is noted that the present report does not address issues related to workers' health.

6.7 Conclusions

This chapter describes a number of measures appropriate for improving Manila's air quality. It was intended to deal with measures, effectiveness, costs, benefits, implemention, and the institutions and authorities involved. An important issue was to indicate the benefits, the reduced health impacts and reduced damage costs, based on reduced population exposure estimate, by the methods described in Ch. 2.4. With the costs of the measures, this information gives clues for prioritizating measures. It should be noted that the quantitative information presented here often must be characterized as rough estimates.

Identifying measures to address traffic emissions was rather straightforward, as some of the major causes of the air pollution are obvious. Listing measures addressing other sources was also straightforward. However, lack of specific information regarding those sources prevented somewhat the elaborating costs and benefits. Nevertheless, the information is useful for drafting a first action plan.

7. Future air quality for some abatement scenarios

In order to draw overall conclusions, the information presented in the preceeding chapters is summarized in two scenarios, forecasts of developments to expect when a specific abatement policy is adopted. The results of the policies are to be combined with the developments according to the reference scenario (Chapter 3).

The first scenario tries to capture the developments in emissions when measures common in other countries are taken in Metro Manila: a "common environmental technology" scenario. The second scenario shows, in addition, the effects of policies requireing more extensive preparation, as they are technically and politically more complex. As the emphasis of this scenario is on the environmental benefits of changing the energy structure, this scenario is entitled the "fuel-shift" scenario.

7.1 The "common environmental technology" scenario

The "common-technology" scenario is based on the following assumptions:

- Adopting a comprehensive strategy to address "smoking" diesel-fueled vehicles (intensification of the anti-smoke belching programme and enforcing existing rules, introducting "clean" diesel fuel, further implementating inspection and mainenance scheme).

- Annual costs (Chapter 6) are estimated assuming the costs of clean diesel being US$ 10 million and costs of clean diesel vehicles at US$ 7 per vehicle (inspection costs).

- Introduction of unleaded fuel is followed by adopting clean vehicle standards (catalytic systems for gasoline vehicles). Motorcycles are either equipped with an open-loop catalyst system (two-stroke) or four-stroke engines, adoption of standards for emissions of vehicles equipped with diesel engines, all for new vehicles sold. It is assumed that from 1996 onwards all new vehicles sold will comply with these standards. The total annual costs are estimated at US$ 50 per vehicle[1] (gasoline), (increased costs of unleaded fuel are not attributed).

- A gradual reduction of the sulfur content of heavy fuel oil used in industry from 4 % in 1997 to 2% in 2000. The cost calculation assumes a cost of US$ 15 per tonne of heavy fuel oil (BOF).

[1] Estimate of depreciation of extra costs of clean vehicle (controlled loop system - extra purchasing costs abuot US$ 400). The "true" figure is lower as motor cycles (open loop systems/four stroke - costs US$ 75) are not yet dealt with separately.

Calculating the emission reduction is carried out by assuming that from 1996 onwards both new vehicles and fuels are "clean" and that the stock of old vehicles diminishes at a specific rate. Table 8.1 summarizes the assumptions used.

Table 7.1: Summary of assumptions for calculating future emissions of vehicles.

Mobile sources	Annual rate of replacement of stock of old vehicles	Emission factors (g/km)	
		Current	New
Passenger cars (gasoline)	10	0.20	0.05
Gasoline Utility vehicles (gasoline)	6	0.33	0.05
Motor cycles	10	0.50	0.10
Taxis (diesel)	10	0.60	0.20
Jeepneys (diesel)	10	0.90	0.50
Utility vehicles (diesel)	10	0.90	0.50
Trucks (diesel)	5	1.50	0.70
Buses	5	1.50	0.70

Note that the rate of replacement is rather high. However, these rates are appropriate as new vehicles tend to have high annual mileages compared to old vehicles. By choosing a high rate of replacement it is possible to account for this experience in the simplified model used in the calculations.

Figure 7.1 shows the developments in the emissions if the indicated measures are taken. This figure should be compared with the reference scenario shown in figure 3.4.

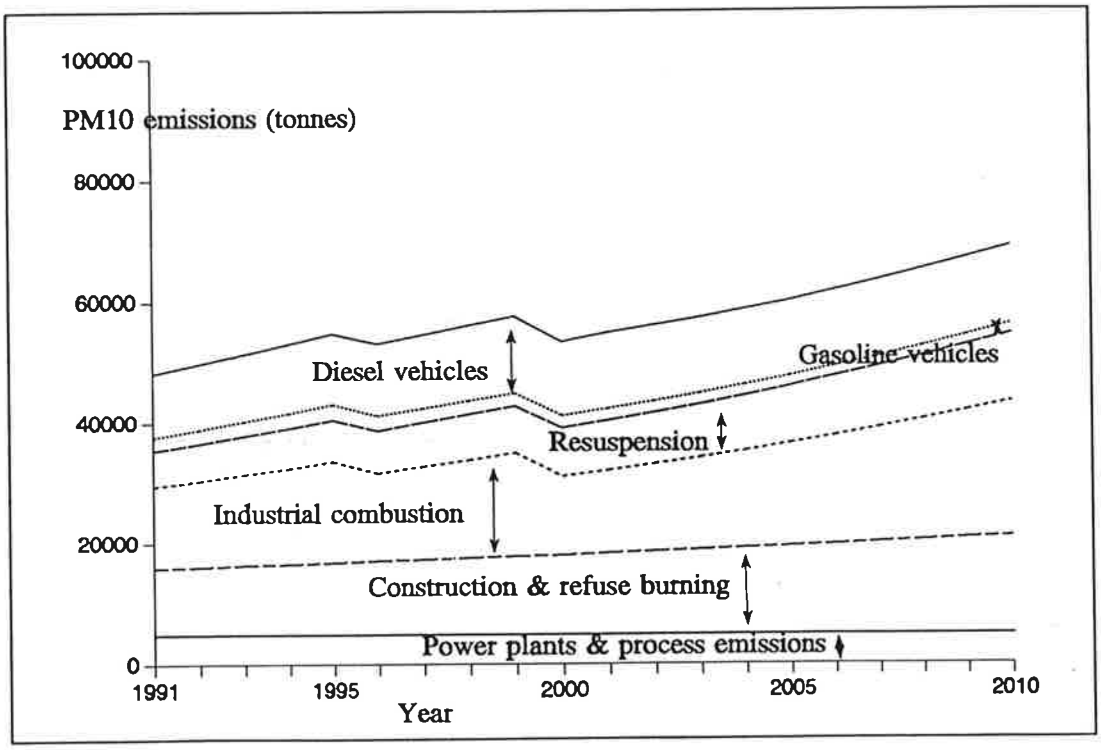

Figure 7.1: Emissions after introduction of clean vehicles, clean fuel and reducing the sulfur content of fuel oil used in industry.

Comparison of figure 7.1 and figure 3.4 shows that according to this scenario the emissions will not increase up to about year 2000. However, after year 2000 growth of the activities in the various sectors more than offsets the results of the environmental measures.

Table 7.2: Characteristics of the "common environmental technology" scenario.

	1995	2000	2010
Emission (1000 tonnes)	54 730	53 279	68 879
Mortality (cases)	1 680	2 114	3 645
Avoided mortality (compared with reference scenario)	1	429	1 711
Respiratory symptoms days (million)	44	56	97
Damage due to PM_{10} (billion Pesos)	5.9	7.3	12.6
Avoided damage due to PM_{10} (billion Pesos)	-	1.5	5.9
Avoided other damage		PM	PM
Costs of measures (billion Pesos)		3	7.2

The scenario shows that PM_{10} emissions tend to increase only slowly, whereas mortality will double over the coming year. This is mainly due to the expected population increase in the area: the number of people exposed to high concentrations increases, while the exposure frequency (Figure 3.1) does not change much.

In the year 2000 annual abatement costs for the industry exceed those for road transport (road US$ 34 million and industry US$ 70 million), while by 2010, when all vehicles are assumed to be clean, the costs are about equally divided.

The costs of the measures exceed the estimated benefits. Several remarks must be made before drawing conclusions:

- About half of the costs relate to gasoline vehicles, which, in particular cars, are not a major source of PM_{10}. Diesel engines are far more important (and two-stroke motorcycles are increasingly important).

- The benefits are to a large extent dependent of the valuation of mortality. The valuation used here must be considered conservative. When using other conceivable valuations (see chapter 4 and the general URBAIR report), the cost-benefit ratio can easily be reversed.

- With reference to the WHO PM_{10} guideline, Metro Manila air-quality will not improve under this scenario.

7.2 A fuel-shift scenario

The second scenario considered includes the assessment of the effects of two measures which clearly interfere with energy policy. The most important measure is restructuringenergy use in Metro Manila by large-scale introduction of natural gas. This effectively addresses emissions from industry, which, according to the reference scenario tend to develop into major sources. Admittedly, this is a rather hypothetical possibility which might not be feasible due to the lack of indigenous sources of natural gas.

The other measure is to extensively use LPG as an automotive fuel. This measure is particulary effective when LPG is used in buses and trucks, the main target group of vehicles to switch to LPG or CNG (see also Table 4.6, about the health impacts from the various source groups).

Such measures will mean a substantial restructuring of the energy sector. Costs of such measures depend on local market prices of fuels. Within the scope of this study it is not possible to indicate costs.

The scenario shows that even when an all-out environmental policy is pursued it proves very difficult to substantially improve air quality. It appears that this requires measures with a significance beyond air-quality alone, such as introducting mass-transit systems, land use planning especially industrial zoning, and improving waste management.

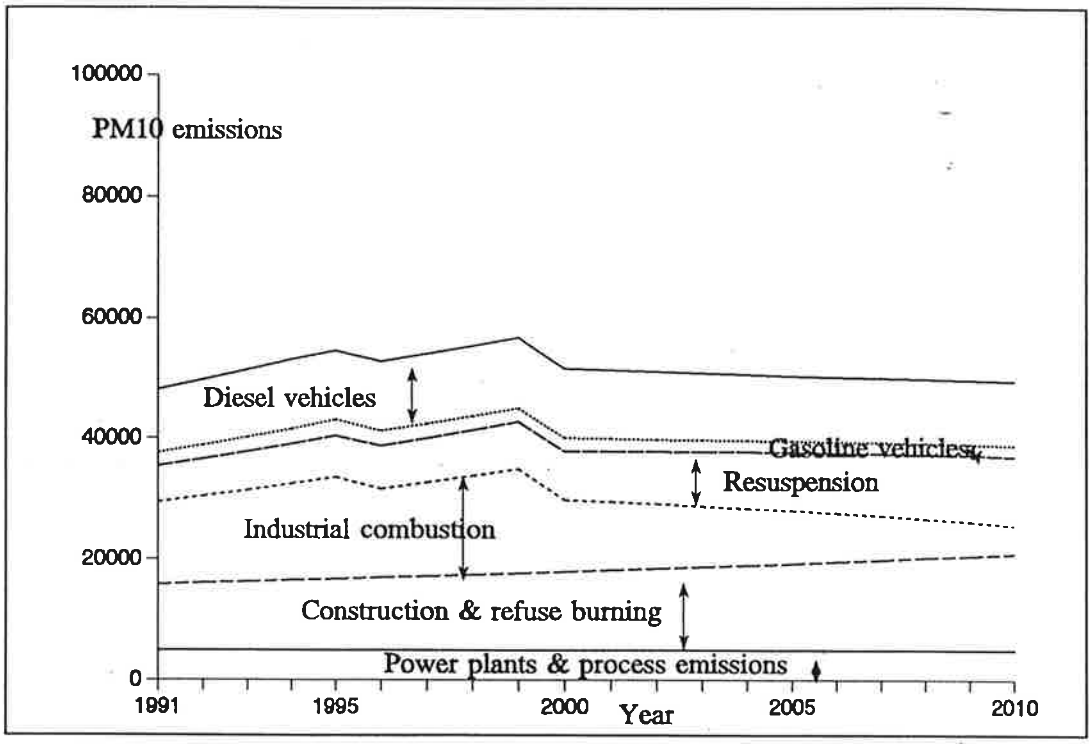

Figure 7.2: Introducing natural gas in industry, and LPG in vehicles (buses).

Table 7.3: Costs, benefits and other characteristics in the "fuel shift" scenario

	1995	2000	2010
Emission (1000 tonnes)	54 560	51 614	49 405
Mortality (cases)	1 615	1 938	1 260
Avoided mortality (compared with reference scenario)	65	605	2 753
Respiratory symptoms days (million)	43	56	69
Damage due to PM_{10} (billion Pesos)	5.6	6.7	9
Avoided damage due to PM_{10} (billion Pesos)	0.3	1.1	9.5
Avoided other damage		PM	PM
Costs of measures (billion Pesos)		over 3	over 7.5

7.3 Conclusions

From the present comprehensive - in a methodological sense - analysis of current and future air quality in Manila (see also chapters 2 and 3) and from a review of the possibilities for its improvement, several conclusions can de drawn:

- Even if obvious measures - from an exclusively monetary point of view - are taken, such as addressing diesel fueled vehicles and improving the quality of heavy fuel oil, the air quality will not detoriate further, but will not improve either. As the number of exposed people increases, impacts will also increase.

- The monetary benefits assessed relate only to the health impacts of PM_{10} and lead. Improvement of the situation with respect to other air pollutants (SO_2, NO_x, CO and VOC) have not been evaluated.

- Industrial combustion emissions can be addressed by improving fuel quality. Other measures, such as flue gas treatment, could not be evaluated due to lack of information.

- The importance of road traffic as a source of pollution (from vehicles and through resuspension) will not decrease. This emphasizes the necessity - from an environmental point of view - to a further development of mass transit systems.

- A similar recommendation is to change the energy stucture and, if feasible, introduce natural gas as an industrial fuel.

- Due to a lack of information regarding the possibilities for addressing emissions from refuse burning, process emissions, and resuspension these have not been evaluated.

It is acknowledged that the conclusions are based on numerous assumptions, which had to be made due to a considerable lack of appropriate information. Decisions to take the "obvious measures" appear to be justified from the monetary point of view alone. Other benefits come in addition.

8. Draft Action Plan

The assessment of air pollution and exposure in NCR, the associated health damage, and the analysis of the costs and benefits of various measures to reduce the exposure and damage, as described in Chapters 2-6, are based on present knowledge and quantification. Shortcomings in the database have been indicated throughout the text. Nevertheless, the analysis forms the basis for proposing an action plan to reduce air pollution in a cost-effective manner. Improveing the database is necessary to extend the action plan to include additional measures.

The "actions" are of two categories:

1. Technical and other measures which will reduce exposure and damage.

2. Improveing the database, and the regulatory and institutional basis for establishing an operative System for Air Quality Management in NCR.

The time frame in which actions and measures should be instigated and will be effective, is proposed as short (<5 years), medium (5-10 years) and long-term (>10 years).

8.1 Actions to improve Metro Manila air quality and its management

8.1.1 Actions to improve air quality

Actions and measures have been proposed by the local Manila working groups, through other World Bank projects, and by the URBAIR consultants.

The proposed actions and measures have been put in the following categories:

1. Improved fuel quality;
2. Technology improvements;
3. Fuel switching;
4. Traffic management; and
5. Transport demand management.

Each action or measure is described briefly, according to the following items:

- What Description.
- How Policy instrument to instigate and carry out the measure.
- When When should actions be instigated.
- When can results be expected.
- Who Institutions and organizations responsible or affected.
- EffectsReduced emission, exposure, and damage costs.
- Cost Cost of measure.
- Feasibility
- Remarks

The full list of proposed measures is presented in section 8.2. In the draft version of the action plan, the columns of the table are not yet fully filled in.

Various technical abatement measures were analyzed in Chapter 6, for costs and benefits.

The draft **Action Plan** of priority short term measures is given in Table 8.1.

Table 8.1: Draft Action Plan of priority abatement measures, for proposed immediate introduction in NCR, based on cost/benefit analysis.

Abatement measure	Benefits: Avoided emissions[2], tons PM_{10}/a	Benefits: Avoided health damage, million US$	Costs of measure million US$	Time frame: Introduction of measure[1]	Time frame: Effect of measure
Vehicles					
Addressing gross polluters: Effective smoke-belching campaign	2, 000	16-20 158 deaths 4 mill. RSD	0.08	Immediate	Short-term
Improving diesel quality	1, 200	10-12 94 deaths 2.5 million RSD	10	Immediate	2-5 years
Inspection/ maintenance	4, 000	30-40 316 deaths 8 million RSD	5.5	Immediate	2-5 years
Fuel switching: diesel → gasoline in vehicles	2, 000	59-73 600 deaths 15 million RSD	?	Immediate	5-10 years
Clean vehicle standards	7, 000	94-116 895 deaths 24 million RSD	5-20	Immediate	5-10 years
Fuel combustion					
Cleaner fuel oil	5, 000	10-20 100 deaths 2.5 million RSD	10-20	Immediate	1-2 years
Power plants					
Clean fuel	500	small	10	Immediate	1-2 years

1 Time frame for starting the work necessary to introduce measure.

2 The various abatement measures are not necessarily independent of each other. Thus, the "decided emissions" stated in this table for each measure separately may not simply be added, if one wants an estimate of the total effect of a packages of measures.

For all measures except cleaner fuel in power plants, the calculated benefits are very substantial, in the tens of millions of US$ annually, and the benefits are, as a rule, much higher than the estimated costs.

Lower lead in gasoline, is an important measure as already initiated through current agreements. Lead-free gasoline is a prerequisite for clean vehicle standards, and is not listed as a separate measure.

The success of the measures rests with the enforcement sector. It is important to ensure that conditions are met for carrying out the technical improvements and adjustments which are necessary,such as workshop capacity and capability for efficient adjustment of engines, and availablility of spare parts at a reasonable cost.

To reiterate Chapter 6, the actions incorporate the following measures:

Addressing gross polluters: Reinforcing the anti-smoke belching program:

- Strict enforcement of smoke opacity regulation.

  Success is dependent upon the maintenance and adjustment of engines actually taking place. Routines for ensuring that must be a part of the action.

Improving diesel quality:

- Importing quality low-sulfur diesel (0.2%), or
- Modificating Philippine refineries;
- Taxes or subsidies to differentiate fuel price according to fuel quality.

Inspection/Maintenance

- Annual or bi-annual inspection;
- Establishment of inspection and maintenance stations (government or private); and
- Basic legislation is in place (PD 1181)

The potential for reduced emissions is the greatest for diesel vehicles. The inspection and maintenance might, at the start, be concentrated on diesel vehicles.

Fuel switching: Diesel-to-gasoline in vehicles:

- Changes in tax and subsidy structure to make gasoline the preferred fuel; and
- Establish a loan scheme to cover cost of engine replacement.

Switching to gasoline will result in increased emissions of VOC and CO. This is a drawback, but can be counteracted by establishing clean vehicle emission standards.

Clean vehicle emission standard:

- Establish state-of-the-art vehicle emission standards for gasoline cars, diesel vehicles and motorcycles; and
- Ensure the availability of lead-free gasoline at a lower price than leaded gasoline.

Cleaner fuel oil:

- Substantial reduce the sulfur content of heavy fuel oil, initially from 3% to 2%.

Table 8.2 lists other selected abatement measures, also of other categories, for which cost/benefit analysis has not been performed, which could be introduced in the short term, and have a beneficial air quality effect.

Table 8.2: Additional measures for short/medium-term introduction.

Abatement measure/action		Time frame	
		Introduction of measure	Effect of measure
Vehicles			
Address dilution and adulteration of fuel		Short term	Short term
Restrict life time of public UVs and buses		Short term	Medium term
Traffic management			
Improve capacity of existing road network	- improve surface - remove obstacles - improve traffic signals	Short term	Medium term
Extend/develop road network: Improve/eliminate bottlenecks		Short/medium term	Medium term
Transport demand management			
Improve existing bus system	- improve time schedules - improve junctions/stations - make integrated plan	Short term	Medium term
Develop parking policy	- restrictions in central area - parking near mass transit terminals - car-pooling	Short term	Short term Short term Short term

8.1.2 Actions to improve the Air Quality Management System

Such actions concern:

- improving Air Quality Assessment;
- improving Assessment of Damage and its Costs;
- improving the institutional and regulatory framework; and
- building awareness among the public and policy-makers.

Chapter 2.7.2 (page 64) presents the necessary actions to improve the Air Quality Assessment. They are summarized in Table 8.4.

Table 8.3: Actions to improve the Air Quality Assessment of Manila NCR.

Air Quality Monitoring
• Improve the ambient air monitoring system. • Upgrade laboratory facilities and manpower capacities. • Establish a quality control system. • Establish database suitable for providing Air Quality information to the public, control agencies and law makers.
Emissions
• Produce an inventory of industrial emissions. • Develop integrated comprehensive emission inventory procedure. • Study resuspension from roads.
Population exposure
• Establish appropriate dispersion modeling tools for control strategy in the NCR.

8.2 A comprehensive list of proposed measured and actions.

Table 8.3 presents the full list of proposed measure to improve the Metro Manila air quality, which was developed by the local working groups established for Metro Manila as part of the URBAIR process , and evaluated by the URBAIR consultants.

Table 8.4: Categorized action list to improve the air quality in Manila NCR. S: <2 years, M: 2-5 years, L: 5-10 years, VL: >10 years

Urban Air Quality Management (URBAIR) Action Plan

	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
I.A	TRAFFIC MANAGEMENT							
1.	Improve traffic flow							
	a. Improve existing road network	Remove obstructions (basketball courts, vehicles, parking, repair shops)	1994-onwards	LGUs, PNCC, MMA	better traffic flow			Improve driver-friendliness of roads
		Ensure proper/timely coordination of all diggings	1994	Utilities Co-ordinating Council, (MMA), LGUs				
		LGUs to study imposition of ordinance on nuisances	1994 onwards	LGUs				
		repair of roads (get inputs from private sector)	1994-onwards	DPWH, PNCC				
		Pass grid lock/law/ordinance	1995	LGU,Congress,MMA				MMA should have a transport/ land use study
	b. Extend/develop road network	- Analysis of the situation (bottlenencks, etc.) - Support responsible agencies - activate other plans like C5	S/M	DPWH, LGUs, DOTC				C3 & C6 completion should be a priority Note: 10 pt. problem of PMA submitted to FVR
	c. Improve/co-ordinate traffic signal systems	Systemize traffic signals (implement PD 207)	S/M	TEC/DPWH, MMLTCC, LGUs, PNP				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
	d. Segregate mass transport from other modes.	Strictly implement bus lanes	ASAP	MMA, LGUs, PNP				
	e. Improve facilities for non-motorized traffic	Construct pedestrian overpasses and second layer roads. Establish side walks	1994 - onwards	DPWH, Private Sector PNCC, DOTC				
	f. Implement Transport Service Rationalization Programs	Study the implementation of a private car utilization restraint policy	1995	DOTC,LGU MMLTCC				
		- set up bus terminals, etc. (park and ride) limit entry within metropolis	1994	LGU, MMA				
		- define and mark the lanes (express lanes, HOV, and enforce bicycle lanes)	1995	TEC/MMA				
		- study staggering of work and study hours/days & day-offs	1995	DOLE,PCCI, Employers' Association Unions				
		- encourage carpooling thru demand management measures like parking regulations (higher parking fee, restricted parking areas, etc.)	1994	MMA,LGU,DOTC				
		- use eco instruments to influence vehicle design and fleet air and quality	1995	DTI/BOI,BPS,DOTC				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
		- designate where PUVs (buses, taxis, jeepneys) can stop and strictly implement	1994 onwards	MMLTCC, MMA, LGUs, PNP				
*P	g. Immediate Improvement of Enforcement/Traffic Laws	Rationalize/standardize traffic laws, rules and regulations by passing traffic code & use standard form	1994	Congress to include creation w/in LTO of traffic court				
		Study implementation of color vehicle coding for PUVs	1995	DOTC/LTO				
		Provide proper training to enforcers/drivers and require them to pass exams	1994 onwards	MMLTCC, LGUs PNP				
		Put in place more stringent drivers licensing system	1995 onwards	MMLTCC, LTO				
		Set up monitoring and evaluation system for enforcers and for violators	1995 onwards	MMLTCC LTO for drivers MMA,DILG for enforcers				
		- more sanctions/stiffer penalties (re-education and suspension of drivers license)	1995 onwards	LTO				
		- incentive program for enforcers	1995 onwards	MMLTCC, PNP, DILG				

*P-priority

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
		Authorize license plates should be immediately available to all who register through expansion of plate making plant (proper specs)	1995	LTO, Private sector				
		Computerize driver/vehicle info in order to determine history of violation	1994	DOTC, LTO				
		Reactivate demerit system for drivers and link this to insurance system	1995	LTO, Insurance commissioner				
		Seriously enforce anti-jay walking law	1994	All LGUs, MMA, PNP				
*P	h. Reactivate and expand computerized information system at LTO	Create technical group to evaluate existing IS and prepare plans	1994	DOTC/LTO				
	i. Strengthen Traffic Safety Program	Effect traffic safety seminars on traffic rules and regulations (re-education)	1994	MMA, DOTC, LTO, NCTS, DILG, PNP, LGU, Phil. Motorist Assn.				
		Immediately strengthen MMLTCC for traffic improvement						
		Create MM Traffic Safety and Advisory Committee	MMLTCC					

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan

	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
		Have better visible traffic policemen present everywhere all the time. Involve barangay officials	1994	PNP,MMA,LGU,DILG				
		Use mass media for information dissemination	1994	PIA, LTO, MMLTCC				
		Estasblishment of sidewalk network	S-M	MMA, LGUs, DPWH				
	Develop network of truck terminals, as part of a scheme for efficient transport of goods.	Designate specific truck terminals	S	LGUs, DILG, MMA, HLURB				
I.B	TRANSPORT DEMAND MANAGEMENT							
1.	Expansion of bus system	Advocate & Support	S-M	DOTC, MMLTCC, NGOs				
2. *P	Provide/implement para transitsystem and other environment friendly transportation	Accelerate (expansion/extension) of LRT and use of railways and improved Metro Ferry	1994	DPWH,NGOs,DOTC, PNR, LRTA, PNCC	Decline in personal travel & increase in mass transit			Accelerate mass transit
		Study feasibility of electric vehicles	ASAP	DOST, NGO, Academe, OP, DOE	Less vehicular emissions			
3.	Survey present mass-transit situation, and develop comprehensive/integrated plan on existing components:	MMLTCC & DOTC to create team to evaluate and make recommendations.	S	MMLTCC, DOTC				There should be a Metro Manila Transport /Land Use Study

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
	- improve time schedules, co-ordination							DPWH should consider driver friendliness of roads, islands, etc.
	- improve junctions/stations, especially where several modes meet							
4.	Survey new concepts for person transport (APM, guideway bus system, point to point buses, etc.) and evaluate its possible use in MM.	Evaluate experiences of other countries & see which ones are applicable	S-M	DOTC				
5.	Promote non-motorized transpo(NMT) incl. improve/construct facilities, such as lanes and roads for NMT	Put in place necessary imfrastructure Encourage thru media	S-M S-M	MMLTCC, LGUs, DPWH PIA, DOTC				
6. *P	Use parking policy to influence traffic mode mix, e.g., higher parking fees, parking restric-tions in central areas, parking facilities near mass transit terminals, carpool guidance system, designate park & ride areas	MMLTCC & LGUs to provide guidelines LGUs, MMA to impose higher fees	1994-1995	LGUs, MMA				Consider plans for emergency situation

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
II.A	IMPROVED FUEL QUALITY							
1.	Address dilution and adulteration of fuel	a Strict enforcement of existing law on fuels	continuing activity	DOE, BPS, Oil industries, truckers, assns of gas stations	10% reduction			Can be minimized through the use of marker dyes and test kits. EIAB is responsible for regular inspection of gas stations, dealers
		b Deputization of NGOs as inspector	ASAP	DOE	TSP			Legal basis is being studied by DOE
		c Frequent inspection esp. in MM	On-going	DOE				
		d Increased/stiffer penalties through legislation	June-Dec 1994 draft legislation	DOE,COCAP, Congress DTI/BOI, ERB, other NGOs				
		e Properly label gas pumps, cars, etc.	S	BPS, DOE				
		f inform public how to detect adulterated and diluted fuel and its effect	S	DOE, PIA				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
2. *P	Decrease lead level in leaded gasoline	Mandatory regulation	S/M	DOE, Petrol Industry	Lower blood lead levels			Program for lead phase-down has been done.
3. *P	Market unleaded gasoline. Identify/Evaluate other additives.	Voluntary-use tax system						
		a Issuance of an E.O. to 1994 accelerate phase in of unleaded gasoline		DOE, Petrol Industry	100% reduction of lead by year 2000			Additives should be registered since some additives are not approved for use in USA and other countries. Standards for underground storage tanks should be determine. DOE subject to the results of the study on the move to certain sectors.
		B IEC on proper use of unleaded	1994 onwards	PIA, DECS, DOE Petrol Industry	increase use of ULG			

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
4.	Phase-out of leaded gasoline. Time schedule.	Mandatory regulation	Jan. 1, '98- urban areas Jan. 1, 2000 - whole country	DOE, Petrol Industry		still being deter-mined		Consider super low lead (.05%) since this may lower the total lead emission sooner than an all-leaded scenario 1. Identify sectors who will be affected and identify safety nets. 2. Note that COCAP's objects to phase-out dates and believes it should be in Jan. 1996 3. DOE agreed with the schedule subject to the result of the study on the impact of this move to certain areas Need to define urban areas.

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
5. *P	Decrease maximum allowable S content in diesel	Regulation, phasing 0.5% by 1996	S/M	DOE/petro-leum companies	reduction of TSP 0.5% sulfur by 1996			
	Decrease maximum allowable S content in fuel oil				3% by 1996 1% by 2001			
6.	Upgrade diesel-fuel quality (viscosity, sulfur & volatility)	Alter fuel quality standards Correct labelling thru dyes	S/M	DOE, Petrol industry, BPS, NEDA DENR			There should be a study on impacts, esp. on issue of equity Requires refinery restructuring/ upgrading	Review of environmental standard *Rigorously study the im-pacts of all these proposals (#2 to #6)
7.	Review energy pricing policy consider impacts to environment (petroleum products and electricity)	a Create technical group to study the issue and make recommendations to remove all price distortion and incorporate all environmental costs	1994 onwards	DOE,ERB,DENR,OP				
		Fee structure should encourage conservation - include environmental costs		ERB,MERALCO,electric coops.				
		examples:						
		i Remove subsidies on diesel, LPG	1996-2007	ERB/DOF				
		ii Pollution tax (recommend to RRP for inclusion in legisla-tion review of leaded gasoline	ASAP	DOF/DENR/ BIR/ DOE ERB-lead agency				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan

	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
		b Study impacts of the removal of subsidy for diesel (phase out of existing subsidy)	1994 onwards	DOE,ERB,DOF,NEDA				
		c Improve the regulators mechanism to make petroleum ' industry more competitive		DOE/ERB				
		d Inform public on impacts of deregulation on prices of diesel gasoline, etc.	ASAP	DOE/ERB				
II.B	FUEL SWITCH							
1. *P	Gasoline for diesel in UVs	Tax/subsidy modification	1995	DOF, Tax Research Center, ERB, DOE				Task force consisting of DOF and Tax Research Center should study restructuring of taxes vis-a-vis diesel and gasoline
		Conduct study on technical requirements, health and safety and price/ market implications.	1994	FILCAR, DOTC, DOE, DENR, DOH				Study possibility to stop registration of new diesel engines.

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
								Same group to study price/ market implications. Action Plan to depend on outcome of the study. Sub-committee on excise tax headed by NTRC is currently reviewing the proposed oil tax restructuring.
2.	LPG for transport (buses, PUV)	Study the use of LPG	1994-1995					Price disparity between home LPG & auto-motive. LPG should be considered.
		Create a Technical Task Force to study LPG utilization for transport	June 30, 1994	DOE/DOTC/ DOF/ ERB LIVECOR, FILCAR				
		Revive & develop infrastructure for the use of LPG	1995-1996	Oil companies/ DOE/DTI-BPS/NGO				To depend on findings of study.
3. *P	CNG, coco-oil, alcohol	Updating R&D study	1995-1997	DOE/DOST				
4.	Natural gas in industry	Study possibilities (resources)	1998	DOE				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
III.A	AIR QUALITY MONITORING							
1.	Design and set up modified/ improved/extended monintoring system	Evaluate existing monitoring system; improve it and seek funding for implementation	S	DOST, DENR				There should be bi-monthly or if possible, weekly advice on air quality conditions
2.	Design and establish Quality/Control/ Quality Assurance System - evaluation of sites; number and location - selection of methods/ parameters monitored/ frequency of operation	Prepare proposal, ask funding support	S	DENR, LLDA, DOST, BPS				
3. *P	Increase and upgrade DENR-LLDA monitoring capability	Encourage collaboration with NGOs, private sector in setting up, private sector in setting up, operating and maintaining monitoring stations	End of 1994	DENR/NGO/ Private Sector/ Donor Community				
		Tap funding agency support	ASAP	community				
		Rehabilitate the air pollution index board along EDSA	ASAP	EMB/MEIP/ ADB				
		Set up additional index boards	1995 onwards	EMB/donors				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
4.	Appropriate budget to environmental agency for the following:	Conduct appropriate researches and studies which will relate to more rational emission standards	S-M	DOST, Academe, accreditation of private firms and laboratories				
		Strengthen the capability of the DENR personnel in the stationary source monitoring and measurements	S-M	DENR, donors				
		Provision of a standardized monitoring equipment to support the setting up of standards	S-M	DENR, donors				
5. *P	Encourage third party participation in environmental monitoring	Solicit active participation of consulting firms and labora-tories thru accreditation (which will act as a third party) in the conduct of compliance monito-ring to encourage compliance and resolve reservations of some sectors on reliability of data	S-M	Consulting firms and laboratories DENR, DOH, DOST, Academe				Estimate cost if NGOs will operate & maintain monitoring stations
6. *P	Establish computerized database of all MM data regarding - air quality - meteorology (dispersion) and share database with all concerned	Improve present database on meteological, air quality data	S-M	PAG-ASA DENR, LLDA				
7.	Minimize re-suspension of dust	Encourage everyone to plant trees, shurbs, etc. and maintain them properly	ASAP	LGUs, MMA, DENR				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan

	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
		Practice turfing	ASAP	LGUs, MMA				
		More frequent watering of roads during the dry months (water from industrial treatment plants may be used for this purpose)	as needed	LGUs, MMA, NPCC, Citizens				
III.B	INVENTORY/DISPERSION MODELING							
1. *P	Develop an integrated and comprehensive emission inventory procedure, incl. emission factor review, update and QA procedures.	Require thru EIS System for new plants By Administrative Order for old plants	S-M	DENR				
		(Ensure smoke stacks have sampling ports to enable monitoring)	ASAP	DENR/LLDA				
2. *P	Improve emission inventory for MM Develop procedures & cost estimates	DENR-LLDA coordination and collaboration Tap funding support for this	start by End of 1994 on-going	DENR/LLDA				Include quantity of lead, number of facilities that use volatile compounds
	a. Produce inventory of industrial emissions (location, process, emissions,stack data)	Require firms to submit data DENR/LLDA to collect and collate data	S	DENR, LLDA				
	b. Improve inventory of road and traffic data	Improve present data gathering	S	TEC, DOTC, MMLTCC				
	c. Conduct inventory of domestic emissions	Seek US EPA assistance	S	DENR, LLDA				
	d. Study resuspension of dusts - from roads - from other surfaces	Set procedure to do this and conduct study	S	DENR, LLDA				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
3. *P	Strictly implement and enforce the requirement for firms to submit data on emissions (Promote self-monitoring by firms through responsible PCOs)	DENR - LLDA/3rd party monitoring	mid 1994	DENR/ LLDA/NGOs				
		Provide training for PCOs	ASAP	DENR/ LLDA/ PCAPI				
		Increase sanctions for mis-reporting	ASAP	DENR/ LLDA/Prof. Regulation Commission				
4.	Assess current modeling tools/methods, and establish appropriate models for control strategy in MM	Add appropriate stations to measure meteorological data (in AQ monitoring)	M	PAGASA, UP College of Meteorology				
5.	Inventory of lead imports by oil companies & correlate to uses	Bureau of Customs can collate data on importations & DENR can monitor thru declarations based on implementation of RA 6969	S-M	Bureau of Customs, DENR				
	Inventory of paint companies & motor shops and car manufacturers	Tap NSO census	S-M	NSO, DTI				
IV.	INSTITUTIONAL AND REGULATORY FRAMEWORK							
1. *P	Implement "polluter's pay principle" thru increased penalties for violators of PD 1181 and PD 984 and other measures	Pass bills (Clean Air Act, Phil. Environmental Code) imposing higher penalties	1994-1995	Congress, DENR, DOTC, LTO, NGOs				
		Strengthen enforcement capabilities for industrial and transport emission control	1994	DENR, LLDA, DOTC, LTO, MMA, LGUs				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
		Study ways to strenghten legal mechanism for compensation of victims	ASAP	DENR, LLDA				
		Consider incorporation of road user charge in the registration fees	1994-1995	DOTC/LTO				
		Improve the insurance policy requirement for vehicle registation-tied to vehicle inspection. Require as part of mandatory insurance.	1994-1995	Insurance Companies, LTO				
		Cancel franchises of violators	ASAP - continuing	LTFRB				
2.	Increase and upgrade the technical capability of government, industry and NGOs in AQM	Tap existing academic institutions to provide training	ASAP	NGOs/Academe/DENR/ LLDA				
		Encourage community participation through NGOs						
		- prepare laymanized versions on what to monitor	S	DENR/EMB				
		- disseminate esp. thru schools	S	DENR/DECS				
		- IEC like komiks, primer	S	DENR, DECS, PIA				
		Upgrade salary scale of the technical staff of regulatory agency	ASAP	DENR/DBM/ LLDA				
		Allow the use of fees and fines to strenghten government capability to monitor and enforce thru passage of appropriate legislation - Clean Air Act & Phil. Env. Code	S	DENR & NGOs to push for this/ Congress				
		Review QS for technical positions	S	DENR, CSC, DBM				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
		Encourage private sector involvement in air pollution monitoring and control	S	DENR, LLDA, NGOs, Phil. Motorist Assn., PCCI, MAP				
		Accredit private laboratories for testing, private group for MVIS and monitoring	S	DOTC/LTO				
3.	Improve the coordination of different government agencies involved in air pollution control	Propose one Traffic Management Authority - long term	1994 - draft bill	Congress, MMA, DOTC				
		Strengthen existing MMLTCC	1994	MMA, PNP, LGUs, LTO, TEC, MM Pollution Control Assn.				
		Prepare common monitoring guidelines for LLDA and DENR (for industries) and strengthen co-ordination between the two	ASAP	DENR/LLDA				
		Study creation of one environmental body/ agency	S	DENR, LLDA, Congress				
4.	Improve LGU technical capability for environmental management	Provide training	S onwards	DENR, MEIP, LLDA, MMA, LGUs, Local Government Academy				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan

	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
5.	Provide more funds for environmental monitoring and enforcement	Provide more budget	1995 onwards	DBM/Congress/LGUs				
		Allow use of environmental fees and establish a trust fund which will train existing staff, get more equipment, etc.	M	Congress to pass law (revised Environment Code, Clean Air Act)				
		Pass ordinance setting aside a portion of the collections from the anti-smoke belching campaign for use to strenghten the air pollution control capability	S-M	LGUs, MMA				
6.	Analysis of regulations by all concerned agencies	Require the tachograph for all vehicles, esp. commercial vehicles	S-M	All concerned agencies				
		Pass Odometer Law	S-M	Congress, DOTC/LTO				
		Require total disclosure						
		Require the sealing of the control rod by authorized manufacturer or service center authorized by manufacturer.	S-M	DOTC guidelines				
		Encourage importation and use of certified standard spare parts (define spare parts to avoid chop-chop)	S-M	BPS to issue guidelines, NEDA-TRM, Tariff Commission				
7.	Passage of Bill on Anti Pilferage	House and Senate Committee on Ecology to support this bill	S-M	Congress				
		Info campaign include schools& churches for awareness building and value formation	S	DECS, PIA				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
8.	Study possible incentives for enforcers and other staff involved in environmental management	Evaluate existing salary scale for merit increases	S-M	DBM, DENR, DILG, Civil Service Commission				
		Tap "Environmental Trust Fund" to provide incentives once it is set up	M	DENR				
9.	Remove issues on jurisdictional boundaries between LLDA and DENR(which causes "gray areas" in the implementation of related rules and regulations)	Provide detailed implementing guidelines of an EO-making LLDA as attached agency of DENR with DENR as chair of LLDA Board	1994	DENR, Inter-Agency Group LLDA				
10. *P	Strenghten enforcement capability of LTO/DOTC, MMA, PNP, LGUs	Train more people	ASAP	DOTC/LTO, DENR, LGUs, MMA				
		Tap NGOs to assist	ASAP	COCAP, LGUs, civic groups like Rotarians				
		Set up "hot line" for public to report violators	ASAP	LTO, MMA, MMLTCC				
		Use mass media (social) pressure	ASAP	PIA, all concerned				
11.	Strictly and uniformly implement anti-smoke belching campaign	Update common manual, which specifies standard procedures	ASAP	DENR, MMA, LTO, LGUs				
		Prepare and publicize conversion chart re comparability of Iyasaka, Hartridge & Bosch type equipment	1994	DENR, LTO				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
		Study qualifications of technicians & provide clear training procedures for LGUs, MMA, LTO & PNCC teams	ASAP	DENR/EMB				
		Encourage NGOs to join teams	ASAP	COCAP, other NGOs, LGUs				
		Encourage garage testing of public utility vehicles	ASAP	DENR, MMA, LGUs, NGOs, PNCC, private operators/ owners assn.				
		Encourage private companies, schools, offices to start their anti-smoke belching projects with technical assistance from government	ASAP	NGOs, industry groups, DECs, DENR, LTO, PNCC, LGUs, PCCI, MAP				
		Encourage LGUs to buy their own smoke meters from fines/fees collected	ASAP	LGUs				
V.	TECHNOLOGY IMPROVEMENT							
1.	State-of-the-art emission control for new cars, gasoline	Extend PD 1181 set time schedule	M-L	DOTC, DTI/BPS				
2.	State-of-the-art emission control for new motorcycles	Extend PD 1181 set time schedule	M-L	DOTC, DTI/BPS				
3.	State-of-the-art emission control for new light duty diesel vehicles (cars)	Extend PD 1181 set time schedule	M-L	DOTC, DTI/BPS				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
4.	State-of-the-art emission control for heavy duty diesel vehicles (UV, buses, trucks)	Extend PD 1181 set time schedule	M-L	DOTC, DTI/BPS				
		Set levels for smoke	M-L	DENR				
5. *P	Address highly polluting vehicles;							
	a. Upgrading of jeepney engines	Enforce existing regulation, I/M engines to system, replacement of comply with new emission regulations. Financing scheme.	S-M	DOTC, LTO, ADB	Less pollution from jeepneys			
	Discourage importation of dirty and/or uncertified engines and vehicles	Require compliance with emission standards of country of origin or Phil. standards - whichever is more stringent	1994	Tariff Commis-sion/ IAC-UTE				Study phase-out of importation of 2nd hand vehicles thru the repeal of EO 782, EO 361, EO 354
		Limit number of years for PUVs by regulation	1994-1995	LTO				High mileage vehicles degrade faster
		Create study group on how uncertified importation of engines could be stopped	1994	NEDA-TRM				Results of study should guide decision makers on necessary steps to be taken.
*P	b. Inspection/maintenance scheme Strictly implement requirement that all vehicles pass emission tests prior to registration (once a year testing for private vehicles and twice a year testing for public utlities	Expand operations/coverage of MVIS	on-going	LTO	Pollutive vehicles will no longer be allowed on the streets			To certify remanufacture of used engines to "as new" specification
		Encourage private sector investment in I&M program through economic incentives and availability of credit	on-going	LTO for guidelines DTI/BOI for incentives ADB for credit				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan

	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
		Study possible accreditation of private entities for motor vehicle inspection system emission testing with clear sanctions and provision for training without conflict of nterest	on-going	DOTC-LTO/DTI				
		Re-activate computerized database on all vehicles and include law enforcement data	ASAP	LTO, PNCC, LGUs, PNP, MMA	Easier monitoring & enforcement			
	Study shift to 2-year registration for new private vehicles	Revise regulations on vehicle registration	1995	LTO				
	C. study income enhancement of jeepney drivers	Prepare measures to carry this out.	1994	LTO Office of Transport Coop				
	d. pass the odometer law, truth in mileage Act; use of speedometer/enforce speed limits; non-removal of tachometers	DOTC/LTO regulations. Draft Bills be prepared	S-M	DOTC/LTO, Congress				
6. *P	Industrial Sources							
	Use of emission control equipment	Licensing (emission reg's)/ Charges on emissions/	1994	Industry associations citizens & NGO, DENR,				
	Process modifications/improvement	Promote good environmental practices	1994	PCAPI, PICHE PCCI, MAP				

Table 8.4: Cont.

Urban Air Quality Management (URBAIR) Action Plan								
	WHAT	HOW	WHEN Action/ Result	WHO	EFFECTS	COST	FEASIBILITY	REMARKS
	Encourage citizen/NGO action vs. industrial polluters		ASAP					

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

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