

## EXECUTIVE SUMMARY

### WANTED: A BREATH OF FRESH AIR!

Urban smog, smoke-belching buses, and industrial smoke stacks. These are prominent and visible reminders of the need to manage air quality. However, air pollution is not just an aesthetic problem; it can also cause acute and long-term health effects – personally and economically very damaging. The health cost of air pollution in four cities (Metro Manila, Davao, Cebu, and Baguio) has been estimated to be more than US\$400 million per year, equivalent to 0.6 percent of the country's national gross domestic product (GDP). These four cities represent more than a quarter of the Philippines' urban population.

According to a perception survey conducted in 2001, more than 72 percent of Manila's residents were alarmed by air pollution and 73 percent said they were not aware that the government was doing something to control it. This public perception is in sharp contrast to the amount of time spent by governmental agencies and non-governmental organizations (NGOs) in discussing and debating air pollution issues in recent years and reflects a general failure to convert analyses and discussions into effective action.

Reliable monitoring is the foundation for sound policy and needs to be established as a priority. In the Philippines, only a patchy network of air quality monitoring stations provides limited information on pollutant levels. It is estimated that while particulate matter levels have decreased since 1995, these still exceed standards at most locations in Manila and in many other cities. The decline in pollution can largely be attributed to improved automotive technology and standards enacted several years ago, and the switch to natural gas use in power plants and industries. Other pollutants such as ozone and nitrogen oxides are on the rise. Although extensive information regarding indoor air pollution is not yet available, preliminary results indicate that this is a problem.

Diesel emissions from buses, jeepneys, utility vehicles, and trucks are recognized as causing cancer, and are estimated to be the largest contributor to urban air pollution. In spite of many anti-smoke-belching campaigns and programs, buses and utility vehicles emitting visible smoke are a common site in Metro Manila and other urban centers.

While there is a general perception that poor air quality negatively impacts health, there is little reliable data on the health impacts of air pollution in the Philippines. Despite extensive policies and laws, air quality management in the Philippines remains a challenge.






The Clean Air Act (CAA) of 1999 aims to provide a comprehensive air pollution control policy for the country. However, implementation difficulties point to the complexities associated with solving a problem involving many agencies. Inter-agency collaboration remains a challenge despite many multi-sectoral working committees and memoranda of agreement. Lack of provincial and local government capacities for air quality management will be further exposed, as these entities are under-prepared to carry out the functions devolved to them by CAA. Preliminary estimates for implementing parts of CAA indicate that the country will need to spend at least PhP25 billion (US\$500 million) between 2000 and 2010 but the benefits are likely to far exceed these costs.






Active non-governmental initiatives have raised public awareness and provided examples of possible actions on a small scale. Their effectiveness is limited; yet, complements government efforts. They can, however, apply pressure on the Government to improve its institutional response.




Implementation of CAA emerges as a national priority to combat air pollution. In so doing, the country will need to address seven key challenges:

- Reducing particulate matter in Metro Manila through improved maintenance for high use commercial vehicles, improved fuel quality, and shifting to four-stroke motorcycles;
- Requiring catalytic converters in gasoline vehicles;
- Improving public transport and traffic management;
- Implementation of CAA with adequate institutional capacity, funding, and political commitment;
- Strengthening enforcement with incentives and penalties;
- Improving air quality management by integrating monitoring and analytical capacity with decision-making; and
- Moving from public awareness to participation.

# PHILIPPINES AIR QUALITY AT A GLANCE

Issue/Topic	Status	Priority
<b>Pollutant</b>		
Total suspended particulates	<ul style="list-style-type: none"> <li>Annual standards are exceeded at 70% (22 out of 32) of the monitoring sites.</li> <li>Metro Manila has the worst readings.</li> <li>Number of days on which standards are exceeded is on the decline (24-hour guideline exceeded 50% of the days; down from 90% of the days monitored).</li> </ul>	
PM <sub>10</sub>	<ul style="list-style-type: none"> <li>PM<sub>10</sub> monitoring is limited and needs to be expanded for health impact assessment.</li> <li>Limited monitoring in Metro Manila shows very high readings.</li> </ul>	
Carbon monoxide	<ul style="list-style-type: none"> <li>Eight-hour standard exceeded in Metro Manila.</li> </ul>	
Ozone	<ul style="list-style-type: none"> <li>One-hour standard exceeded in seven out of eight months in 2001-2002 in Metro Manila.</li> </ul>	
Lead	<ul style="list-style-type: none"> <li>Ambient levels are down due to the elimination of lead in gasoline since January 2001.</li> </ul>	

<b>Sources</b>		
Transport	<ul style="list-style-type: none"> <li>Vehicle ownership is rising rapidly (from 1.2 million in 1983 to 3.9 million in 2001).</li> <li>Diesel vehicles: Over 65% of the fleet are high mileage vehicles; suspected of contributing to majority of urban exposure and health impacts.</li> <li>Motorcycles: 75% are two-stroke engines whose exhaust contains high levels of unburned fuel and lubrication causing PM emissions and HC emissions.</li> </ul>	
Resuspension and construction	<ul style="list-style-type: none"> <li>Total contribution is not available and should be quantified. Contribution to PM<sub>10</sub> may be small.</li> <li>Controlling these sources is the most cost-effective way to reduce pollution load and dust.</li> </ul>	
Waste burning	<ul style="list-style-type: none"> <li>Burning of agricultural waste and refuse is widely practiced. It contributes significantly to particulate matter and should be quantified.</li> </ul>	
Indoor air pollution	<ul style="list-style-type: none"> <li>An emerging problem in Metro Manila.</li> </ul>	
Industry and power	<ul style="list-style-type: none"> <li>Not a major source in Metro Manila or across the Philippines for urban air pollution but has localized impacts and needs to be controlled.</li> </ul>	

<b>Responses</b>		
Analysis and actions	<ul style="list-style-type: none"> <li>Lack of data and systematic analyses are major impediments toward the formulation of effective action plans and their implementation.</li> </ul>	
Inter-agency cooperation	<ul style="list-style-type: none"> <li>Air quality management requires all agencies to cooperate, which has not been easy across sectors and government departments.</li> </ul>	
Enforcement and institutional capacity	<ul style="list-style-type: none"> <li>Enforcement of legislation and regulations is weak including the recently enacted CAA.</li> <li>Need to strengthen the institutional capacity to enforce these rules and regulations.</li> </ul>	



High



Medium



Low



# INTRODUCTION

## Air Pollution

An air pollutant is any substance in air that could, in sufficient concentration, harm humans, animals, vegetation, or material. Air pollutants may occur in the form of solid particles, liquid droplets, and/or gases. They are generally grouped into two main classes: i) primary pollutants, which are those emitted directly from sources, and ii) secondary pollutants, which are those produced in the air by an interaction between two or more primary pollutants, with or without sunlight. There are over 100 identified air pollutants. They fall into the following major categories: particulate (various sizes), oxides of sulfur and nitrogen, volatile organic compounds (VOCs), and ozone (O<sub>3</sub>). Noise and odor are also considered pollutants.

Air pollution is not limited to the visible smoky automobile exhaust or the plume from an industrial chimney. Such emissions invoke public concern because of the health hazards and odor nuisance these present. However, several pollutants, such as carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), and fine particles, are not visible but are equally or even more damaging for human health and the environment.

## Sources and Impacts of Air Pollution

Sources of air pollution in and around the population centers in the Philippines include emissions from (i) mobile sources – vehicles; (ii) stationary sources – power plants and factories; and (iii) area sources – refuse burning, road dust, open cooking. Burning of agricultural waste in rural areas also causes air pollution.

Increased levels of air pollution are threatening the well being of city dwellers, and imposing not just a direct economic cost by impacting human health but also threatening long-term productivity (material and vegetation damage, quality of life, reduced tourism to the country, discourage foreign investment, etc.). In recent years, health studies in various countries have established a direct relationship between daily concentrations of particulate matter and premature deaths and excess morbidity. Some of these can be quantified, while others can only be expressed qualitatively. For example, preliminary estimates carried out by World Bank staff for the Philippines show health costs in four urban centers to be over US\$400 million per year.

## Guidelines

In 1999, the Government approved CAA, which is the most comprehensive legislation enacted to address air pollution. It proposes limits for ambient levels of major pollutants (Table 1). These limits are set to protect public health and the environment.

Table 1. Philippines, US-EPA and WHO ambient air quality guidelines for common pollutants, 1999

POLLUTANT	TIME (averaging)	WHO (µg/m <sup>3</sup> )	US-EPA (µg/m <sup>3</sup> )	PHILIPPINES (µg/m <sup>3</sup> )
Total suspended particulates (TSP)	daily annual	** **		230 90
Particulate Matter less than 10 microns (PM <sub>10</sub> )	daily annual	** **	150 50	150 60
Sulfur dioxide (SO <sub>2</sub> )	daily annual	125 50	365 80	180 80
Nitrogen dioxide (NO <sub>2</sub> )	daily annual	40	- 100	150
Ozone (O <sub>3</sub> )	1 hour 8 hours	120	235 15	140 60
Carbon monoxide (CO)	1 hour 8 hours	30 mg/m <sup>3</sup> 10 mg/m <sup>3</sup>	40 mg/m <sup>3</sup> 10 mg/m <sup>3</sup>	35 mg/m <sup>3</sup> 10 mg/m <sup>3</sup>
Lead (Pb)	3 months annual	0.5	-	1.5 1.0

Source: Clean Air Act of 1999 and WHO/SDE/OEH/00.02, Geneva 2000.

Notes

\*\* WHO no longer recommends air quality guideline for PM because there is no safe lower limit.

-Values of US-EPA are for primary standards.

-Annual average is an average of daily measurements taken during a period of one year.

-µg/m<sup>3</sup> is a unit of measurement and refers to one millionth of a gram of a pollutant in a cubic meter of air.

-Guideline refers to the safe level of a pollutant, for the given averaging time, to protect the public from acute health effects.

## Monitoring Air Pollution

Ambient monitoring is essential to evaluate compliance with standards and the need for action. It provides primary data to estimate damage to human health, ecosystems, and material infrastructure. Human exposure is calculated by multiplying the ambient concentration with the population exposed. This information forms the basis for analyzing the costs and benefits of control options, public participation, and policy response.

In the Philippines, air pollution is caused by transport, industries, power plants, and area sources such as road dust, construction, and waste burning. National level source inventories are not available. There are estimates for Metro Manila but they contain significant discrepancies. Area sources are either not accounted for or their contribution is under represented.

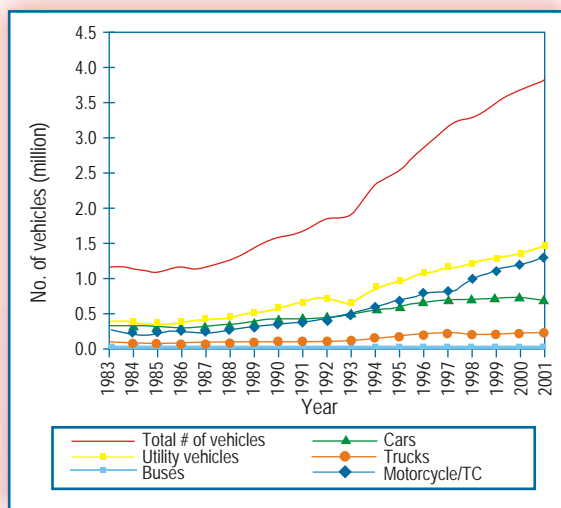
**Mobile Sources: Transport**

**Transport is a significant contributor.** In 2001, there were 3.9 million registered vehicles in the country – a threefold increase within the past two decades (Figure 1). Of these vehicles, 70 percent are gasoline-fueled and 30 percent are diesel-fueled. Nationally, utility vehicles<sup>1</sup> outnumber cars, with a 2:1 ratio. Beginning in 1994, motorcycles and tricycles have surpassed cars as the second largest group of vehicles. In Metro Manila, utility vehicles marginally outnumber cars (44 percent to 36 percent) and motorcycles/tricycles account for only 14 percent of the 1.3 million vehicles (Figure 2). Judging from the experience of other Asian countries, personal vehicle ownership will rise as individual incomes increase in the Philippines. Despite advances in control technology for newer vehicles, a high growth in vehicle ownership, combined with low turnover, contributes significantly to air pollution.

**Diesel-powered vehicles emit a significant amount of fine particles.** The number of diesel-powered vehicles has grown rapidly in recent years, and these account for nearly a third of all vehicles. Of the 1.2 million diesel-fueled vehicles, over 65 percent are high mileage (utility vehicles, buses, and trucks). Repeated anti-smoke belching campaigns carried out by local governments and the Metropolitan Manila Development Authority (MMDA) over the last decade have reduced the number of smoky vehicles in the main roads. In Metro Manila, pollution caused by jeepneys may have declined because of the use of larger and cleaner second-hand engines by the manufacturers; however, introduction of van-type “FX-taxis” may have negated this gain.

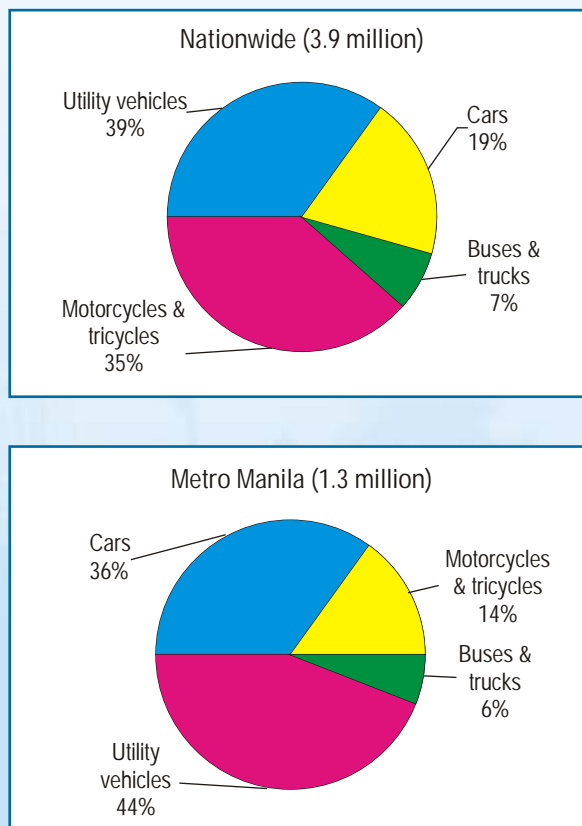
<sup>1</sup>Utility vehicles include taxis, jeepneys, and vans.

Figure 1. Registered motor vehicles in the Philippines, 1983-2001



Source: Land Transportation Office (LTO), Central Office, Quezon City, 2002.

Figure 2. Vehicle composition, nationwide and in Metro Manila, 2001



Source: Land Transportation Office, 2002.

**Two-stroke engines dominate the motorcycle market.**

Two-stroke engines power more than 75 percent of motorcycles and tricycles. Their exhaust contains a high level of fine particles, unburned fuel and lubricants as compared to four-stroke engines. The motorcycle industry is beginning to use fuel-efficient and less polluting four-stroke engines in their production. The cost of four-stroke motorcycles is similar to that of two-strokes. Furthermore, other countries in the region have already moved to four-stroke engine production.

**Jeepneys remain the popular choice for daily transport in Metro Manila.**

According to a survey<sup>2</sup> taken in 1996, the 10 million residents of Metro Manila took over 23 million trips daily, with jeepneys accounting for over 40 percent of these trips. Of these trips, 80 percent were by public transport, while 20 percent was made by cars and utility vehicles (Figure 3). The survey also indicated that only 20 percent of households owned cars, far fewer than many large cities in the region. A third of the trips in Metro Manila covered a distance of less than two kilometers, which may contribute substantially to both congestion and pollution. Tricycles, cars, and jeepneys are responsible for 95 percent of such short-distance trips.

**Stationary Sources: Industry**

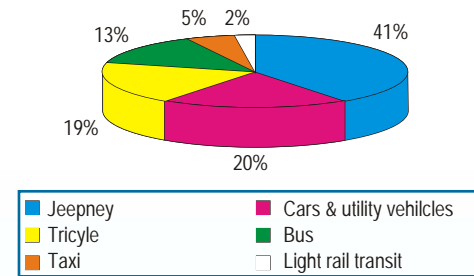
**Most industrial sources are located in the Metro Manila airshed.**

The major types of industry contributing to air pollution are thermal power stations, cement manufacturing plants, and oil refineries (Table 2). These are mostly located within the Metro Manila airshed.

An initial attempt at constructing a source inventory indicates that food products, textiles, and iron and steel industries most likely account for nearly 80 percent of the particulate emissions from the industrial sector (Table 3). Of the 737 establishments, nearly two-thirds do not have the necessary air pollution control facilities.<sup>4</sup> The air

pollution control devices installed in the remaining one-third are not operational because companies believe these are very expensive to operate.

Figure 3. Motorized trips in Metro Manila, 1996



Source: Metro Manila Transportation and Traffic Situation Study, 1996.

Table 2. Composition of industrial air pollution sources

Industry	National	MM Airshed
Cement	19	8 (42%)
Oil Refining	3	3 (100%)
Others (air polluting)	2,800	737 (28%)

Note: Metro Manila figures are for the airshed, which include geographical areas outside of NCR.

Source: EMB/DENR, 2001.

Table 3. Estimated emissions in the industrial sector, Metro Manila, 1997 (in metric tons)

Industry	Fuel Cons (1000 lit.)	PM	PM <sub>10</sub>	SO <sub>2</sub>	NO <sub>x</sub>	VOC	CO
Food products	78,370	681	610	5,184	528	2.89	49
Textiles	56,348	489	439	3,727	380	2.08	35
Paper products	24,173	210	188	1,599	163	0.89	15
Industrial chemicals	11,675	101	91	772	78	0.43	7
Other chemicals	10,332	89	80	683	69	0.38	6
Iron and steel	45,784	398	356	3,028	308	1.69	29
TOTAL	226,682	1,970	1,766	14,994	1,529	8.36	144

Source: Department of Energy, ENRAP, 1997.

<sup>2</sup> The Metro Manila Transportation and Traffic Situation Study of 1996 included a household survey that interviewed 235,000 residents from 50,000 households (about 2.5 percent sample size).

<sup>3</sup> EMB has designated the area between Batangas to the South and Bataan to the North as the Metro Manila Airshed, as required by the CAA.

<sup>4</sup> DENR, 1998.

**Stationary Sources: Power Plants**

*Two-thirds of the country's electricity is supplied by thermal sources.* In 2000, the Philippines had a total installed (as opposed to actual production – Figure 4) generation capacity of 13,264 MW, of which 66 percent is thermal, 19 percent hydro, and 14 percent geothermal. About 2,000 MW of the oil-fired generation capacity, located in the two highly populated regions – the National Capital Region (NCR) and the Southern Tagalog Region (Region IV) – are scheduled for decommissioning by 2005. The Rockwell Power Station in Makati and the Manila Power Station in Isla de Provisor have been shut down.

*Power generation is a major source of sulfur-dioxide.* Based on recent estimates<sup>5</sup>, oil and coal-fired power plants emit 223,000 metric tons (MT) of SO<sub>2</sub>, annually. However, recent plant closings and the proposed shut down of other power plants are expected to reduce these emissions substantially.

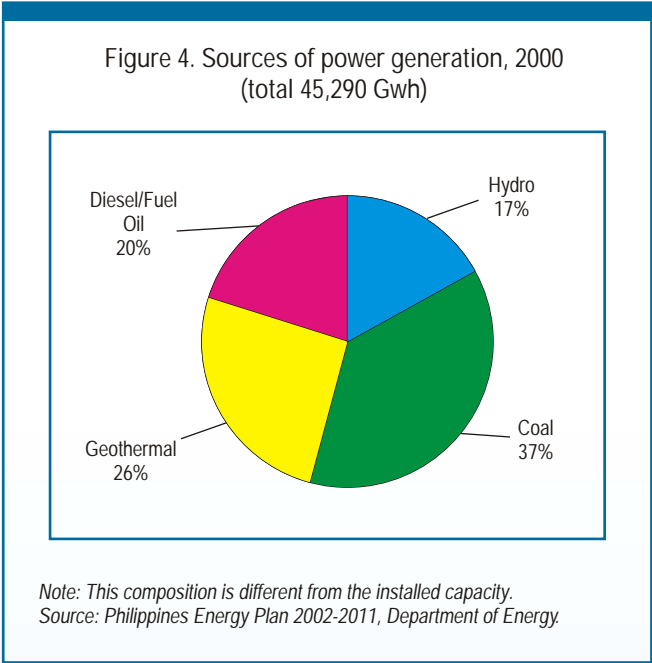
Existing pollution control measures in power plants target mainly particulate matter. To minimize SO<sub>2</sub> emissions, fuel with lower sulfur content is used. Only the latest coal-fired power plants are equipped with flue gas desulfurization (FGD) systems to control SO<sub>2</sub> emissions. The shift to the use of natural gas will eliminate SO<sub>2</sub> emissions from the power generation sector.

**Area Sources**

*Incomplete inventories.* Area sources of pollution are widespread, difficult to estimate in inventories, and generally overlooked. Important area sources include the following:

- resuspended road dust;
- refuse, forest and agricultural burning; and
- open cooking fires using fossil fuels.

Unpaved roads and pavements, building activity, and traffic are the main contributors to resuspended (or reentrained) dust. The contribution of refuse burning to local air pollution has not yet been well quantified even for cities like Bangkok.



Local and transboundary haze pollution arising from land and forest fires has been an increasingly significant issue for Southeast Asian countries. Regional haze problems became acute during the 1997 Indonesian forest fires in which about 4.5 million hectares of Indonesia's national forests were scorched. An estimated 20 million people in the region were exposed to high levels of pollutants over several months.

Natural sources also contribute to the background level of air pollution and need to be better accounted for. The eruption of Mount Pinatubo in 1991 created a vast amount of pollution including particulates that covered a wide land area.



<sup>5</sup> ENRAP.

## POLLUTANTS PARTICULATE

Particulate matter (PM) is a complex mixture of dust, dirt, smoke, and liquid droplets, varying in size and composition, which are emitted into the air. These particles are either emitted directly or are formed in the atmosphere. Total Suspended Particulates (TSP) are composed of particles of different sizes. Finer particles called  $PM_{10}$  and  $PM_{2.5}$  (less than 10 or 2.5 microns in diameter, respectively) are receiving increasing attention because of their more serious health impacts. However, the majority of ambient measurements gathered in the Philippines are still for TSP. Measures to control TSP and PM and the degree to which they have been used in the Philippines, are summarized in Table 4.

**Fine particulates are generated as a result of combustion processes.** Particle pollution is generated from fossil fuel burning for steam generation; heating and household cooking; agricultural and forest waste burning; diesel-fueled engine combustion; and various industrial processes. Coarse or larger particles usually contain geological materials and fugitive dust from roads and industries.

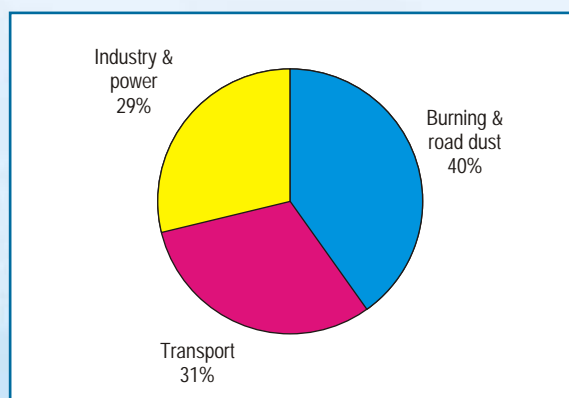
**Metro Manila residents are exposed to over 100,000 tons of  $PM_{10}$  annually.** The most comprehensive emissions inventory for Metro Manila was done in 1990. This inventory is now outdated. A partial update done for the Metro Manila airshed in 2001 reported that stationary and mobile sources contribute 37,000 and 39,000 metric tons per year to  $PM_{10}$ , respectively. Area sources (burning of agriculture and solid waste, construction, and road dust) contributed 51,000 tons per year based on the 1990 inventory. Based on these two studies, the 2001 emissions inventory for Metro Manila (Figure 5) is about 127,000 tons annually. Accordingly, area sources dominate the overall emissions.

However, the extent of health impact is determined by the amount of exposure, which is dominated by the transport sector in urban centers. Thus, air quality action plans for urban areas focus on the transport sector.

Table 4. PM control options and their use in the Philippines

Sources	Control options	Status
<i>Mobile</i>		
Motorcycles	- Regular maintenance - Switch to 4-stroke engines	- 75 percent are 2-stroke motorcycles
Trucks / buses	- Regular maintenance - Reduced sulfur in fuel	- Existing inspection/maintenance system not functioning effectively
PUVs	- Trap oxidizer	
<i>Stationary</i>		
Industry and power	End-of-pipe control measures (e.g., venturi scrubbers, electrostatic precipitators, fabric filters, and cyclones)	- Less than 10 percent of the identified air polluting industries have installed control measures, which are poorly operated. - Power plants switching to cleaner fuels
<i>Area</i>		
Refuse burning	- Disposal in sanitary landfills	- Widespread burning of garbage - No proper disposal facilities
Reentrainment	- Regulating movement of trucks carrying debris - Better construction practices - Paved roads	- Truck movement unregulated - Ineffective controls at most construction sites
Agricultural waste burning	- Composting of waste	- Unknown

Figure 5. Source contributions to total  $PM_{10}$  emissions in Metro Manila, 2001 (tons per year)



Note: Total emissions of 127,000 tons; data for area source extrapolated from 1990 data.

Source: ADB MMAQISDP, 2001.

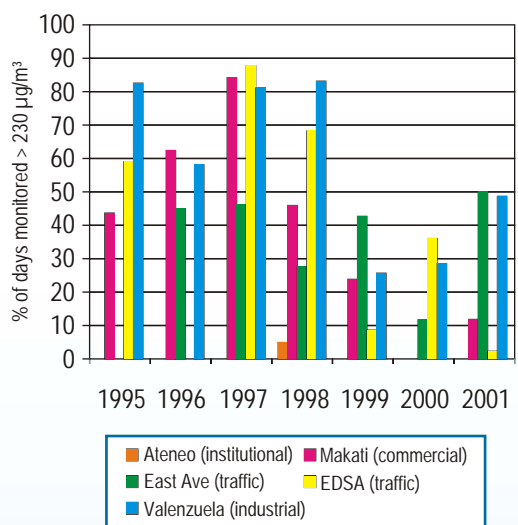
***PM<sub>10</sub> levels in Metro Manila continue to exceed guidelines, but on a declining number of days.*** The Environmental Management Bureau (EMB) of the NCR maintains 12 stations, 11 manual and one automatic. Sporadic monitoring of TSP from 1995 to 2001 shows that in 1997 and 1998, the 24-hour average air quality guideline (230  $\mu\text{g}/\text{m}^3$ ) was exceeded at some sites on as many as 90 percent of the days monitored. Recently, this frequency has dropped to about 50 percent (Figure 6).

A recent study supported by the Asian Development Bank (ADB) analyzed the annual geometric mean concentrations of TSP at all available sites in Metro Manila since 1987.<sup>6</sup> The average results for each year confirm the downward trend in concentrations since 1995. However, all the values are still above the annual guideline of 90  $\mu\text{g}/\text{m}^3$  (Figure 7).

***PM<sub>10</sub> and PM<sub>2.5</sub> monitoring is recent.*** The Manila Observatory initiated monitoring for PM<sub>10</sub> and PM<sub>2.5</sub> at three sites in Metro Manila in April 2002.<sup>7</sup> The three selected sites are representative of residential, traffic, and commercial activities. Preliminary results for two months are shown in Figure 8. The initial results indicate that 55 to 60 percent of PM<sub>10</sub> is the finer PM<sub>2.5</sub>, which can penetrate deep into the lungs, causing serious health problems.

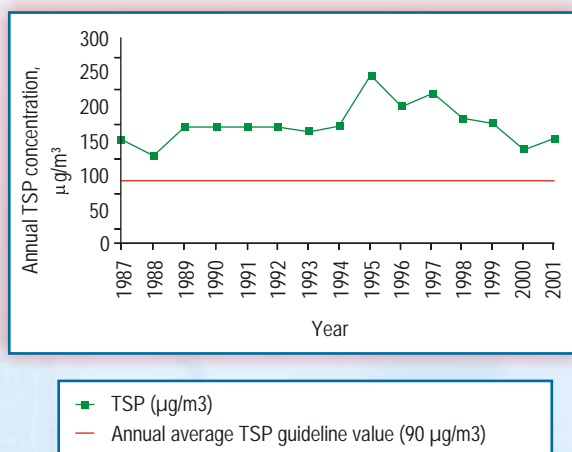
Two of the three sites are co-located with EMB sites, which are collecting TSP and PM<sub>10</sub> data. This combination of two sets of monitoring stations under two different institutions should result in a unique primary data set for TSP, PM<sub>10</sub>, and PM<sub>2.5</sub>.

Figure 6. TSP exceedances for selected air quality monitoring stations in Metro Manila, 1995-2001



Source: DENR-EMB, Central Office, Quezon City, 2002.

Figure 7. Annual mean total suspended particulate (TSP) concentration in Metro Manila, 1987-2001



Source: Preliminary Assessment of Outdoor Air Pollution and Health in Metro Manila, 30 October 2001.

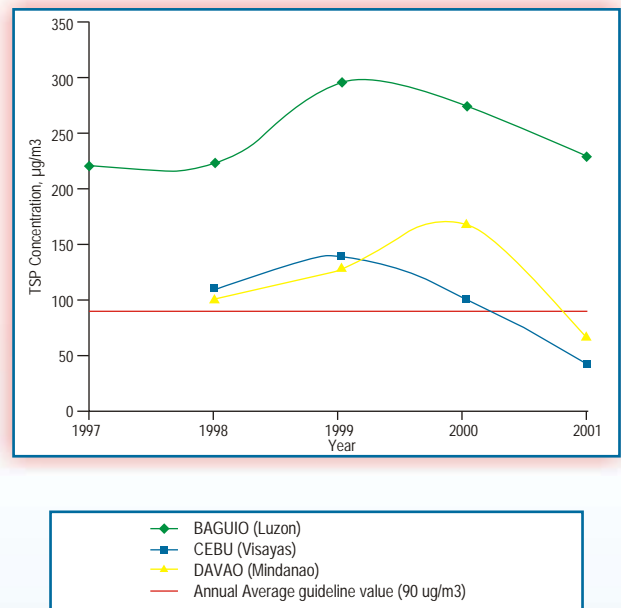
<sup>6</sup>Preliminary Assessment of Outdoor Air Pollution and Health in Metro Manila”, University of the Philippines, Diliman, October 2001.

<sup>7</sup>This monitoring was undertaken as a background study for this Monitor. The site at the Manila Observatory located at Loyola Heights is representative of a mixed residential/traffic area. The National Printing Office at Epifanio de los Santos Avenue (EDSA) is a traffic-dominated site. The Philippine General Hospital (PGH) site located at the Padre Faura area is a mixed institutional/commercial site.

# POLLUTANTS PARTICULATE

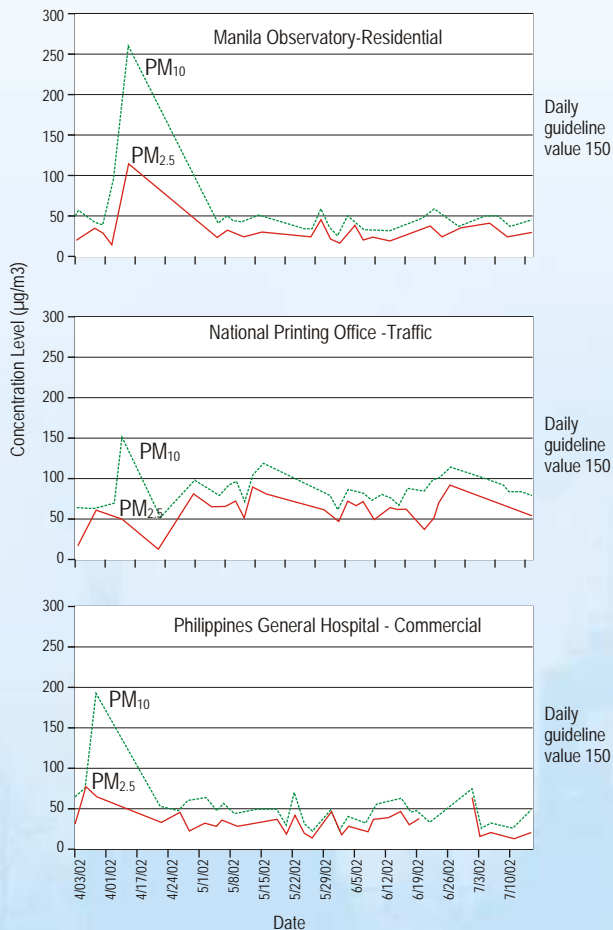
*Air quality in other urban areas is also poor.* DENR monitors TSP at over 40 stations in the Philippines. Monitoring data for three highly urbanized areas in the country (Baguio, Cebu, and Davao) from 1997-2001, suggests that annual TSP averages exceed guidelines for most years (Figure 9). In Cebu and Davao, TSP levels are beginning to decline, whereas in Baguio, the TSP levels are two to three times the annual guidelines. This is partially due to an increasing urban activity and the unfavorable meteorological conditions that limit dispersion and result in higher pollution levels. Figures 10A and B show annual TSP concentrations and their exceedance over the guideline value for various stations for all regions for 2000 and 2001. Region 9 (Zamboanga City) values are skewed because the monitoring stations are located close to major roads and traffic intersections. The EMB has already taken steps to relocate these stations.

Figure 9. Annual total suspended particulate (TSP) concentration in major cities nationwide, 1997-2001



Source: DENR-EMB Central Office and Regional Office - CAR, R7, R11, 2002.

Figure 8. PM<sub>10</sub> and PM<sub>2.5</sub> results for three stations



Source: Manila Observatory, 2002.



# POLLUTANTS PARTICULATE

Figure 10A. Annual average TSP concentration for the National Capital Region (NCR) and the Cordillera Autonomous Region (CAR), 2000 and 2001

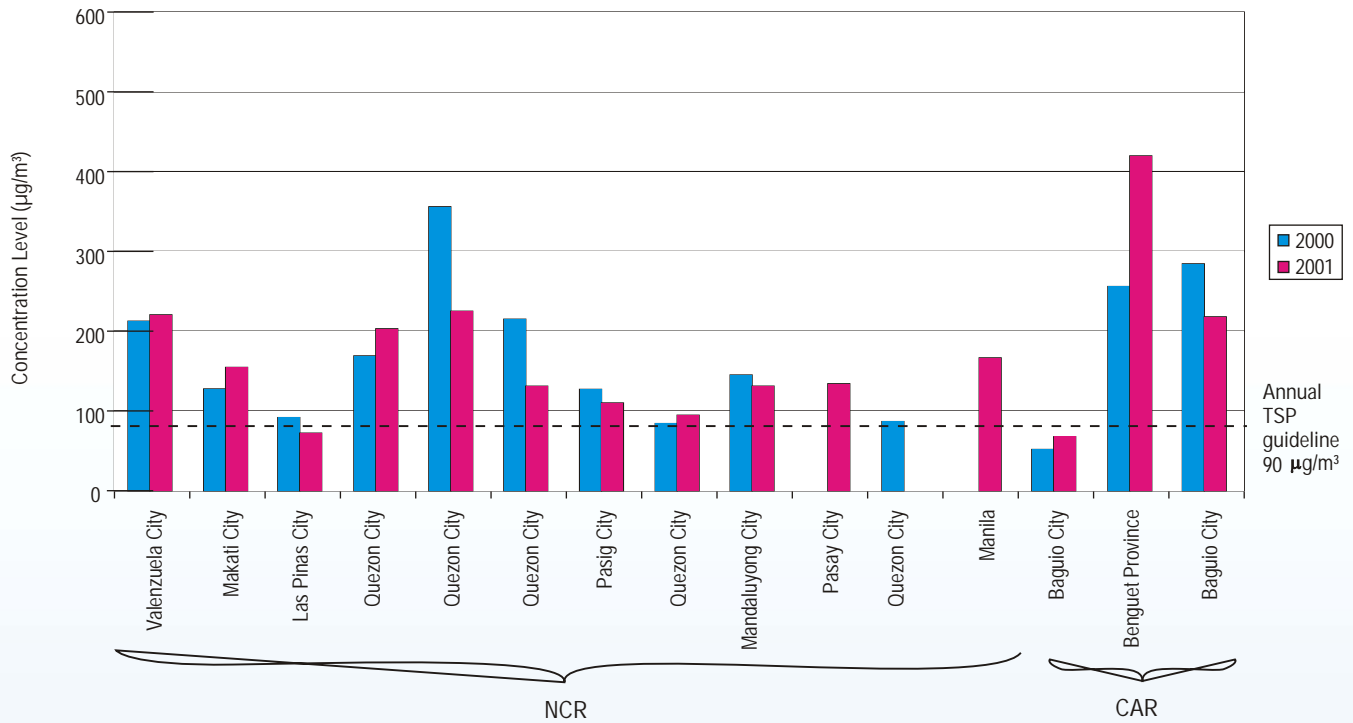
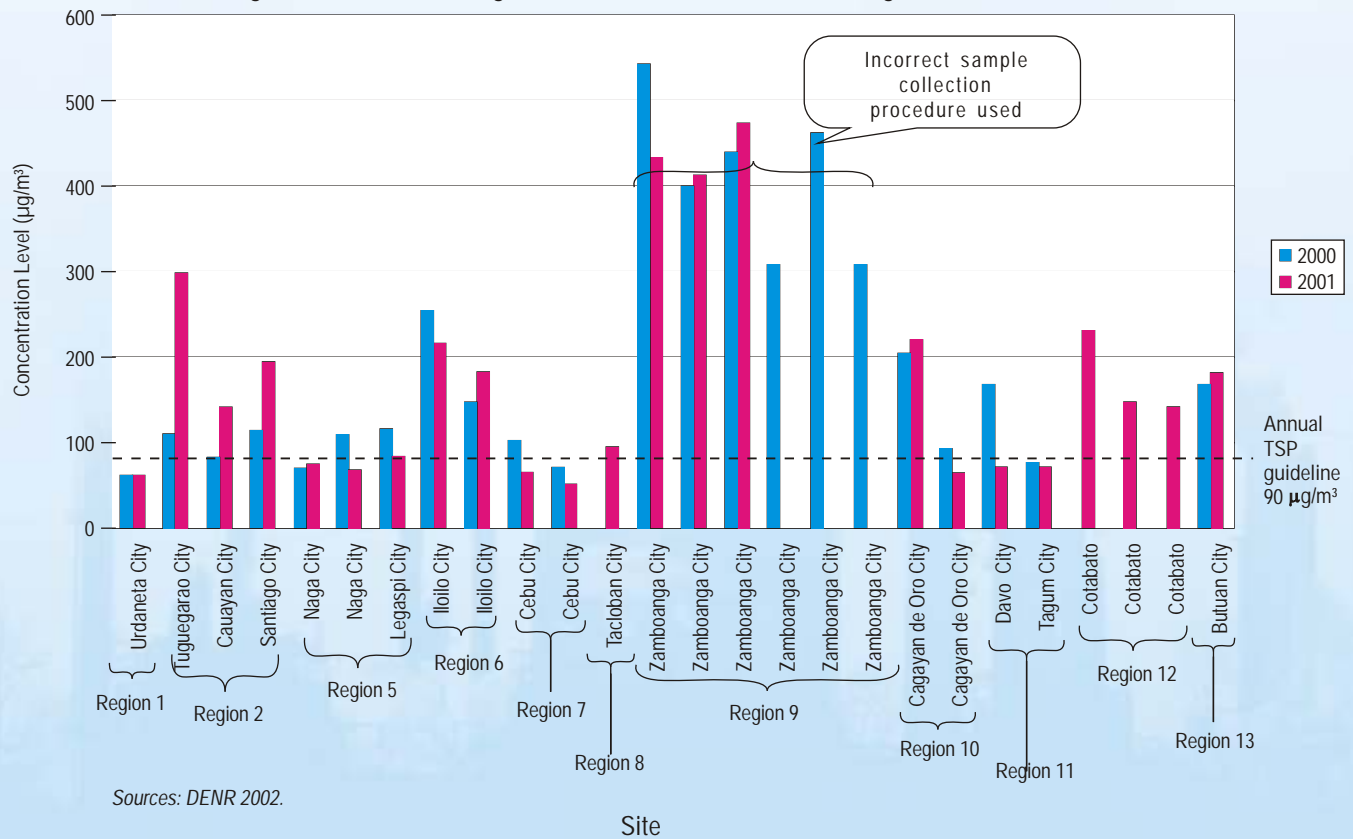


Figure 10B. Annual average TSP concentrations for all other regions, 2000 and 2001



Sources: DENR 2002.

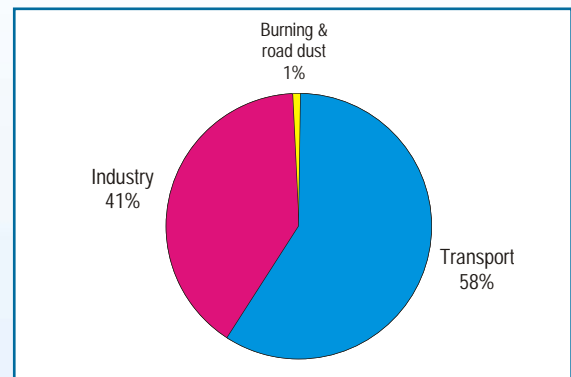
## POLLUTANTS OXIDES OF NITROGEN

An oxide of nitrogen, or  $\text{NO}_x$ , is a collective term used for nitrogen oxide ( $\text{NO}$ ) and dioxide ( $\text{NO}_2$ ), which are in gaseous forms. However,  $\text{NO}_2$  is used as a measurement indicator for  $\text{NO}_x$ . In urban areas, these oxides are emitted mainly from fuel combustion.  $\text{NO}_2$  emissions play a major role in the formation of ozone, particulate matter, and acid rain. The effects of  $\text{NO}_x$  on human health depend on its reaction with other pollutants. With hydrocarbons (HC),  $\text{NO}_x$  creates smog; with sulfur dioxide,  $\text{NO}_x$  creates acid rain; and with ammonia, moisture, and other compounds, it reacts to form nitric acid and harmful nitrate.  $\text{NO}_x$  also causes retardation and leaf bleaching in plants. Measures to control  $\text{NO}_x$  and the status of their application in the Philippines are summarized in Table 5.

**Diesel-powered vehicles are the worst offenders.** A partial update of the emissions inventory for Metro Manila in 2001 indicates that transport sources contribute 58 percent, while industrial sources contribute 41 percent to the total emissions of nitrogen oxides (Figure 11). Transport, especially diesel-fueled vehicles, is the principal contributor of nitrogen oxides. Results available from a monitoring site at the Ateneo station in Quezon City (control site) show that  $\text{NO}_2$  levels range from 58 to 214  $\mu\text{g}/\text{m}^3$  (Figure 12). No reliable inference can be made from these results, as some measurements exceeded the guideline value while others conformed.

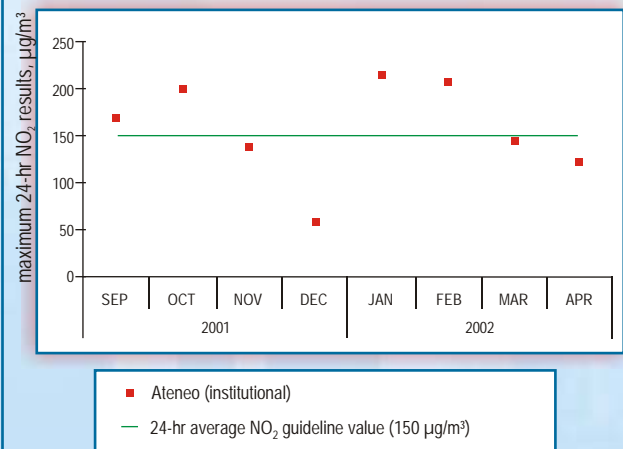
Sources	Control options	Status
<b>Vehicles</b>		
Cars	- Regular maintenance	- Use of catalytic converters for gasoline vehicles not mandated
Motorcycles	- Catalytic converters	
Trucks/buses	- Regular maintenance	- High sulfur content in diesel deters the use of catalytic converters
PUV's	- Catalytic converters	
<b>Stationary</b>		
Power & Industry	- Low $\text{NO}_x$ burners	- Not prevalent

Figure 11. Source contributions to  $\text{NO}_x$  emissions in Metro Manila, 2001 (tons per year)



Notes: Total emissions 239,000; data for area contribution extrapolated from 1990 data.  
Source: ADB, 2001.

Figure 12.  $\text{NO}_2$  concentrations at the Ateneo Station, September 2001-April 2002



Source: DENR-EMB, Central Office/ Manila Observatory, Ateneo de Manila University Campus, Quezon City, 2002.



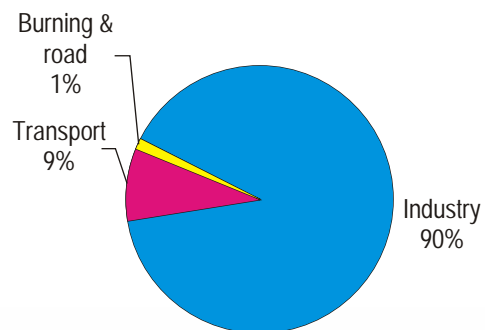
## POLLUTANTS SULFUR DIOXIDE

Sulfur dioxide (SO<sub>2</sub>) is a colorless gas, formed when fuel that contains sulfur (coal and oil) is burned in energy production and other industrial processes. SO<sub>2</sub> is one of the leading causes of respiratory problems in humans. The deposition of sulfurous and sulfuric acids on metallic parts of equipment, building roofs, etc., results in corrosion, reducing the life of built surfaces and increasing repair costs. SO<sub>2</sub> can also severely damage plants. SO<sub>2</sub> control measures and the extent to which they have been applied in the Philippines are summarized in Table 6.

**Coal and oil-fired power plants are major contributors.** Fuel combustion, largely from coal-fired power plants, accounts for most of the anthropogenic SO<sub>2</sub> emissions in the Philippines. This is evident from the 2001 update of the inventory for Metro Manila (Figure 13). For example, when three power plants were operating in Metro Manila, more than 90 percent of industrial emissions of SO<sub>2</sub> were attributed to them.

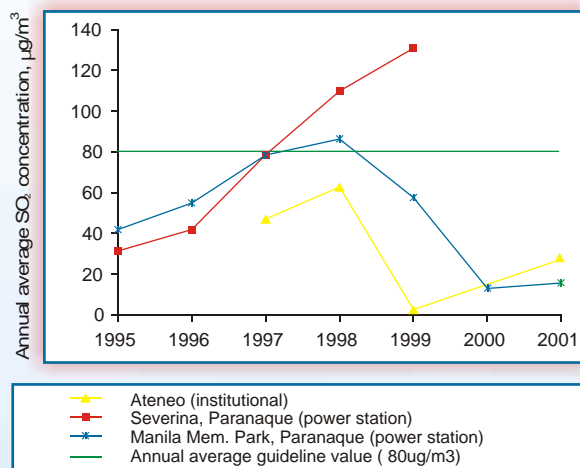
**Ambient sulfur dioxide (SO<sub>2</sub>) levels are declining.** Following the closure of Sucat, Rockwell, and Manila power plants, there has been a remarkable decline in ambient SO<sub>2</sub> level. Levels of SO<sub>2</sub> at the Ateneo station have consistently been below the guideline (Figure 14).

Figure 13. Source contributions to SO<sub>2</sub> emissions in Metro Manila, 2001 (tons per year)



Notes: Total emissions=176,000 tons; data for area sources extrapolated from 1990 data.  
Source: ADB, 2001.

Figure 14. Sulfur dioxide (SO<sub>2</sub>) trends for air quality monitoring stations in Metro Manila, 1995-2001



Source: DENR-EMB, Central Office/ Manila Observatory, Ateneo de Manila University Campus, Quezon City, 2002.

Table 6. SO<sub>2</sub> Control options and their use in the Philippines

Sources	Control options	Status
<b>a. Stationary</b>		
Power	- Low sulfur fuel - Flue gas de-sulfurization	- Two diesel power plants closed, remaining will be decommissioned by 2010 - Few plants converted to natural gas, while the use of low sulfur coal is increasing - The recently approved Energy Plan proposes to expand natural gas use during the next 10 years
Industry	Same as above	- Few enterprises have installed control measures and are poorly regulated - Availability of natural gas in Southern Luzon will allow replacement of fuel oil and coal with natural gas
<b>b. Mobile</b>		
Trucks/ buses	- Efficient public transport system - Low sulfur diesel	- Sulfur content in diesel reduced from 0.5 to 0.2 percent in 2001 - Functioning Light Rail Transit (LRT) system in Metro Manila, but is only 2 percent of the daily ridership - Introduction of CNG being studied
PUVs	- Use of Compressed Natural Gas (CNG)	

## POLLUTANTS CARBON MONOXIDE/OZONE

### Carbon monoxide (CO)

Carbon monoxide (CO) is a colorless, odorless, tasteless gas, slightly lighter than air. It is formed when carbon in fuel is not burned completely. Once emitted into the atmosphere, CO is oxidized to carbon dioxide (CO<sub>2</sub>). The inhalation of CO can disrupt the supply of necessary oxygen to the blood, causing a major health threat. With prolonged exposure, CO affects the nervous system and can be lethal for people with weak hearts.

**Motor vehicles are the major source.** Almost all the CO emissions in Metro Manila come from vehicles (99.2 percent). Proper maintenance and use of catalytic converters in vehicles will reduce CO emissions by over 90 percent. Recent monitoring of CO in the area shows the concentration to be above the eight-hour guideline value of 10 mg/m<sup>3</sup>, but under the one-hour guideline value of 35 mg/m<sup>3</sup> (Figure 15).

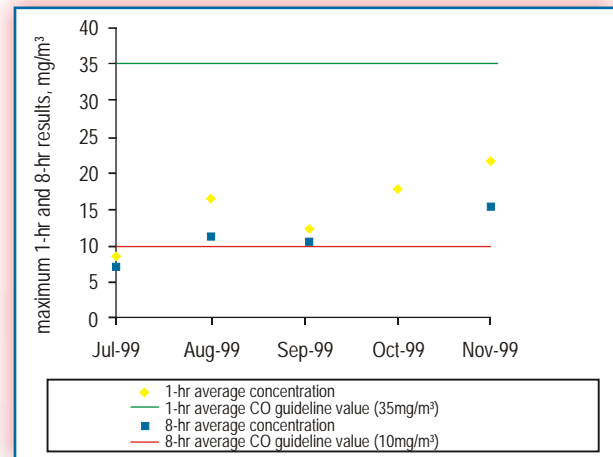
### Ozone (O<sub>3</sub>)

Ozone (O<sub>3</sub>) is a highly oxidizing gas formed by the reaction of VOCs and NO<sub>x</sub> in the presence of sunlight. Ozone can cause a range of acute effects including eye, nose and throat irritation; chest discomfort; cough; and headache. Other effects include pulmonary impairment in children and young adults, and increased incidence of asthmatic attacks and respiratory symptoms, along with damage to materials and vegetations.

Recent results of ozone monitoring at the Ateneo site in Metro Manila show that concentrations are higher than the one-hour guideline of 140 µg/m<sup>3</sup> in seven out of eight months monitored between 2001 and 2002 (Figure 16).

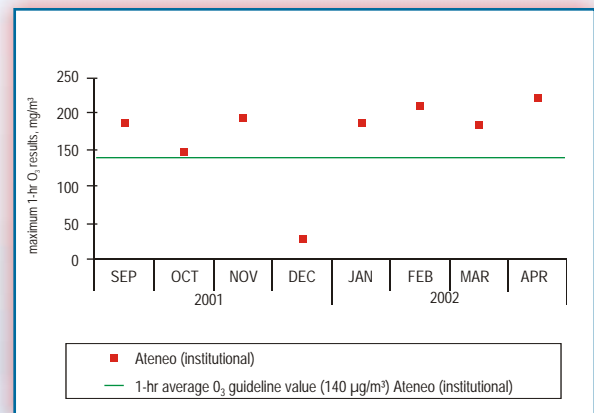


Figure 15. Carbon monoxide (CO) concentration at the Ateneo monitoring station, July-November 1999



Source: Manila Observatory, Ateneo de Manila University Campus /DENR-EMB, Central Office / Electrobyte-Opsis Open Path System, 2001.

Figure 16. Ozone (O<sub>3</sub>) concentrations at the Ateneo Quality Monitoring Station, September 2001-April 2002



Source: DENR-EMB, Central Office/ Manila Observatory, Ateneo de Manila University Campus, Quezon City, 2002.

## POLLUTANTS LEAD

**Lead has been phased-out.** Lead can damage vital human organs and also affect the brain. Among children, prolonged exposure to lead can lead to neurological impairment. The seriousness of the health impacts of lead was recognized around the mid-1990s in the Philippines. In 1993, the President of the Philippines signed a Memorandum of Agreement with three oil companies – Shell, Petron, and Caltex – to reduce, and eventually eliminate, the lead content of gasoline. Lead was eliminated from all gasoline in the Philippines starting in January 2001 (see Box 1).

Although Metro Manila phased out leaded gasoline nine months ahead of the schedule set by CAA, it took longer for the rest of the country to follow. The removal of lead additives from gasoline has the following benefits:

- removes a toxic substance from the environment;
- reduces vehicle maintenance; and
- reduces other pollutants by the use of catalytic converters in vehicles.

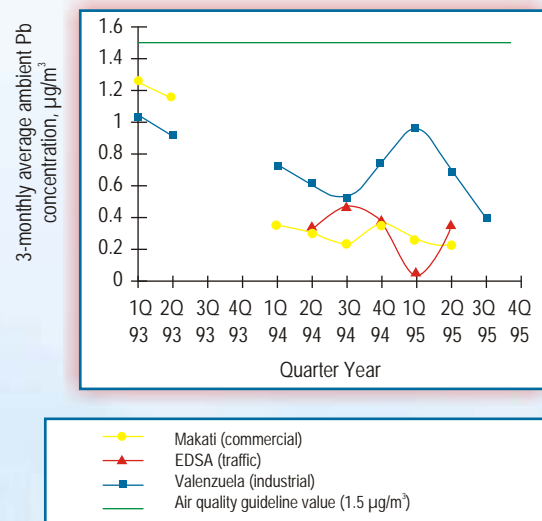
**Ambient lead monitoring discontinued.** Lead concentrations have been slowly decreasing since 1994, and were generally below the air quality guideline of  $1.5 \mu\text{g}/\text{m}^3$  (Figure 17) by 1995. These levels are expected to drop further. However, DENR has discontinued the ambient monitoring of lead.



### Box 1. Lead phase-out in the Philippines

April 1993	Lead content in gasoline was reduced from 0.6 g/l to 0.15 g/l
February 1994	Introduction of unleaded gasoline (ULG)
January 1995	Oil Deregulation Law lowered tax on ULG, and priced it cheaper than leaded-gasoline ULG sales rose
April 2000	Leaded gasoline phased-out in Metro Manila
December 31, 2000	Leaded gasoline completely phased-out in the Philippines

Figure 17. Ambient lead levels recorded at air quality monitoring stations in Metro Manila, 1993-1995



Source: DENR-EMB, Central & NCR Office, Quezon City. 1997.

## POLLUTANTS GREENHOUSE GASES

The Philippines was among the first countries to respond to the United Nations Framework Convention on Climate Change (UNFCCC) in 1991. The Philippines Inter-agency Committee on Climate Change (IACCC), composed of 15 government and non-government representatives, will propose climate change policies, and develop, update, and publish information on inventories of greenhouse gases (GHG).

### Global Warming

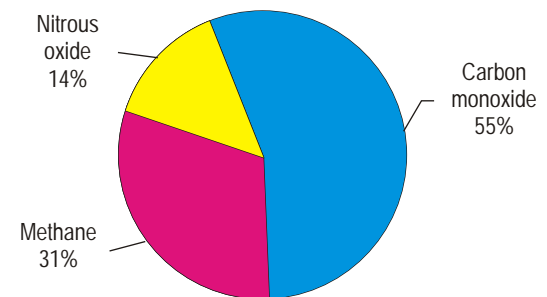
**Energy and transport sectors contribute the most amount of GHG.** Based on 1999 estimates, national GHG emissions are 100,738 gigagrams (Gg or  $10^9$  gram of equivalent  $\text{CO}_2$ ). Of the total GHG emissions, 50 percent are from the energy and transport sector, followed by agriculture (33 percent), industry (10 percent), and solid waste (7 percent). Forest and land use changes contribute 65,000 Gg of  $\text{CO}_2$  but the woody biomass of forests is a major sink for GHG and takes up 68,000 Gg of  $\text{CO}_2$ . This results in an overall reduction of 3,000 Gg of  $\text{CO}_2$  from land use and forestry sector.

Out of the total emission of 100,738,  $\text{CO}_2$  is estimated to be 55,157, methane 31,335, and nitrous oxide 14,246 Gg (Figure 18).

Much of the new power generated in the country will use natural gas, and a number of oil and coal-fired stations are being phased-out. However, with the projected doubling of power generation over the next 10 years, and the continuing high demand for motor vehicles, the energy and transport sectors are likely to remain the major sources of emissions.

The Philippines stands to benefit from the Clean Development Mechanism (CDM) process under the Kyoto Protocol. Opportunities for investments in renewable energy and other  $\text{CO}_2$  reducing activities should be harnessed and promoted with private sector participation. CDM process enables investments at low cost through carbon trading, as well as enables the country to cut-back on both local and global air pollution.

Figure 18. Philippines greenhouse gas emissions, 1999



Total  $\text{CO}_2$  emissions 100,738 gigagrams

Source: Manila Observatory, Ateneo de Manila University Campus, Quezon City, 2001.



## POLLUTANTS OZONE DEPLETING SUBSTANCE

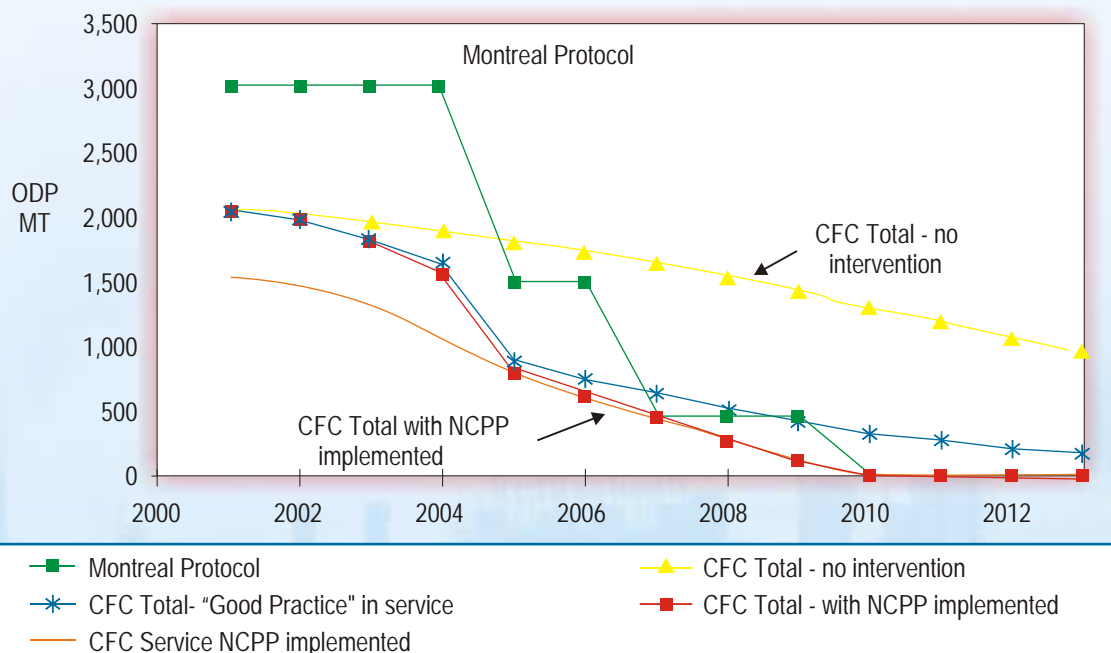
### Ozone-Depleting Substances (ODS)

In 1987, the Philippines adopted the Montreal Protocol (MP), an international convention, which aims to protect the ozone layer in the upper atmosphere. In 1991, the Philippines ratified the MP, in which developed and developing countries agreed on a common strategy to address a global environmental problem.

**Total phase-out of ODS by 2010.** According to the Protocol, ODS consumption in the Philippines must be reduced to 50 percent by 2005, 85 percent by 2007, and 100 percent by 2010 (Figure 19). To meet these targets, US\$23 million has been provided by the Multilateral Fund to replace equipment, hold training programs, and pay extra operating costs. The fund served as a financial mechanism to help developing countries meet the agreed incremental cost of fulfilling the Protocol's control measures.

**Fifty-five percent reduction in ODS consumption.** Most of the ODS used in the Philippines are for servicing existing refrigeration and air conditioning equipment (70 percent), manufacturing foam (23 percent), and refrigeration manufacturing (7 percent). The use of solvents that were once a major source of ODS, has almost vanished, with the help of the multilateral fund described above. Between 1995 and 1999, ODS consumption fell by 55 percent, from 3,625 to 1,640 metric tons. Future reductions to meet phase-out targets may come from the foam and servicing sectors, but these reductions may be more difficult to achieve. A national phase-out proposal that includes a series of investment and non-investment activities including policy and regulatory reforms is currently being formulated to assist the Government in meeting its obligations.

Figure 19. Consumption and projection of ODS use in the Philippines



Note: ODP - Ozone Depletion Potential; CFC - Chlorofluorocarbon; NCPP - National CFC Phaseout Plan  
Source: Annual UNEP draft Report on the status of Montreal Protocol to Ozone Secretariat, 2002.

Detrimental effects of various pollutants include impact on health, productivity, infrastructure, and overall quality of life. As shown in Figure 20, PM<sub>10</sub> contributes the most to health damage, and a significant portion of the non-health cost.

**Fine particles (PM<sub>10</sub>) represent a threat to human health.** Fine particles can penetrate the upper defenses of the respiratory tract and deposit deep in the lungs. Vulnerable groups within the population – children, the elderly, and people with heart and lung diseases – are most at risk.

There are few reliable quantitative environmental health studies conducted for the Philippines. Epidemiological data from hospitals and clinics have not been used to verify health cost estimates that rely on population numbers, ambient measurements, and dose-response equations.

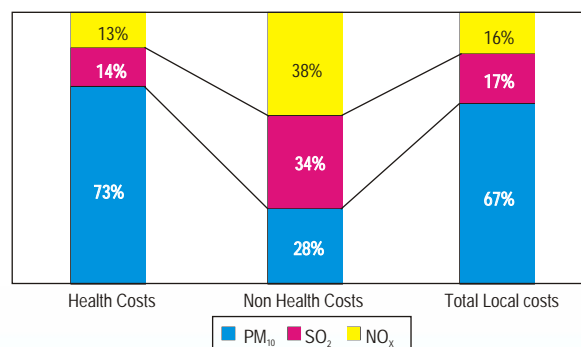
**Valuing the health cost.** An initial analysis of the cost of health impacts of PM<sub>10</sub> in four urban areas of the Philippines – Metro Manila, Davao, Cebu, and Baguio – was undertaken as a background study for this Monitor. Based on earlier international studies, this analysis computed the numbers of excess deaths and incidence of disease due to impacts of pollutants.

Based on the methodology outlined in Box 2, the yearly cost of exposure to PM<sub>10</sub> in the four cities is estimated as follows:

- Over 2,000 people die prematurely. This loss is valued at about US\$140 million.
- Over 9,000 people suffer from chronic bronchitis, which is valued at about US\$120 million.
- Nearly 51 million cases of respiratory symptom days in Metro Manila (averaging twice a year in Davao and Cebu, and five to six times in Metro Manila and Baguio), costs about US\$170 million. This is a 70 percent increase, over a decade, when compared with the findings of a similar study done in 1992 for Metro Manila, which reported 33 million cases.<sup>8</sup>

<sup>8</sup>This is reported in the Philippines Environment Monitor 2000, based on studies of DOH.

Figure 20. Contribution of emissions of various pollutants to local damages from fuel burning in six cities, 1993 (percent)



Source: *Environmental Costs of Fossil Fuels – A Rapid Assessment Method with Application to Six Cities*, by K. Lvovsky et al., The World Bank, 2000.

## Box 2. Methodology for estimating health costs

- An increase in PM<sub>10</sub> concentration by 1 µg/m<sup>3</sup> was estimated to increase mortality rate by 0.084 percent, chronic bronchitis cases to 3.06 per 100,000, and incidence of respiratory symptoms to 18,300 per 100,000 adults.
- Health impacts were estimated by multiplying these dose-response coefficients with exposed populations and the PM<sub>10</sub> levels above the safety threshold of 20 µg/m<sup>3</sup>.
- It is very difficult to put a monetary value on health, and on human life. In the willingness-to-pay methodology in several countries, individuals are asked how much they would be willing to pay to avoid a certain symptom or illness. Per capita incomes were used to adjust the unit values of statistical lives in different cities. The value of statistical life in the four Philippine cities is estimated between US\$25,000 to \$70,000, at lower bounds.
- The unit cost of chronic bronchitis (per person) is estimated at US\$12,750 and respiratory symptoms at US\$3 per incident. The monetary values of the health damages are finally estimated by multiplying the health damages with the unit values.

**An estimated loss of over US\$430 million.** The total cost of the exposure to PM<sub>10</sub> in these four cities alone adds up to over US\$430 million (Table 7). These costs are equivalent to 2.5 to 6.1 percent of per capita incomes in these cities. The population of the four cities represents 28.4 percent of the urban population. If the rest of the country's population is assumed to be exposed to levels similar to those in the four cities, then the urban health cost is extrapolated to be over US\$1.5 billion for the country per year.

**Jeepney drivers and children face the greatest exposure to vehicular pollution.** The University of the Philippines has carried out studies on the impact of vehicular emissions on vulnerable populations in Metro Manila during 1990-91 and 1994. Results showed the prevalence of chronic obstructive pulmonary diseases<sup>9</sup> (COPD) to be highest among jeepney drivers, the most exposed group, at 32.5 percent. Commuters had the lowest prevalence of chronic respiratory symptoms at 14.8 percent. Incidence of pulmonary tuberculosis (PTB) is also highest among jeepney drivers at 17.5 percent, compared to 9 percent for commuters. The prevalence of respiratory symptoms among school children ranged from 4.8 to 27.5 percent and from 15.8 to 40.6 percent among child vendors. A comparison of the pulmonary functions of urban school children with those in rural areas, showed more compromised pulmonary functions for children in Metro Manila.

**The extent of indoor air pollution is yet to be quantified.** Since people spend a large portion of time indoors, poor indoor air quality can cause or contribute to the development of chronic respiratory diseases such as asthma and hypersensitivity pneumonitis (inflammation of the lungs). There are many sources of indoor air pollution: tobacco smoke, cooking and heating, and vapors from building materials, paints, furniture, etc. Studies have found that exposure to high levels of indoor air pollution is increasingly a major health problem in the Philippines (Box 3).

Table 7. Estimates of health impact and costs by PM<sub>10</sub> in four cities for 2001

City	PM <sub>10</sub> Annual average (µg/m <sup>3</sup> )	Population in million	Excess deaths	Chronic bronchitis	Respiratory symptoms in million	Cost in million US\$
Metro Manila	65.8	10.04	1,915	8,439	50.5	392
Davao	39.8	1.018	83	429	2.6	15
Cebu	45.0	0.73	170	336	2.0	16
Baguio	75.2	0.26	49	262	1.6	9
Total	--	12.11	2,217	9,466	56.7	432

Notes:

1. The PM<sub>10</sub> data are from monitoring stations and estimates based on an air quality projection model.
2. Excess deaths, chronic bronchitis, and respiratory symptoms caused by PM<sub>10</sub> are estimated based on simplified methodologies.
3. The total cost of death, chronic bronchitis and respiratory symptoms caused by PM<sub>10</sub> is estimated by first multiplying the unit costs with the respective cases and then adding up the costs for different categories. Since only death, chronic bronchitis and respiratory symptoms caused by PM<sub>10</sub> are included in the health damage estimation, the total costs presented in the above table are only lower bounds of the total costs caused by air pollution.

Box 3. Indoor air pollution: health impact

The Department of Health (DOH) conducted a baseline health profile of communities in Metro Manila during 1999. It covered 108 randomly selected households, in 54 barangays. DOH found that ambient standards for PM<sub>10</sub> were exceeded in 9 out of 19 study areas (47 percent). Indoor monitoring showed that 42 percent of households exceeded the standard. The average hourly levels obtained (209.5 µg/m<sup>3</sup>) are indicative of unhealthy conditions. While vehicular traffic could be a major source, results indicate that smoking inside the house and cooking with kerosene, wood, and charcoal were primary contributors in these households. A similar study in 1995 in urban slums in Metro Manila found similar results.

<sup>9</sup>Chronic obstructive pulmonary disease is manifested by a chronic cough and phlegm, wheezing and shortness of breath.



**Non-health impacts.** While health impacts are no doubt the most compelling reason to take action, the non-health costs of pollution are also significant. These costs include those stemming from congestion and loss of productivity, damage to ecosystems and physical infrastructure. One study estimates that in six cities, including Metro Manila, the non-health costs of  $\text{NO}_x$  and  $\text{SO}_2$  outweigh health costs. In the case of particulate pollution, however, health costs significantly outweigh non-health costs.

Transboundary and global impacts include acid rain, global warming, and damage to stratospheric ozone. In the Philippines, no studies have been done to value these impacts. Typical impacts caused by some of the pollutants are described in Table 8.

Table 8. Non-health impacts of air pollution

Pollutant	Receptor	Impacts
$\text{SO}_2, \text{NO}_x$	Vegetation, materials and structures	- Leaf discoloration, spotting, increased susceptibility to pathogen - Corrosion, deterioration
$\text{O}_3$		- Leaf spotting, flecking - Cracking, fading
PM		- Stunted growth - Soiling, deterioration, fading, chipping