Country Synthesis Report on Urban Air Quality Management

Indonesia

Discussion Draft, December 2006

ADB

CLEAN AIR INITIATIVE for Asian Cities

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Urban Air Quality Management

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Printed in the Philippines.

ADB facilitated this study through its Regional Technical Assistance 6291: Rolling Out Air Quality Management in Asia.

The Study was led by the CAI-Asia Secretariat and the information contained in this report was developed by the CAI-Asia Secretariat with inputs by a range of organizations and air quality experts from across Asia and elsewhere.

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Abbreviations

ADB	Asian Development Bank
API	air pollution index
AQ	air quality
AQM	air quality management
BRT	bus rapid transport
CAI	Clean Air Initiative (for Asian Cities)
CO	Carbon monoxide
GDP	gross domestic product
km	kilometer
km^2	square kilometer
MOE	Ministry of Environment
NO_X	Nitrogen oxide
O_3	ozone
Pb	lead
PM	particulate matter
$PM_{2.5}$	particulate matter with diameter equal or less than 2.5 micrometers
PM_{10}	particulate matter with diameter equal or less than 10 micrometers
RC	regional center
SO_2	Sulfur dioxide
SPM	suspended particulate matter
TSP	total suspended particulate
$\mu g/m^3$	microgram per cubic meter
US	United States (of America)
US EPA	United States Environment Protection Agency
WHO	World Health Organization

Note: "$" means "US dollar" in this publication.

Acknowledgments

This series of country and city synthesis reports (CSRs) is the first time that a comprehensive overview of urban air quality management (AQM) at the country and city—in the case of Hong Kong Special Administrative Region of the People's Republic of China (PRC)—levels has been prepared in Asia. Research compilation for this country and city synthesis reports on Urban Air Quality Management was led by the Clean Air Initiative for Asian Cities (CAI-Asia) Secretariat with inputs by a range of organizations and air quality experts from across Asia and elsewhere, and facilitated by the Asian Development Bank (ADB) through its Regional Technical Assistance No. 6291: Rolling Out Air Quality Management in Asia. The primary authors of the reports are Ms. Aurora Fe Ables, Ms. May Ajero, Mr. Herbert Fabian, and Ms. Ninette Ramirez, all from CAI-Asia, under the supervision of Mr. Cornie Huizenga, Head of Secretariat, CAI-Asia.

The CSRs were prepared with assistance from volunteer authors from the different countries, and facilitated by CAI-Asia local networks in Nepal (Clean Air Network-Nepal), Pakistan (Pakistan Clean Air Network), Philippines (Partnership for Clean Air [PCA]), the People's Republic of China (PRC) (CAI-Asia Project Office), Sri Lanka (Clean Air Sri Lanka), and Viet Nam (Viet Nam Clean Air Partnership). CAI-Asia local networks have also organized a development partners meeting on clean air in the respective countries and city where initial drafts of the CSRs were presented to local AQM stakeholders.

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» Part One

General Information

Geography and Climate

Indonesia is the largest archipelago in the world, consisting of five major islands (Sumatra, Sulawesi, Kalimantan, Java, and Irian Jaya) and an estimated 17,508 islands. The territory of the Republic of Indonesia stretches from 6°08' north latitude to 11°15' south latitude, and from 94°45'–141°05' east longitude with a land area of 2,630 square kilometers (km^2). The capital Jakarta is located in the northeast coast of Java island and covers 661.52 km^2.

The archipelago is almost entirely tropical in climate, with the coastal plains averaging 28°C, the inland and mountain areas averaging 26°C, and the higher mountain regions, 23°C. The area's relative humidity ranges between 70–90%. There are extreme variations in rainfall linked with the monsoons: dry season (June to September) and a rainy season (December to March). Prevailing wind patterns interact with local topographic conditions to produce significant variations in rainfall throughout the archipelago with the western and northern parts of Indonesia generally experiencing the most precipitation. The city of Bogor, near Jakarta, lays claim to having to world's highest number of rainstorms at 322 per year. The islands closest to Australia and the eastern tip of Java tend to be dry, with some areas experiencing less than 1,000 millimeters per year. To complicate the situation, some of the islands of the southern Malukus experience highly unpredictable rainfall patterns, depending on local wind currents (US Library of Congress 2005).

Urbanization and Population

Indonesia is the fourth most populous country in the world (after the People's Republic of China, India, and the United States [US]), with a population of 205.8 million according to the 2000 census. With an estimated 1.3% annual growth rate, the 2004 population has been estimated at 216.4 million and a density of 114 persons per km^2 (Asian Development Bank [ADB] 2005).

Indonesia's capital, Jakarta, is home to 13.2 million Indonesians as of 2005 and is classified as a megacity. The other five most populous cities in Indonesia are Bandung (4.126 million), Surabaya (2.992 million), Medan (2.287 million), Palembang (1.733 million), and Ujung Pandang (1.284 million). The cities of Bogor, Malang, Pekalongan, Semarang, Surakarta, Tegal, and Yogyakarta have less than a million inhabitants each as of 2005. Together, these cities comprise 48.1% of the population in Indonesia. According to the United Nations' (UN) calculations, Indonesia's urban population is forecast to reach 58.5% of the total population by 2015 (United Nations Department of Economic and Social Affairs 2006).

Economy and Industry

Indonesia has a large and diverse industrial sector that includes food, chemical, petroleum, coal, rubber, and plastic product manufacturers. Except for large-scale facilities such as power plants, glass factories, and steel smelting factories, the majority of point source emissions come from boilers, generators, diesel engines, gas turbines, dryers, and incinerators. In 2000, 2,143 other industries were identified as possible air pollution sources in Jakarta. Majority of these industrial sources are textile and wearing apparel, chemicals, petroleum, coal, rubber, and plastic product, food and beverages, paper, and paper products. (Wirahadikusumah 2002)

In particular, Surabaya has a rich history as a competitive industrial city in Indonesia. Its potential has been developed since World War II and during the Netherlands East Indies' rule. Its location has been strategic in establishing heavy or manufacturing industries (Kono 2003). Key industries include shipbuilding, the manufacture of machinery, textile, glass, and metal products and the processing of food and petroleum. Surabaya has adopted a policy that does not allow heavily polluting manufacturers in the city. Middle- and low-emission manufacturers were allowed under the condition that they must be equipped with waste treatment facilities.

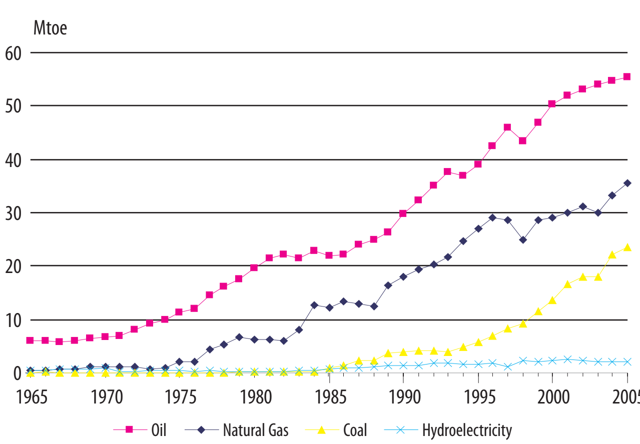
Energy

Indonesia is a large oil and natural gas producing country, and the only Southeast Asian member of the Organization of the Petroleum Exporting Countries. At some point, Indonesia was the world's leading liquefied natural gas and dry gas exporter. In 2004, the country produced 2.8% of the world's natural gas. Although it is only the 8th producer of hard coal (2.8% of world total), it is the 2nd highest exporter of hard coal (14.2%) next to Australia (28.9%) (International Energy Agency [IEA] 2005).

Indonesia consumed 116.4 million tons of oil equivalent (mtoe) of energy in 2005, which accounts for 1% of the world's total energy consumption. This energy demand is supplied largely by fossil fuels such as oil, natural gas, and coal (Figure 1.1). Renewable energy sources supply less than 10% of the energy demand (British Petroleum [BP] 2006).

FIGURE 1.1

Energy Consumption by Source



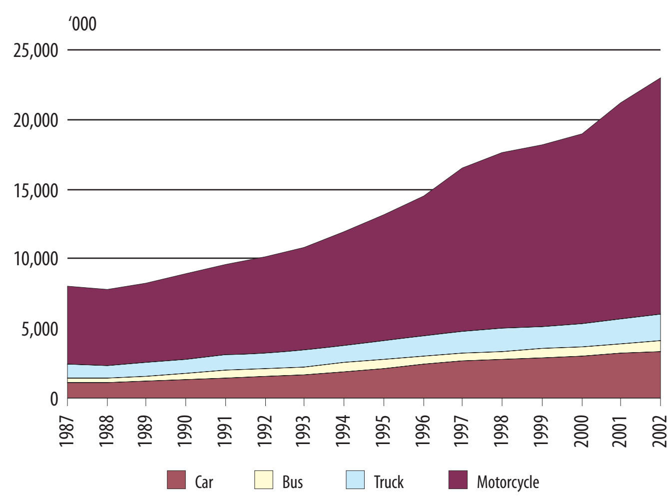
Mtoe = million tons of oil equivalent
Source: British Petroleum. 2006. *BP Statistical Review of World Energy.* June. Available at: www.bp.com/statisticalreview.

Transport

A wide variety of vehicles are used for road transport in Indonesia but the major type of motor vehicle is the motorcycle (Figure 1.2). Vehicle fleet in 2002 was largely dominated by motorcycles (74%) and passenger cars (15%). Vehicle fleet in the country has more than doubled from 10.2 million in 1992 to 23.0 million in 2002. Motorcycles and passenger cars have increased during the same period by 245% and 214%, respectively. By the end of 2005, the Indonesian police headquarters has reported over 35 million units of motor vehicles of which 70.5% were motorcycles. Gaikindo, the association of vehicle manufacturers in Indonesia, posted 2005 sales of new four-wheel motor vehicles at 550,000 units, an increase of approximately 15–20% annually. The Association of Motorcycle Industries Indonesia has likewise posted total sales of 3.4 million motorcycle units—15% lower than that of 2004. If this rate of increase continues, the 2006 end-of-year forecast is approximately 750,000–800,000 units of four-wheeled motor vehicles and 4.0 million units of motorcycles plying the streets of Indonesia (Bakri 2006).

FIGURE 1.2

Motorization in Indonesia



Note: East Timor figures have been excluded from the national totals since 1999.
Source: State Police of Indonesia. Quoted by BPS Statistics Indonesia. Available at: www.bps.go.id/sector/transpor/land/yearly/table3.shtml.

In Jakarta, the total number of motor vehicles in Jakarta has more than doubled from 2,478,934 in 1995 to 5.1 million in 2006 and motorcycles comprise the bulk (Polda Metro Java 2000 and Febrina 2006). Jakarta metropolitan police 2005 data reports that Jakarta has 2.5 million motorcycles, 1.3 million cars, 400,000 cargo vehicles, and more than 250,000 buses (US

Embassy Jakarta 2006). Almost 50% of vehicles registered in Jakarta are motorcycles of which more than 60% are 2-stroke motorcycles. The motorcycle is a popular mode of transport among low- to middle-income Indonesians due to its relatively low cost and easier mobility during traffic jams. Motorcycles are used not only for personal transportation but also for informal-commercial transportation and for the delivery of goods (Wirahadikusumah 2002).

Approximately 71% of Jakarta's citizens use motorized transport and 55% rely on public transport services (ADB 2002). However, the local government of Jakarta has invested a lot of resources in improving public transportation in the last few years. The bus rapid transit (BRT) system called TransJakarta opened in January 2004 to improve public transport and alleviate traffic congestion. It is the 1st closed BRT system in Asia. Three corridors operate: corridor I (Blok M-Kota), corridor II (Pulogadung-Harmoni), and corridor III (Harmoni-Kalideres). Four corridors are under construction and are expected to be launched by January 2007 (Berita Jakarta 2006). Corridor I spans a length of 12.9 km. It uses 56 high-platform air-conditioned Euro 2 compliant diesel buses capable of carrying 83 passengers each. As of 2005, TransJakarta ridership averages 65,000 passengers per day on weekdays and 45,000 passengers per day on weekends. The entire 1st phase of TransJakarta BRT system is planned to have lines along 15 corridors (Wikipedia 2005).

In other cities, like Surabaya, urban transportation modes vary widely from buses, *mikrolets* (small buses that can seat 9–12 people), *bemo* (small van that can carry about 7 passengers), *bajaj* (motor tricycle or rickshaw that can carry 2 passengers), to motorcycles, and *becaks* (nonmotorized three-wheeler). Private motor vehicles including motorcycles often dominate the transport system. In Surabaya, vehicle registration data for 2000 showed that there were 160,902 passenger cars, 126,878 non-passenger cars, 687,790 motorcycles, and 3,017 rickshaws (Hartono 2003).

» Part Two

Sources of Air Pollution

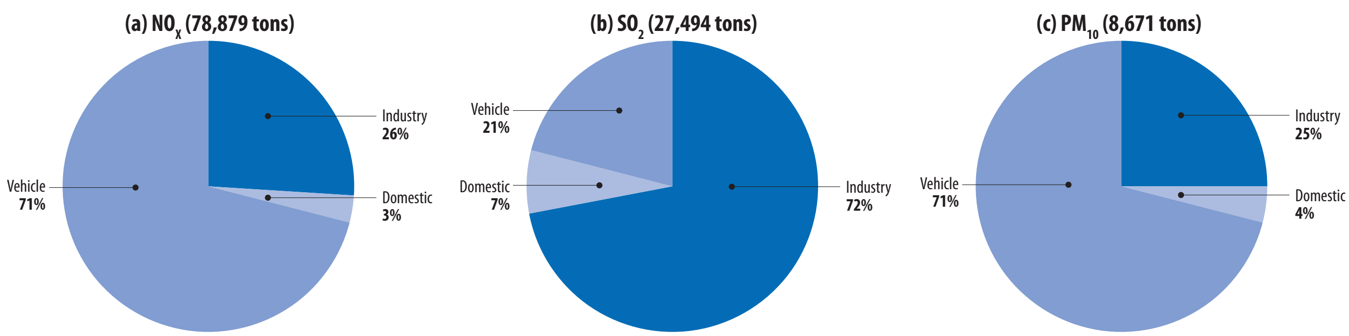
Inventories of emissions from various sources of air pollution in Indonesia are not well established. Although inventories are conducted, there is limited information as to how often these are conducted and reported. Different agencies compile inventories and cover different source categories. For instance, a 1998 emissions inventory in Jakarta (Figure 2.1) covered only the following sources: vehicle, domestic, and industry; whereas, the 1999 emissions inventory for the same city (Table 2.1) covered stationary and mobile sources, industry, and solid waste.

A 1991 estimate of emission levels in Surabaya indicated that more then 95% of Carbon monoxide (CO) and hydrocarbons (HCs) were emitted from the transport sector. Industry was estimated to emit about 40% of NO_X and more than 80% of Sulfur dioxide (SO_2). Other sources of Nitrogen oxide (NO_X) were transport and domestic sources. Domestic sources also emitted a large proportion of particulates.

The Ministry of Environment (MOE) is currently revisiting the methodology and developing technical guidelines to estimate emission loads from motor vehicles. The estimation will use vehicle kilometers traveled (VKT) derived from fuel consumption data. When finished, this methodology will be used by local governments in preparing the local State of Environment report (Syahril 2006 and Harwati 2006).

FIGURE 2.1

Emission Share by Source Type in Jakarta, 1998



NO_x = Nitrogen oxide; PM = particulate matter; SO_2 = Sulfur dioxide

Source: Asian Development Bank. 2002. Action Plan: Integrated Vehicle Emission Reduction Strategy for Greater Jakarta, Indonesia. Prepared by Indonesian Multi-sectoral Action Plan Group on Vehicle Emissions Reduction. Prepared for Asian Development Bank Regional Technical Assistance 5937: Reducing Vehicle Emissions in Asia. July. Available at: www.adb.org/vehicle-emissions/actionindo.asp.

TABLE 2.1

Emission Estimates in Surabaya for 1991 (tons/year)

Pollutant	Transport	Domestic	Refuse burning	Industry	Total
CO	53,051.88	142.48	1,419.32	186.32	**54,800**
NO_X	1,896.71	1,214.18	96.62	2,442.49	**5,650**
SO_2	267.26	1,711.43	16.1	14,105.21	**16,100**
HC	2,202.24	228.16	533.82	135.78	**3,100**
TSP	784.35	3,185.96	532.86	1,722.46	**6,225.63**

CO = Carbon monoxide; HC = hydrocarbon; NO_2 = Nitrogen dioxide; PM = particulate matter; SO_2 = Sulfur dioxide; TSP = total suspended particulate

Source: Soedomo, M., M. Irsyad, M.H. Soejahmoen, A.J. Effendi, and Y. Melianty. 1992. Air pollution status in 5 metropolitan cities: Jakarta, Surabaya, Bandung, Semarang, and Medan, report (in Indonesian). BAPEDAL (Environmental Protection Agency of the Republic of Indonesia) and Lembaga Penelitian ITB (the Institute for Research). Bandung, Indonesia.

» Part Three

Status of Air Quality

Air Quality Monitoring

Monitoring of ambient air quality (AQ) in Jakarta started in 1976 by the Bureau of Meteorology and Geophysics (BMG) for parameters SO_2, NO_2, Ozone (O_3) and suspended particulate matter (SPM). The number of monitoring stations increased to 37 stations in large cities throughout the country that monitor SPM and rainwater. In 1995, with the assistance of the World Meteorological Organization (WMO), an international reference station was installed at Kototabang, Bukit Tinggi that monitors SO_2, NO_2, rainwater, aerosol, ozone surface, black carbon, polyaromatic hydrocarbons (PAH), solar radiation, and meteorology parameters such as wind speed and direction, temperature, and relative humidity (MOE 2005).

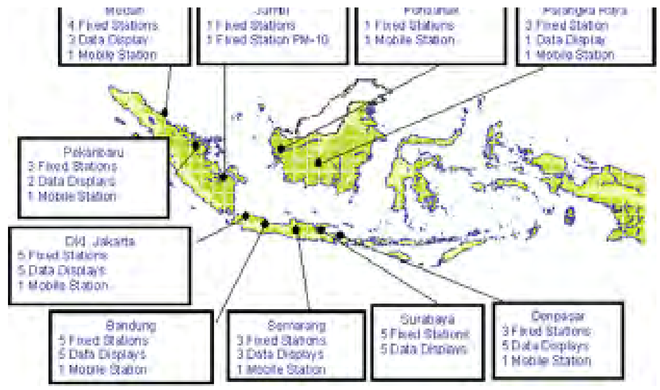
In Jakarta, the monitoring of ambient air by the local government started in 1991 using the manual system. Three years after, in 1994, it used the continuous system. Results of monitoring were not used as inputs to develop policies for air pollution control. MOE started air pollution monitoring activities, including the establishment of a laboratory in 1992 (Tamin 2006).

Through an Austrian loan, the Indonesian government established between 1999 and 2001 a network of ambient AQ monitoring stations in 10 cities. The network consisted of 33 ambient AQ monitoring stations, 9 mobile stations, 8 regional centers, 8 regional calibration centers, 1 main center, and 1 main calibration center in 10 cities in Indonesia: Jakarta, Bandung, Semarang, Surabaya, Denpasar, Medan, Pekanbaru, Palangka Raya, Jambi, and Pontianak. Figure 3.1 shows the location of the stations, a description on the number and type of stations, and the capacity to display results publicly. (Tamin 2006)

This network was installed primarily to provide the public with information on the status of AQ, implement the pollutant standard index (PSI) system, as well as monitor transboundary AQ issues such as forest fires and acid deposition. The stations can monitor the following pollutants NO_2, SO_2, PM_{10}, CO, and O_3, as well as meteorological parameters that include wind direction, wind speed, humidity, solar radiation, and temperature (ADB 2002).

FIGURE 3.1

Location of the Integrated Air Quality Monitoring Stations



Source: Ministry of Energy. 2003. As quoted in Tamin, R., and A. Rachmatunisa. 2004.

The ambient AQ network in each city consists of a monitoring station, meteorology station, a regional center (RC), and data display. RCs operate and maintain the monitoring stations and function as data centers. At each RC, the online data are used to calculate the PSI values, which are then published on data displays to the public. The PSI number provides information about the city's AQ condition with the following index: good, moderate, not healthy, very unhealthy, and dangerous. Furthermore, each RC compiles monthly and annual reports to evaluate AQ status (ADB 2002).

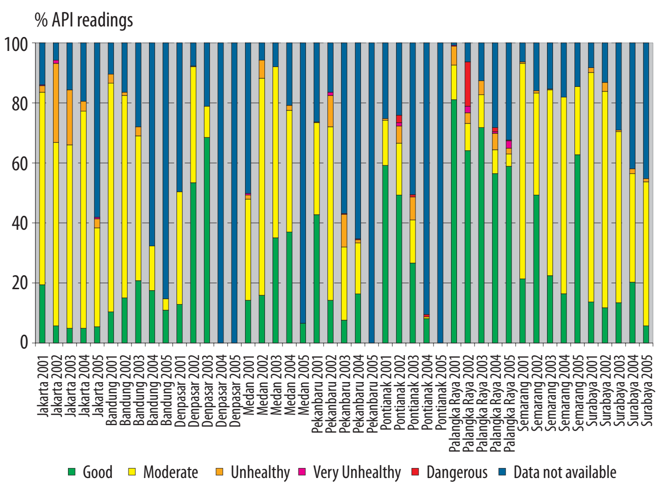
Air Quality Data and Reporting

AQ data in Indonesia are available in two formats, as air pollution index (API) and as ambient air concentration, with the latter being the least available. These are both reported in Indonesia's annual State of the Environment Reports (SLHI) that can be accessed through the internet and on hard copy.[1] Figure 3.2 shows results of AQ monitoring in nine cities through the relative percentages of their API readings.

[1] See www.menlh.go.id/archive.php?action=info&id=25#.

FIGURE 3.2

Percentage Compositions of Air Pollution Indexes for Nine Cities in Indonesia, 2001–2005



API = Air Pollution Index; % = percent

Source: Tamin, R., and A. Rachmatunisa. 2004. For 2001–2003 data. Ministry of Environment. *Status Lingkungan Hidup Indonesia (SLHI) 2004* or Status of Indonesia Environment 2004 for 2004 data; Ministry of Environment. 2005. Indonesia State of Environment Report 2005 (SLHI 2005). Indonesia.

Considering the number of days that cities had good and moderate APIs, five cities showed worsening air pollution as indicated by the decreasing number of "good and moderate" days from 2001 to 2003. On the other hand, Medan is increasingly breathing better air as indicated by increasing number of "good and moderate" days from 2001 to 2003. The remaining three cities did not show one specific trend—Pelangka Raya and Semarang had lesser days of good AQ in 2002, but saw better days in 2003. Denpasar, however, had improved AQ in 2002, but was worse in 2003.

If one takes into account the number of days that cities had "unhealthy to dangerous" AQ levels, no city showed consistent increasing or decreasing trends in "unhealthy to dangerous" days. Eight cities showed an increase of "unhealthy to dangerous" days in 2002, then decreasing in 2003. Only Bandung experienced decrease in "unhealthy to dangerous" days in 2002 and increasing days in 2003. In 2001, there were also no days with "dangerous" categories for all nine cities.

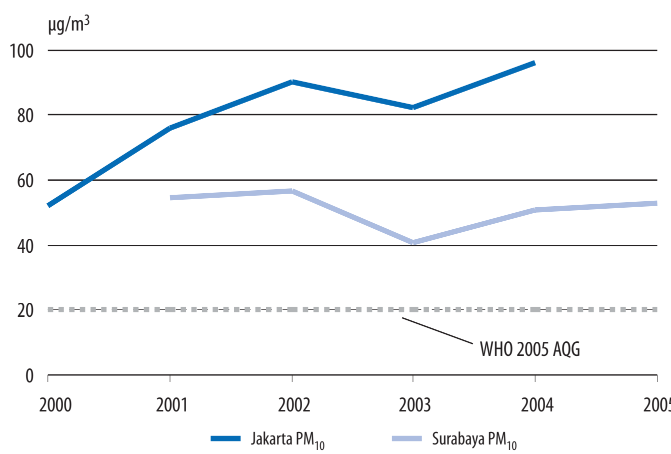
It should be noted that in some instances, the quality of AQ monitoring or results can be considered weak and the number of days without API has consistently increased through the years. In 2005, six out of nine cities had no data for at least half of the year. The significant lack of data limits the capacity to assess the trends of AQ. AQ data in the API format also does not include information on which pollutants are of concern to the specific cities.

As indicated earlier, some cities also make available AQ data in ambient air concentrations. The following describes the status of AQ in Indonesia in terms of PM, NO_X, SO_2, CO, Pb and O_3 for Jakarta and Surabaya.

PM with diameter less than or equal to 10 micrometers (PM_{10}) is monitored. Figure 3.3 below shows the annual average of 24-hour mean concentrations of PM_{10} in Jakarta and Surabaya for 2000–2005 in comparison with WHO guidelines. PM_{10} averages in Jakarta and Surabaya from 2000–2004 exceeded the 2005 update of the WHO air quality guideline (AQG) for PM_{10}.

FIGURE 3.3

Annual Averages of 24-hour Mean Concentrations of PM_{10} in Jakarta and Surabaya



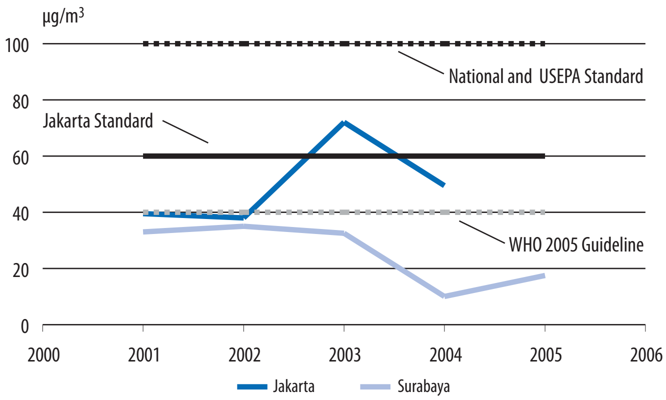
AQG = air quality guideline; PM_{10} = particulate matter with diameter less than or equal to 10 micrometers; WHO = World Health Organization; μg/m³ = micrograms per cubic meter

Source: Data from the Ministry of Environment. 2005. Indonesia State of Environment Report 2005 (SLHI 2005). Indonesia.

NO_2 ambient concentrations for Jakarta and Surabaya show compliance to Indonesia and Jakarta's annual ambient concentration standards, except for 2003 in Jakarta. However, these annual averages would fail to meet the 2005 WHO AQG (Figure 3.4).

FIGURE 3.4

Annual Average NO_2 Concentrations in Jakarta and Surabaya

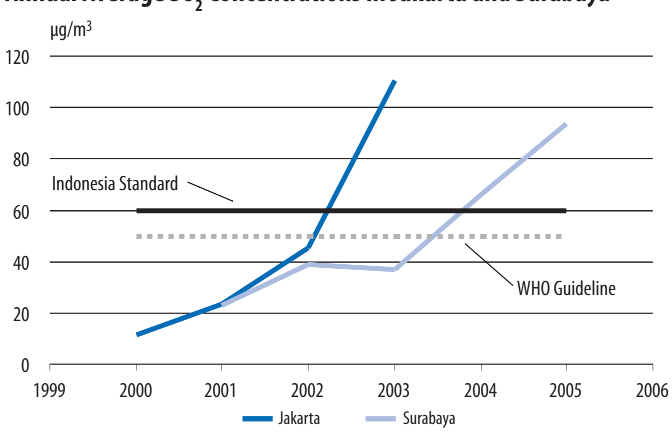


NO_2 = Nitrogen dioxide; US EPA = United States Environment Protection Act; WHO = World Health Organization; µg/m^3 = micrograms per cubic meter
Sources: Jakarta data from Ministry of Environment. 2005. Indonesia State of Environment Report 2005 (SLHI 2005). Indonesia; Surabaya data from Air Laboratory of Surabaya, Environment Department of Surabaya, 2003.

SO_2 annual average concentrations in Jakarta and Surabaya were found to have increased from 2000 onwards, reaching levels exceeding the ambient AQ standards. In Jakarta, the 2000 average ambient level was 11µg/m^3, which more than doubled in 2001 at 23 µg/m^3, increased to 45 µg/m^3 in 2002 and finally reached 111 µg/m^3 in 2003. According to MOE, these data for Jakarta were not accurate since one of the stations had problems that could lead to this being misinterpreted as an alarming increase in SO_2 levels (Rachmatunisa 2004). As for Surabaya, SO_2 levels in 2001–2003 complied with annual standards of 60 µg/m^3, but data from 2004 and 2005 showed noncompliance (Figure 3.5).

FIGURE 3.5

Annual Average SO_2 Concentrations in Jakarta and Surabaya

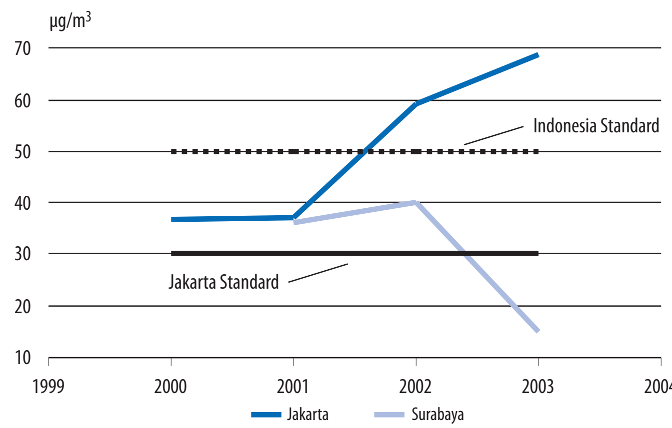


SO_2 = Sulfur dioxide; WHO = World Health Organization; µg/m^3 = micrograms per cubic meter.
Sources: Jakarta data from the Ministry of Environment. 2005. Indonesia State of Environment Report 2005 (SLHI 2005). Indonesia; Surabaya data from Air Laboratory of Surabaya, Environment Department of Surabaya, 2003.

O_3 ambient concentrations in Jakarta have increased from 2001–2003 (Figure 3.6). These concentrations exceeded the 30 µg/m^3 Jakarta limit for annual averages with concentrations in 2003 exceeding the limit more than twofold. Measurements of O_3 in Surabaya for 2001–2003 show the annual levels are also within the standards for 1-year national standard (50µg/m^3). The 2001 ozone level is 36 µg/m^3 and the 2002 level is 40 µg/m^3. The observed annual mean for 2003 of about 15 µg/m^3 seems very low compared to the 2001 and 2002 levels. This merits further clarification of the data.

FIGURE 3.6

Annual Average O_3 Concentrations in Jakarta and Surabaya



O_3 = ozone; µg/m^3 = micrograms per cubic meter
Sources: Jakarta data from the Ministry of Environment. 2005. Indonesia State of Environment Report 2005 (SLHI 2005). Indonesia; Surabaya data from Air Laboratory of Surabaya, Environment Department of Surabaya, 2003.

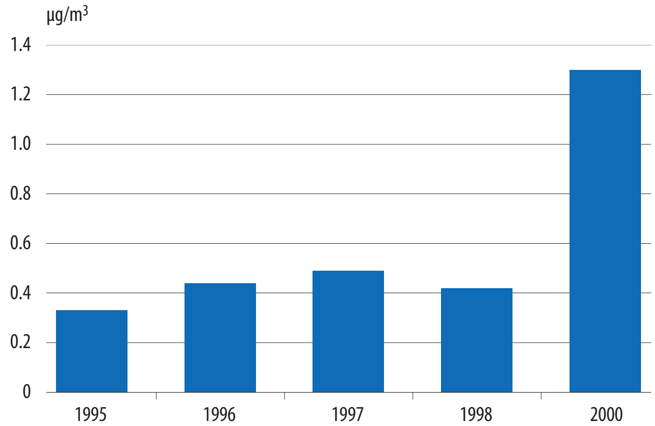
Pb emissions from gasoline have been identified as one of the major threats to Indonesians, especially to children. Atmospheric lead pollution in Jakarta increased from 0.42 µg/m^3 in 1996 to 1.3 µg/m^3 in 2000 (see Figure 3.7). This is attributed to the increase in the number of vehicles as Indonesia's economy recovers. More recent data (Nugroho 2003) reveal a decrease in the average lead concentrations at various sampling locations in Jakarta city (Central, North, East, West, and South Jakarta) and at control sites (Bekasi, Bogor, and Tangerang).

Since gasoline was the primary Pb contributor to ambient air, MOE and *Komite Penghapusan Bensin Bertimbel* (KPBB) in 2006 had conducted fuel quality monitoring in 20 cities from May to August 2006 (Figure 3.8). The fuel quality monitoring activity supplemented the ongoing air pollution control efforts. In terms of Pb levels, the quality of gasoline distributed in Indonesia has improved in 2006, especially with the recent move of Pertamina to remove Pb from all gasoline production starting in July 1 (Huizenga 2006). The 2006 survey showed that the average Pb content in gasoline was 0.038 grams per liter (g/L). Current average Pb levels in gasoline have gone down by 71.43% compared to the 2005 average level of 0.133 g/L. It expected that the Pb concentration in ambient air will decrease further as old stocks of leaded gasoline are used and replaced by unleaded gasoline.

CO, during 2001–2003, the 24-hour levels of CO in Surabaya complied with the standards for 24-hour averaging (10,000µg/m^3). The annual average of 24-hour values for CO were 1,280, 1,180, and 1,090 µg/m^3. These, however, cannot be compared with 24-hour levels for 2001, 2002, and 2003 respectively.

FIGURE 3.7

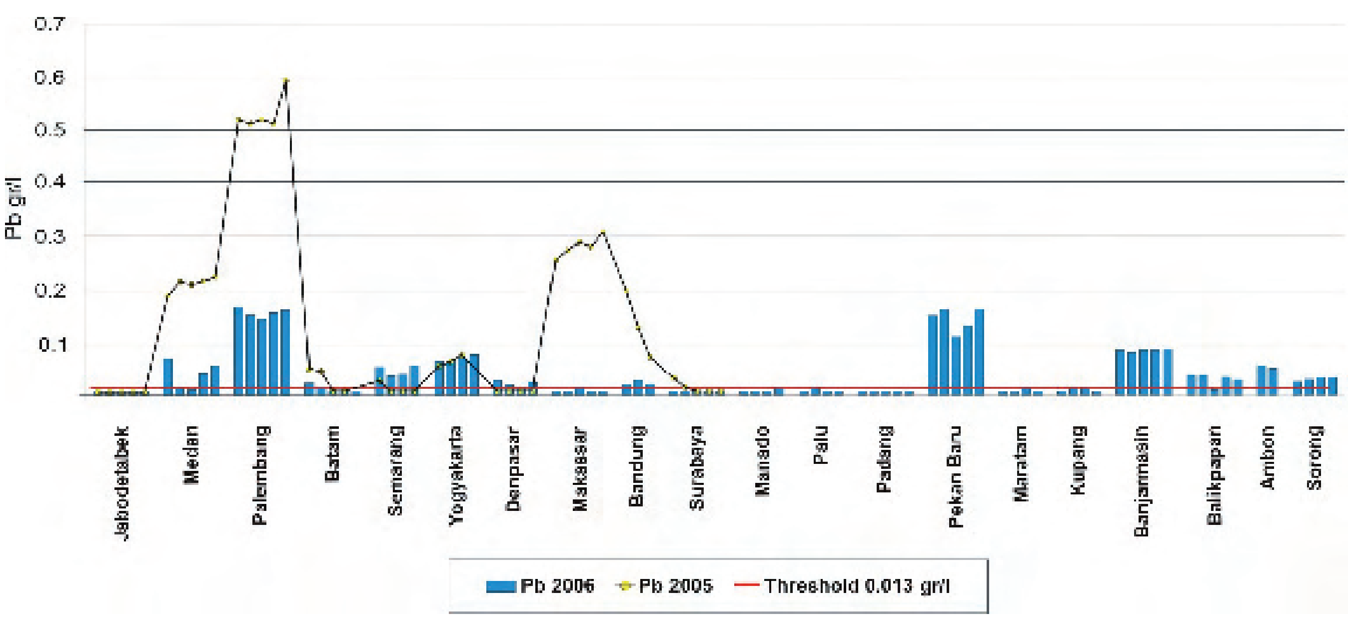
Concentrations of Pb in Jakarta, 1995–2000



Pb = Lead; µg/m^3 = micrograms per cubic meter.
Note: Standard for lead is 1 µg/m^3 as an annual mean.
Source: World Bank. 2003. World Bank Indonesia Environment Monitor 2003. Available at: http://siteresources.worldbank.org/INTINDONESIA/Resources/Publication/03-Publication/indo_monitor.pdf.

FIGURE 3.8

Pb Content of Gasoline in 20 Cities



Pb = Lead; gr/l = grams per liter
Source: Ministry of Environment. Republic of Indonesia and Joint Committee for Leaded Gasoline Phase-out (KPBB). 2006. *Indonesian fuel quality report 2006.* Indonesia.

» Part Four

Impacts of Air Pollution

A number of studies and research have been conducted to facilitate better understanding of the impacts of air pollution on public health as well as on the economy. These studies were conducted either by local researchers from within the country or international researchers from abroad, and focused mostly on Jakarta.

One of the first methods to estimate air pollution impacts on health employed dose-response functions. At the time of study, there was still limited information specific to the tropics, so the studies used dose-response functions derived from epidemiological studies in US cities.

Pb and fine particulate pollution were the major public health concerns in Jakarta. Ambient levels of lead emitted from leaded gasoline posed a significant health threat. However, recent amendments to fuel regulations have led to the phaseout of lead in gasoline, resolving most of the general lead exposure issue.

Aside from estimating the effect of air pollution on public health, some studies also estimate the corresponding costs. In 1994, health impacts due to pollution from vehicle emissions and their corresponding costs were estimated through the 3rd Jabotabek Urban Development Project (JUDP III). Both the health impacts and costs were projected to future levels up to 2005 (see Tables 4.1 and 4.2).

The health impacts and costs of air pollution in Jakarta for PM_{10} and NO_2 in 1998 have been estimated to cost $181 million equivalent to 1% of Jakarta's GDP. This is mainly due to PM, while NO_2 estimates accounts for $4.24 million (see Table 4.3).

TABLE 4.1

Health Impacts Due to Vehicles Emissions in Greater Jakarta

Year	1990	1995	2000	2005
Affected urban population (million persons)	10.9	13.60	16.50	19.90
TSP pollution level (μg/m³)	200	200	200	200
TSP mortality	4,580	5,000	5,450	6,120
Work loss (million days)	15.82	19.74	23.95	28.88
Restricted activity (million days)	30.77	38.39	46.58	56.17
Hospital admissions ('000 cases)	67	84	101	122
Outpatient/clinic visits ('000 cases)	155	194	235	283
Asthma ('000 days)	318	396	312	358
Bronchitis in children ('000 cases)	247	270	312	358
Airborne lead pollution (μg/m³)	1.3	1.3	1.3	1.3
Child IQ decrement (number)	765,000	835,000	965,000	1,106,000

TSP = total suspended particulate; μg/m³ = micrograms per cubic meter
Source: Third Jabotabek Urban Development Project (JUDP III). 1994. Quoted in Asian Development Bank (ADB). 2002. Action Plan: Integrated Vehicle Emission Reduction Strategy for Greater Jakarta, Indonesia. Prepared by Indonesian Multi-Sectoral Action Plan Group on Vehicle Emissions Reduction. Prepared for Asian Development Bank Regional Technical Assistance 5937: Reducing Vehicle Emissions in Asia. July. Available at: www.adb.org/vehicle-emissions/actionindo.asp.

TABLE 4.2

Corresponding Health Cost Estimates Due to Vehicles Emissions in Greater Jakarta (billion rupiah)

Parameter	1990	1995	2000	2005
TSP pollution level (μg/m³)	200	200	200	200
TSP mortality	687.0	750.0	817.5	918.0
Work loss (million days)	98.1	122.4	148.5	179.1
Restricted activity (million days)	24.6	30.7	37.3	44.9
Hospital admissions ('000 cases)	34.8	43.7	52.5	63.4
Outpatient/clinic visits ('000 cases)	5.0	6.2	7.5	9.1
Asthma ('000 days)	1.6	2.0	2.4	2.9
Bronchitis in children ('000 cases)	2.8	3.0	3.5	4.0
Airborne lead pollution (μg/m³)	176.0	192.1	222.0	254.4
Child IQ decrement (number)	1,029.9	1,150.1	1,291.2	1,475.8

TSP = total suspended particulate; μg/m³ = micrograms per cubic meter
Source: Third Jabotabek Urban Development Project (JUDP III). 1994. Quoted in Asian Development Bank (ADB). 2002. Action Plan: Integrated Vehicle Emission Reduction Strategy for Greater Jakarta, Indonesia. Prepared by Indonesian Multi-Sectoral Action Plan Group on Vehicle Emissions Reduction. Prepared for Asian Development Bank Regional Technical Assistance 5937: Reducing Vehicle Emissions in Asia. July. Available at: www.adb.org/vehicle-emissions/actionindo.asp.

TABLE 4.3

Estimated Health Impacts and Costs of Air Pollution in Jakarta, 1998

Health Effects	Number of Cases	Costs ($US million)
PM_{10}		
Premature mortality	3,307	30.94
Restricted activity days	18,194,822	31.94
Hospital admissions	5,905	0.49
Emergency room visits	115,845	1.59
Asthma attacks	1,323,551	3.31
Lower respiratory illness (children)	296,909	0.36
Respiratory symptoms	90,057,542	108.8
Chronic bronchitis	30,118	0.18
NO_2		
Respiratory symptoms	3,506,535	4.24
Total		**181.4**

Source: Syahril, S., B. Resosudarmo, and H.S. Tomo. 2002. Study on Air Quality, Future Trends, Health Impacts, Economic Value and Policy Options, Jakarta, Indonesia. Prepared for the Asian Development Bank. September. Available at: www.adb.org/Documents/Studies/Air_Quality_INO/air_quality.pdf.

Duki et al. (2003) reported respiratory health impacts in a survey of children and their mothers including estimates of health expenditures incurred by the families. They related prevalences of various respiratory symptoms with NO_2 concentrations as an indicator of air pollution in Jakarta and Tangerang, using less exposed parts of Jakarta as control regions. Symptoms were assessed by a standardized questionnaire. Table 4.4 shows prevalence results for children and their mothers, the strength of the correlation between symptom prevalence and NO_2 concentrations, and the costs incurred for the families per event in child or mother. The results showed that mother's respiratory symptoms often occur less than their children's symptoms. Symptom prevalence was found to be related to NO_2 concentrations, except for persistent cough that was associated with smoking and living close to a road.

As indicated, most health impact-studies have been conducted for Jakarta city. No reports on the health and environmental impacts of air pollution in Surabaya, the country's second largest city, appear to exist in the international literature. Surabaya has no official cost figures with regard to the environmental and health effects of air pollution due to air pollution.

TABLE 4.4

Prevalence Rates, Correlation Strengths, and Estimated Costs of Health Impacts

	Prevalence (%)				
Symptoms	Students	Mothers	Correlation with NO_2	Cost per Child and Episode (million rupiah)	Cost per Mother and Episode
Cough§	11.6–41.0	16.5–29.3	**	380–730	320–630
Phlegm§	6.0–36.6	6.0–16.4	*	310–600	290–570
Persistent cough	3.3–18.5	4.0–11.9	–	148–390	85–170
Wheezing§	3.0–17.4	–	***	190–372	–
Asthma	2.0–12.3	0.9–7.9	***	165–320	185–360

NO_2 = Nitrogen dioxide; % = percent

§ without cold; * $p<0.05$; ** $p< 0.01$; *** $p<0.005$

» Part Five

Air Quality Management

Legal Basis and Mandate

The 1997 Government Act No. 23 on Environmental Management and the 1999 Government Regulation No. 44 on Air Pollution Control are the main acts controlling air pollution in Indonesia. The 1997 Act mandates MOE to regulate all aspects of pollution control (including air pollution) and the 1999 Act details the mandate of MOE to set up standards and acceptable practices in air pollution control efforts both for stationary and mobile sources (ADB 2002). Indonesia is currently developing a clean air act that will provide a comprehensive framework on air quality management (AQM).

In Jakarta, the local government has been mandated through Government Regulation No. 25 to implement environmental management at the local level. The Environmental Management Board DKI Jakarta (BPHLD DKI) is responsible for monitoring ambient AQ, including roadside monitoring. Their task also includes the coordination of other agencies on various environmental issues. Other government agencies include the local Communication Office (*Dishub*) through the Traffic and Road Transport Division with a mandate to implement periodic vehicle tests and to manage traffic and transport and the local Development Planning Board (*Bapeda*), which is responsible for planning the region's transport system and integrating this with land use planning.

AQM in Surabaya follows the national policy on environment. However, the city council is preparing a local act for management of AQ. A draft is currently available and will be discussed among related agencies. The draft adopts general issues from the National Air Quality Management Act. A final discussion will be undertaken by the city council before it is implemented. Table 5.1 presents environmental legislation relating to AQM in Indonesia. Local government in Indonesia is responsible for environmental management under Government Regulation No. 25 (2000). Two agencies under the Mayor are involved in AQM in Surabaya. General planning and budgeting is carried out by City Development Planning Board (*Badan Perencanaan Pembangunan Kota* or BAPPEKO), and the implementation of technical AQ programs and activities is undertaken by the Environment Department of Surabaya (*Dinas Lingkungan Hidup Kota Surabaya*/DLH). Overall environmental issues including AQM are coordinated by the City Development Planning Board. DLH and the local government of Surabaya closely coordinate with MOE (Hartono 2003).

Two regulations in the country, Act No. 22 (1999) on Regional Autonomy and Government Regulation No. 25 (2000) on Government Authority and Provincial Authority as Regional Autonomy, determine how AQM is shared between the national and local governments. The national government plays a vital role in establishing legislation, regulations, and guidelines as well as providing human resources development on AQM. Table 5.2 lists the important sectors and their corresponding AQM-related responsibilities.

Act No. 22 (1999) has been replaced by Act No. 32 (2004) on regional autonomy, but nothing has changed on the national Government's role. The AQM roles shared between provincial and regency/municipality still remain unclear.

The local government, on the other hand, executes environmental management as per Government Regulation No. 25 (2000). Some of these offices are listed under Table 5.2 below:

The National Development Planning Board (*Bappenas*) has drafted a national action plan on urban air quality improvement (UAQI) through a technical assistance grant from ADB. A summary of the detailed activities identified in the National Strategy and Action Plan for Air Quality Improvement is found in Box 5.1.

TABLE 5.1

National Government Offices and Their AQM-related Responsibilities

Office	AQM Responsibility
MOE	Assist the President in the formulation and coordination in the field of environment management and control – Presidential Decrees No. 2 (2002). Establish national vehicle emissions standards which conform with international standards.
MoE&MR	The Directorate General of Oil and Gas (Ditjen Migas) under MoE & MR mandates acceptable fuel specifications. The Directorate of Indonesia National Petroleum Research and Development (Lemigas) under MoE&MR conducts research related to fuel quality.
(MoI&T)	Under the MoI&T, the Directorate General of Industry of Metal, Machine, Electronic, and Divers (Ditjen ILMEA) prescribes the vehicle models and technology requirements for vehicle production and importation, issues industrial permits, and provides accreditation and certification to private garages for vehicle inspection and maintenance.
(MoC)	The Directorate General of Road Transportation (Ditjen Hubdat) provides guidelines for type approval tests, and vehicle inspection and maintenance.
State Police	The State police are responsible for enforcing legislation and regulations stipulated by other institutions.
Other national offices with AQM responsibilities include: Ministry of Health, Ministry of Home Affairs and Regional Autonomy	

AQ = air quality management; MOC = Ministry of Communication; MOE = Ministry of Environment; MoE&MR = Ministry of Energy and Mineral Resources; MoI&T = Ministry of Industry and Trade
Source: Asian Development Bank (ADB). 2002. Action Plan: Integrated Vehicle Emission Reduction Strategy for Greater Jakarta, Indonesia. Prepared by Indonesian Multi-Sectoral Action Plan Group on Vehicle Emissions Reduction. Prepared for Asian Development Bank Regional Technical Assistance 5937: Reducing Vehicle Emissions in Asia. July. Available at: www.adb.org/vehicle-emissions/actionindo.asp.

TABLE 5.2

Local Government Offices and Their AQM-related Responsibilities

Office	AQM Responsibility
Local Environmental Management Board	BPLHD DKI is responsible for monitoring ambient AQ. This includes roadside monitoring, establishing vehicle emissions standards, and coordinating sectors and agencies on various environmental issues.
Local Communication Office *(Dishub)*	The Traffic and Road Transport Division (LLAJ) under Dishub has the mandate to implement periodic vehicle tests and to manage traffic and transport.
Local Development Planning Board *(Bapeda)*	Bapeda is responsible for planning the region's transport system, integrated with land use planning.
Other local offices with AQM responsibilities include: Dinas Industri, Dinas Pertamanan, Dinas Tata Kota, and Diskes	

AQ = air quality; AQM = air quality management
Source: Asian Development Bank (ADB). 2002. Action Plan: Integrated Vehicle Emission Reduction Strategy for Greater Jakarta, Indonesia. Prepared by Indonesian Multi-Sectoral Action Plan Group on Vehicle Emissions Reduction. Prepared for Asian Development Bank Regional Technical Assistance 5937: Reducing Vehicle Emissions in Asia. July. Available at: www.adb.org/vehicle-emissions/actionindo.asp.

BOX 5.1

National Strategy and Action Plan for Air Quality Improvement

Strategy to prevent air pollution
The strategy to prevent air pollution is to reduce factors that cause air pollution, increase awareness on air pollution, and promote the involvement of the community and the Government in improving air quality (AQ). Strategic interventions toward the following targets are proposed:
- Deconcentration and planned urban development based on zoning system;
- Integrated transportation system and urban land-use rationalization;
- Promotion of responsible use of motorized vehicles;
- Promotion of energy conservation and the use of alternative fuel; and
- Publicity and information campaign.

Strategy to control air pollution
The strategy to control air pollution is to reduce air pollution at the source by applying clean technology to industries and motorized vehicles; establishing emission standards; improving the transportation and traffic system; and using clear fuels. Proposed strategic interventions to achieve these targets are the following:
- Improvement of fuel quality;
- Application of emission standard;
- Application of effective traffic and transportation management;
- Application of emissions standard for industries; and
- Control of air pollution at the source.

Strategy to monitor exposure
The strategy to monitor exposure to air pollution is to provide information about AQ and emission load at the national and local levels that can be used to evaluate and prepare AQ improvement policies at the respective levels and increase public awareness. Proposed strategic interventions to achieve these targets are:
- Integrated monitoring system of ambient AQ;
- Improved AQ monitoring systems at the national and local levels;
- Preparation of database of sustainable emissions inventory;
- Development of AQ prediction method; and
- Regular dissemination of AQ information.

Strategy to mitigate the impacts of air pollution
The strategy to mitigate the impacts of air pollution involves comprehensive monitoring of health risks of indoor and outdoor air pollution; conducting research on the impacts of air pollution on vegetation, buildings, and economic loss; regularly maintaining heritage buildings and introducing energy-saving and alternative or renewable energy sources. Proposed strategic interventions to achieve these goals are the following:
- Comprehensive surveillance of the risks and health impacts of air pollution;
- Control of air pollution sources that negatively affect vegetation;
- Control of air pollution sources that negatively affect buildings;
- Control of air pollution sources that negatively affect the economy; and
- Mitigation of greenhouse gas emissions.

Strategy to strengthen institutional capacity
The strategy to strengthen the institutional capacity involves the provision of a strong legal basis for the institution concerned for improving urban AQ that covers clear regulation, skilled personnel, funds, and the inter-sectoral coordination mechanism to avoid overlapping tasks and responsibilities. The AQ improvement program can be conducted more effectively under a strong institutional setup. Proposed strategic interventions are focused on the following:
- Establishment of an inter-sectoral coordination team for AQ improvement program;
- Synchronization of regulations and technical guidelines;
- Law enforcement;
- Improvement of local government for urban AQ improvement; and
- Mobilization of funds for AQ improvement

Source: Asian Development Bank (ADB). 2006. Urban Air Quality Improvement (UAQI) National Strategy and Action Plan. Final draft 31 October.

Air Quality Standards and Indices

The 1999 Government Decree No. 41 established the National Ambient Air Quality Standards (NAAQS) (Table 5.3). Under the 2001 Jakarta Governor's Decree No. 551, the city of Jakarta has developed its own set of standards that are stricter than the national standards for some pollutants. Table 5.4 shows that standards for SO_2 and NO_2 are more lenient compared to WHO's guidelines.

Management of Mobile Sources

The current national standards for vehicle emissions at the national level were legislated in the 1993 MOE's Decree No. 35

TABLE 5.3

PM_{10} Exceedance Days in DKI Jakarta, 2001–2003

Location	Year	Number of Exceedance Days/ Year	Number of Observation Days/Year	Data Capture/ Year (%)	% Exceedance/ Observation Days
JAF1	2001	5	362	99.20	1.38
JAF1	2002	15	329	90.10	4.56
JAF1	2003	5	277	75.90	1.81
JAF3	2001	0	29	7.90	0.00
JAF3	2002	2	331	90.70	0.60
JAF3	2003	0	124	34.00	0.00
JAF4	2001	1	111	30.40	0.90
JAF4	2002	6	232	63.60	2.59
JAF4	2003	1	326	89.30	0.31
JAF5	2001	0	155	42.50	0.00
JAF5	2002	3	340	93.20	0.88
JAF5	2003	0	266	72.90	0.00

TABLE 5.4

Indonesia and Jakarta's Air Quality Standards Compared to WHO Guidelines

Pollutant	Average Time	Jakarta	National	WHO 2005 Update
SPM	24-hour	230	230	–
	1-year	90	90	
PM_{10}	24-hour	150	150	50
	1-year	–	–	20
SO_2	1-hour	900	900	–
	24-hour	260	365	20
	1-year	60	60	–
NO_2	1-hour	400	400	200
	24-hour	92.5	150	–
	1-year	60	100	40
O_3	1-hour	200	235	–
	8-hour	–	–	100
	1-year	30	50	–
Pb	1-year	–	1	–
CO	1-hour	26,000	30,000	–
	8-hour	–	–	–
	24-hour	9,000	10,000	–

CO = Carbon monoxide; O_3 = ozone; NO_2 = Nitrogen dioxide; Pb = lead; PM_{10} = particulate matter with diameter less than or equal to 10 micrometers; SO_2 = Sulfur dioxide; SPM = suspended particulate matter; WHO = World Health Organization; µg/m³ = micrograms per cubic meter
Note: Values are based on the atmospheric conditions at 25°C and pressure 1 atm.
Source: Asian Development Bank (ADB). 2002. Action Plan: Integrated Vehicle Emission Reduction Strategy for Greater Jakarta, Indonesia. Prepared by Indonesian Multi-Sectoral Action Plan Group on Vehicle Emissions Reduction. Prepared for Asian Development Bank Regional Technical Assistance 5937: Reducing Vehicle Emissions in Asia. July. Available at: www.adb.org/vehicle-emissions/actionindo.asp.
Syahril, S., B. Resosudarmo, and H.S. Tomo. 2002. Study on Air Quality, Future Trends, Health Impacts, Economic Value and Policy Options, Jakarta, Indonesia. Prepared for the Asian Development Bank. September 2002.
Available at: www.adb.org/Documents/Studies/Air_Quality_INO/air_quality.pdf.
World Health Organization. 2005. WHO Air Quality Guidelines Global Update 2005 Meeting Report. Bonn, Germany. 18–20 October. Available at: www.euro.who.int/Document/E87950.pdf.

on motor vehicle exhaust emissions standards. The legislation stipulates the permissible limits for CO and HCs for gasoline-fuelled motorcycles and vehicles and black smoke for diesel-fuelled vehicles. CO and HC are measured at idle conditions and smoke is measured at free acceleration (ADB 2002).

MOE's Decree No. 05/2006 regulates motor vehicle exhaust emissions standards. CO and HC are measured at idle conditions and opacity is measured at free acceleration. These standards are applied to regular inspection throughout Indonesia. (Harwati 2006)

There are plans to strengthen and revise the national emissions standards such that they become equivalent to international standards. The proposed standards were planned to be strengthened in three phases: Step 1, from 2001–2003; Step 2, from 2000 –2006; and Step 3, beyond 2007. Step 2 of the planned emissions standards was equivalent to Euro 1, while Step 3 was equivalent to Euro 2 standards (ADB 2002). Step 1 of this plan was not enforced as scheduled, but MOE has issued The State MOE Decree No. 141/2003 concerning Emission Standards for New Type Motor vehicle and Current Production, a notice of the enforcement of Euro 2 type approval standards that took effect in 2005. The standards were decreed by MOE on 13 October 2003 (Tamin and Rachmatunisa 2004 and Harwati 2006).

In Jakarta, the standards for in-use vehicles are stricter than those of the national Government as notified under the 2001 Governor of DKI Jakarta Decree No. 1041. This legislation was implemented to support the development of the inspection and maintenance system for private passenger vehicles in Jakarta. National and local standards specify the emissions standard based on the production year and vehicle technology (ADB 2002 and Harwati 2006).

In 2000, the Local Government of Jakarta has introduced an inspection and maintenance (I&M) program that requires all vehicles to comply with emission quality standards. It stipulates that the inspection and maintenance system will use a decentralized system, involving the private sector with the local government as the facilitator (Tamin and Rachmatunisa 2004 and World Bank 2003). Results from voluntary I&M program in DKI Jakarta showed substantial reductions of CO (±50%), HC (±35%), and opacity (±45%) emissions from failed vehicles which underwent necessary repair (ADB 2006).

The 1999 Ministry of Energy and Mineral Resources Decree (No. 1585/K/32/MPE) required phaseout of lead in gasoline for the whole country by 1 January 2003. From July 2001, unleaded gasoline has been available to residents of greater Jakarta. Four other areas now supply the same unleaded gasoline and these are: Cirebon and vicinity (October 2001); Bali (January 2003); Batam (June 2003); and Surabaya (September 2005). In 1 July 2006, Pertamina stopped the production of leaded gasoline in the country (Huizenga 2006). Unleaded gasoline is expected to be available to more areas with the proposed onset of private sector suppliers (Tamin 2006).

Management of Stationary Sources

Legislation addressing stationary sources in Indonesia includes MOE Decree No. Kep-13/MENLH/3/1995 and the BAPEDAL (Environmental Impact Management Agency) Decree No. Kep-205/BAPEDAL/07/1996. The main difference is that the BAPEDAL decree provides the technical guidelines regarding the emissions standards for stationary sources.

Based on 1995 Decree No.13, five types of emission standards were established for stationary sources of air pollution. The standards were applied to sectors of iron and steel, pulp and paper, cement, and coal-fired power, with all other industries grouped as "other industries." All standards have been applied since May 1995 and stricter emission standards were implemented from the 2000 onwards. Indonesia intends to improve the regulation to become twice as strict for almost all parameters (GEF 1998). The latest addition on emissions standard for stationary sources is the State Minister for Environment Decree No. 129 on exploration and production in oil and gas industry, released in 2003.

Area Sources

Haze due to forest fires has affected Indonesia as well as the neighboring countries of Malaysia and Singapore, especially during 1997 and 1998. Severe semi-annual forest fires occur in Sumatera and Kalimantan. Aside from severe droughts induced by the El Niño phenomenon, factors that contribute to forest fires include human error, limited resources (trained fire fighters, funds, facilities, and infrastructure), and weak law enforcement. Indonesia is the only member of the Association of Southeast Asian Nations (ASEAN) that has yet to sign the association's agreement on haze pollution that crosses borders.

Public and Nongovernment Participation

The private sector is required to comply with government policies and regulations on fuel supply, motor vehicle production, the development of technology, infrastructure provision, and the implementation of vehicle I&M. Several state-owned enterprises have been mandated with special duty, such as the state-owned mining and oil company's (Pertamina) control of oil and gas business prior to Act No. 22 (2001), and the state-owned gas company (PGN) overseeing the supply and distribution of gas. Other private sector groups involved in AQM include: Association of Motorcyle Assemblers and Manufacturers, Association of Automotive Workshops, Association of Indonesian Automotive Industries, and the Indonesia Petroleum Association.

The role of civil society is to raise the public's awareness and to stimulate government to act on AQ issues. Universities, on the other hand, conduct research and studies in support of emission reduction strategies. Active civil society groups and the academe in Indonesia include: Pelangi of the Institute of Technology in Bandung, Joint Committee for Leaded Gasoline Phaseout (KPBB), Universities of Gajamada, Indonesia, and Atmajaya.

» Part Six

Conclusion

Increased levels of urbanization and motorization have resulted to corresponding increases in energy consumption and vehicular emissions. Particulate matter, the regional haze problem, and possibly O_3 and SO_2 appear to be the primary challenges for Indonesia's AQ. However, the poor quality of information produced by AQ monitoring makes any current assessment tentative. Adequate assessment of sources, trends effects on health and the environment, and assessment of policy initiatives are highly dependent on AQ monitoring data of adequate quality.

Even if AQ information was reported on a more regular basis through APIs, there still is a need to compile, analyze, and make available AQ data in original concentrations to allow analyses of the status of each major air pollutant.

The past 5 years have shown limited improvement in AQ monitoring, but the recent increase of AQ-related regulations that address mobile and stationary sources, as well as the current measures to develop a comprehensive clean air act and mobile emissions inventory methodology, has shown some promise toward better AQM.

An effective countrywide AQM system is needed in Indonesia. Although improvements have occurred in recent years, and AQ-related activities in different sectors (such as removal of Pb from gasoline) are being initiated, an integrated framework for AQM is needed if AQ is to be significantly improved. AQ monitoring and the compilation of emissions inventories remain as weaknesses. There is also a need to conduct further studies to understand the impacts of air pollution on health and the environment, to guide policy development

The active participation of the general public in putting AQ policies forward both on a local and national level continues to be an asset and has helped the Government in the eventual phaseout of leaded gasoline production and in building capacity through multi-stakeholder programs and activities.

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