Country Synthesis Report on Urban Air Quality Management

Pakistan

Discussion Draft, December 2006

ADB

CLEAN AIR INITIATIVE for Asian Cities

Pakistan Clean Air Network

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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

$\mu g/m^3$	micrograms per cubic meter
ADB	Asian Development Bank
AQ	air quality
AQM	air quality management
Btu	British thermal unit
CAI–Asia	Clean Air Initiative for Asian Cities
CDG	City District Governments
CNG	compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
ENERCON	National Energy Conservation Centre
EPA	Environmental Protection Agency
FERTS	Fuel Efficiency in Road Transport Sector
GDP	gross domestic product
GEF	Global Environment Facility
IAEA	International Atomic Energy Agency
I&M	inspection and maintenance
JICA	Japan International Cooperation Agency
km	kilometer
km^2	square kilometer
ktoe	kilotons of oil equivalent
LPG	liquefied petroleum gas
MoE	Ministry of Environment
NEAP	National Environmental Action Plan
NGO	nongovernment organization
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxide/s
NWFP	North–West Frontier Province
O_3	Ozone
PAH	polyaromatic hydrocarbons
PCAP	Pakistan Clean Air Programme
PEPC	Pakistan Environment Protection Council
PM	particulate matter
PM_{10}	particulate matter with a diameter not more than 10 microns
$PM_{2.5}$	particulate matter with a diameter not more than 2.5 microns
ppb	parts per billion
ppm	parts per million
RON	Research Octane Number
SO_2	Sulfur dioxide
SO_x	Sulfur oxide/s
SPM	Suspended Particulate Matter
SUPARCO	Pakistan Space and Upper Atmosphere Research Commission
toe	tons of oil equivalent
TSP	total suspended particulates
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USEPA	United States Environmental Protection Agency
VOC	volatile organic compounds

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

Acknowledgments

This series of country reports is the first time that a comprehensive overview of urban air quality management (AQM) at the country level has been prepared in Asia. Research compilation for this country synthesis report (CSR) 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 in the respective countries a development partners meeting on clean air where initial drafts of the CSRs were presented to local AQM stakeholders.

For the Pakistan Country Synthesis Report, CAI–Asia extends its sincerest thanks to Director Zia Ul Islam of the Pakistan Environmental Protection Agency for reviewing the report and providing additional information. Mr. Mohammad Aqib, Coordinator of the Pakistan Clean Air Network; Mr. Ahmad Saeed of the World Conservation Union (IUCN); and Mr. Hassaan Ghazali, Research Analyst, Urban Unit of the Government of Punjab, have been instrumental in coming up with a first draft of the report and for providing additional information.

CAI–Asia would like to thank ADB for facilitating the research, and especially to Mr. Masami Tsuji, Senior Environment Specialist; Dr. David McCauley, Senior Environmental Economist; and Mr. Nessim Ahmad, Director—all from the Environment and Social Safeguard Division, Regional and Sustainable Development Department—for providing guidance. Ms. Glynda Bathan, Mr. Michael Co, Ms. Agatha Diaz, and Ms. Gianina Panopio of CAI–Asia are also acknowledged for their logistical and technical support for the CSR team.

CAI–Asia and the respective country Ministries of Environments reviewed the volume—with technical review inputs from Prof. Frank Murray of Murdoch University. Ms. Agnes Adre and Ms. Ma. Theresa Castillo copyedited this series of country reports. Mr. Segundo dela Cruz, Jr. handled the graphic design and the layout.

» Part One

General Information

Geography and Climate

Pakistan is divided into four major provinces that generally correspond to the major geographical formations in the country: the North–West Frontier Province (NWFP) in the highlands up north bordering Afghanistan and the People's Republic of China; the Balochistan Plateau; and Punjab and Sindh Provinces in the plains divided by the Indus River. These plains are the most fertile and also the most densely populated area in Pakistan.

The country has a wide altitudinal variation spanning a number of ecological regions ranging from coastal ecosystems; deserts; floodplains; and mountains, such as the Himalayas and Hindu Kush ranges, covering an area of 796,095 square kilometers (km^2). The climate is generally arid, characterized by hot summers and cool winters, and wide variations between extremes of temperatures at given locations. Pakistan has four seasons, with temperatures ranging from 0°C to 32°C, which to some extent influence the movement of air pollutants. Wind speed, which is essential for flushing air pollution, is low in its major cities. In the dry and low wind days, natural dust and anthropogenic pollution takes longer time to disperse (Pakistan EPA 2005).

Population and Urbanization

Pakistan's population was estimated at 148 million in July 2004, with a population density of 187 persons/km^2. Its urban population, estimated at 33.5%, makes Pakistan one of the most urbanized countries in South Asia (ADB 2005). The most populated cities in Pakistan are Karachi and Hyderabad in Sindh Province; and Lahore, Faisalabad, and Rawalpindi in Punjab Province. Quetta and Peshawar, the capitals of Balochistan and NWFP, respectively, have relatively fewer people compared with the other major cities.

Karachi has an estimated population of 11.97 million people, with a density of 3,394 persons/km^2, while Lahore has 6.49 million people, with a density of 6,396 persons/km^2 in 2006. Karachi became the capital of Pakistan when the country gained independence in 1947 and, as a result, achieved faster rates of urbanization compared to the other cities. The port of Karachi and the nearby port of Qasim have substantially contributed to the growth of the city and its economy. Karachi is considered as the financial center of Pakistan (Wikipedia 2006b,c).

With rapid growth and the concentration of activities and investments in Karachi, the Government felt the need to establish a new capital where government agencies and function can be concentrated. In 1960, the capital was transferred to Islamabad, which is located immediately north of Rawalpindi. Urban growth in Islamabad was slow at first, but began to pick up when all the major government buildings were built in the 1980s. Islamabad's close proximity to Rawalpindi (about 5 kilometers [km]) has resulted in strong linkages among its urban services and a larger conurbation.

Economy and Industry

Pakistan's economy grew, from 2002 to 2004, as a result of changes in government policies and the resumption of international lending. The country's gross domestic product (GDP) achieved record growth rates, accompanied by buoyant levels of investment and sustainable fiscal balances. Its GDP growth rate has increased, from a low of 1.9% in 2001, to a high of 8.4% in 2005 (ADB 2006). Pakistan is considered as one of the fastest-growing economies in the Asian region. This high growth rate translates to high level of demand for mobility and services in its major urban areas. It has also fueled rapid changes in consumer spending patterns. In particular, the middle class is becoming an increasingly dominant force.

Per capita income, defined as gross national product at market price divided by the country's population, grew by an average of 13.9% in the last 4 years—from $582 in 2002–2003 to $847 in 2005–2006 (MoF 2006).

The major industries in Pakistan are on textiles, cement, fertilizer, steel, sugar, electric goods, shipbuilding, and the automobile manufacturing industry. Karachi and Lahore have emerged as the cities with the most number of industrial activities. Karachi is home to the busiest port in Pakistan, which produces substantial number of activities and trade and contributes 65% to the country's GDP (Wikipedia 2006b). The industries are located mostly in the provinces of Punjab and Sindh, which have 53% and 37%, respectively, of the 4,753 industrial facilities in Pakistan. These facilities are found within and around the periphery of its major cities.

Despite the devastating earthquake in the northern part of Pakistan on 8 October 2005 and the extraordinary surge in oil prices, consumer spending remained buoyant, with investors remaining upbeat on the strength and sustainability of its growth. The key drivers of this growth had been the service and industry. The construction industry continued to show strong performance, partly due to the activity in the private housing market, spending on physical infrastructure, and reconstruction activities in the earthquake-affected areas (MoF 2006).

Agriculture remains as the country's principal industry, accounting for more than 60% of exports and 25% of GDP (Pakistan EPA 2006). However, recent statistical information on GDP output by sector shows a decrease in the annual percentage change for agriculture—from 4.1 in 2003 down to 2.6 in 2004—while the industry sector accounted for an annual percentage change from 5.8 in 2003 to 13.1 in 2004 (ADB 2005). The manufacturing industry is the second largest sector of the economy, accounting for 18.2% of GDP (MoF 2006).

Energy

Pakistan's energy consumption has nearly tripled in the last 20 years, from 0.6 quadrillion British thermal units (Btu) in 1980 to 1.9 quadrillion Btu in 2001. One quadrillion Btu is equal to about 45 million tons (t) of coal, or 1 trillion cubic feet (TCF) of natural gas, or 170 million barrels of crude oil (Wilcoxen 2006). Pakistan accounts for less than 0.5% of the world's total energy consumption. Pakistan's per capita energy consumption was 12.9 million Btu in 2001 (Pakistan EPA 2005).

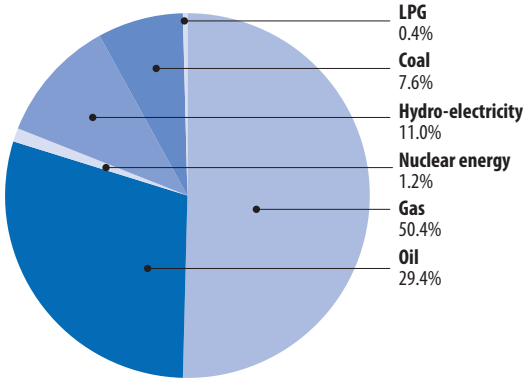
The total primary energy consumption in Pakistan is estimated at 60 million t of oil equivalent (toe), with 70% based on the use of hydrocarbons (Pakistan EPA 2005). Natural gas and petroleum are the main sources of energy for Pakistan, accounting for 50% and 29%, respectively. Figure 1.1 shows the shares of different energy sources in the country for 2004–2005. The use of petroleum products has shown a declining trend since 2000. This is mainly due to the Government's efforts to promote local compressed natural gas (CNG) and liquefied petroleum gas (LPG) for use in the transport, agriculture, and power sectors because of the high costs of imported oil. Natural gas and LPG consumption have increased by an average of almost 16% in the period 2003 to 2005. Imported oil accounts for 82% of the total oil consumed while indigenous natural gas accounts for 50% of the total gas consumed (MoF 2006).

To increase usage of indigenous resources, the Government of Pakistan is putting a lot of efforts to attract local and foreign investors in the exploration, production, and exploitation of natural gas and oil in the country. Although Pakistan has 26.8 TCF of proven gas reserves, it currently produces only 0.8 TCF of natural gas per year, all of which is domestically consumed.

Pakistan's demand for natural gas is expected to rise substantially in the next few years, according to the Ministry of Petroleum and Natural Resources, because of its plans to make natural gas the "fuel of choice" for future electric power generation projects (Pakistan EPA 2005).

FIGURE 1.1

Primary Energy Supplies in Pakistan by Source, 2004–2005



Source: Hydrocarbon Development Institute of Pakistan (HDPI) in MoF (2006).

Transportation

Road transport is the backbone of Pakistan's transport system. It has played a substantial role in the economic growth currently experienced by the country, contributing 10% to its GDP and 20%–25% of Federal Public Sector Development Programme (PSDP) in recent years (World Bank 2006). Passenger and freight traffic have grown much faster than the country's economic growth in recent years. With the country's booming economy, continued investments in the transport sector are expected over the next years.

Pakistan's road traffic has been growing at an average annual rate of 14.1% during the 20-year period between 1985 and 2005. Pakistan Railways' freight traffic, on the other hand, declined by 48%, from 11.8 million t in 1985 to 6.1 million t in 2005. Rail passenger traffic stagnated during this period and, as a result, all the growth was handled by the road sector, which now carries more than 95% of the inland freight (273 million t/year) and 90% of the passenger traffic. Pakistan has about 4.9 million vehicles on the road, whose number is growing by about 8% annually. The road transport industry is deregulated and predominantly in the private sector (World Bank 2006).

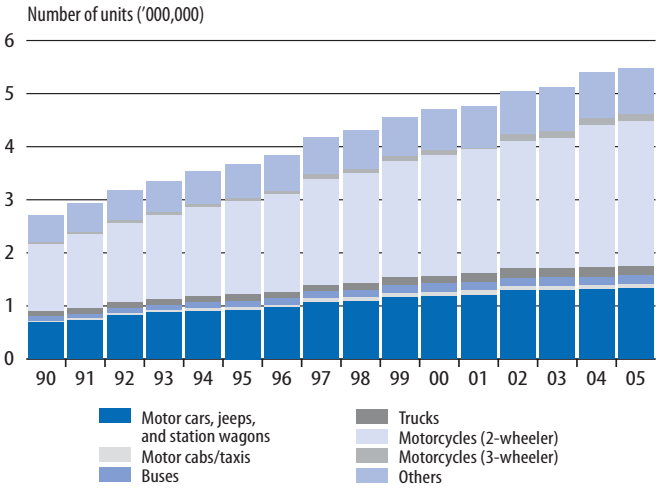
Urban transportation systems in Pakistani cities are characterized by the dominating presence of colorful auto-rickshaws, known locally as *rickshahs*; colorful buses and trucks; and cars. To a certain extent, bicycles are still being used for daily commuting but mostly only by the poorer sector of the society (Wikipedia 2006).

Public transportation is generally poor in Pakistan. The number of intercity minibuses is insufficient to handle the passengers in Pakistani cities and its levels of service are found to be very low and often unattractive toward the public. Because of this, the general public has found stronger preference to travel within the city using rickshaws, motorcycles, and cars.

Figure 1.2 shows the number of registered motor vehicles in Pakistan. The country's vehicle fleet has doubled from about 2.7 million in 1990 to about 5.4 million in 2005. The biggest share of motor vehicles (about 80%) is from cars and motorcycles, most of which are privately owned and operated. The fastest growth has been seen in two-wheelers, a large part of which are running on 2-stroke engines. The number of diesel trucks and buses has also increased up to three times in this period (Pakistan EPA/World Bank 2006). The increase in the use of 2-stroke motorcycles and three-wheelers poses a major concern for most Pakistani cities because of their high rates of emissions.

FIGURE 1.2

Number of Registered Motor Vehicles in Pakistan



Source: Pakistan EPA/World Bank (2006).

Owing to the vast reserves and availability of natural gas in Pakistan, the Government has adopted several measures in promoting its use in the transport sector. Apart from reducing the dependence on imported petroleum products, air pollution issues have also driven the Government to promote CNG for transportation. The Government has implemented a price differential between CNG and motor gasoline tariffs as an incentive for CNG usage.

Pakistan is the largest CNG-using country in Asia and the third largest in the world. In 2005, there were 700,000 CNG vehicles in the country, the majority of which are converted gasoline vehicles. The number of CNG refueling stations was 766 in 2005 (ANGV 2006). Several initiatives at the local government level have been geared toward replacing 2-stroke gasoline rickshaws to CNG in order to reduce air pollution in the urban area.

» Part Two

Sources of Air Pollution

The major sources of air pollution in Pakistani cities are combustion of fossil fuels from vehicles, factories, and power plants. However, there are no emissions inventories that show the estimated air pollutant emissions from these sources. The Government does not conduct regular emissions inventories in the cities.

The air pollution problem is aggravated by the aging fleet of vehicles in poor mechanical condition and low levels of fuel efficiency. The increasing number of diesel trucks has further added to the problem. According to the Pakistan Environmental Protection Agency (EPA), a major share of the emissions load from motor vehicles, although not quantified, can be attributed to a relatively small number of smoky diesel and 2-stroke vehicles found in many Pakistani cities (Pakistan EPA/World Bank 2006).

The high levels of sulfur in automotive diesel (0.5%–1%) and furnace oil (1%–3.5%) is seen as a major contributor to Sulfur dioxide (SO_2) and particulate matter (PM) in ambient air. Emissions from large-scale facilities, such as cement, fertilizer, sugar, steel, and power plants, many of which use furnace oil; and a wide range of small- to medium-scale industries (including brick kilns, steel rerolling, steel recycling, and plastic molding) cause a disproportionate share of pollution through their use of dirty "waste" fuels, such as old tires, paper, wood, and textile waste. Industrial emissions are further compounded by the widespread use of small diesel electric generators in commercial and residential areas in response to the poor reliability of electricity supplies (Pakistan EPA/World Bank 2006).

The burning of municipal solid waste is also a significant source of air pollution in the urban area. Almost 48,000 t of solid waste is generated each day, most of which is either dumped in low-lying areas or burned. The burning of solid waste at low temperatures not only generates PM, but also produces other carcinogenic pollutants (Pakistan EPA/World Bank 2006).

One source apportionment study conducted by the Pakistan Institute of Nuclear Science and Technology investigated the composition of PM in Nilore, an industrial area in Islamabad. The analysis showed high levels of heavy metals, particularly antimony (Sb), in the samples, both for PM_{10} and $PM_{2.5}$. The International Atomic Energy Agency cites motor vehicle emissions, paints, coal and refuse combustion as the probable source of antimony (Ahmad 2004).

» Part Three

Status of Air Quality (State)

Air Quality Monitoring System

There is no air quality monitoring network in place in Pakistan. Most of the available air quality monitoring data is done on an ad hoc/commercial basis mostly by the Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) and the Japan International Cooperation Agency (JICA) in cooperation with the Ministry of Environment (MoE) and Pakistan EPA. There is also some ad-hoc monitoring of air quality from other projects conducted by the Pakistan Atomic Energy Agency (PAEC) and the Pakistan Council of Scientific and Industrial Research (PCSIR).

Air Quality Data

The limited air quality data available for Pakistani cities makes it quite difficult to provide a conclusive remark on the major pollutants of concern in Pakistan. However, several of these ad-hoc studies on air quality in Pakistani cities have shown that PM and Nitrogen oxides (NO_x) are above the WHO guideline values.

Pakistan EPA, in cooperation with JICA, carried out in 2000 an initial investigation of the air pollution in Pakistan and assessed the ambient air quality in Lahore, Rawalpindi, and Islamabad. Air quality sampling was conducted using a mobile station that measured hourly concentrations of air pollutants from 0700 to 2400 taken on different days in April and May 2000. The concentrations of Suspended Particulate Matter (SPM), $PM_{10,}$ and lead (Pb) were found to have greatly exceeded the WHO guideline values. The average SPM for the three cities was 2,000 µg/m³, while PM_{10} averaged 700 µg/m³ (Pakistan EPA/JICA 2001). The new WHO guidelines limit for 24-hour monitoring of PM_{10} is set at 50 µg/m³. There is no guideline value for SPM under the new guidelines set by WHO (WHO 2005). The only guidelines for SPM or total suspended particulate (TSP) matter from WHO was last issued in 1979, and the guidelines for 24-hour monitoring ranged from 150 µg/m³ to 230 µg/m³.

The ambient concentrations of SO_2, NO_x, and Carbon monoxide (CO) were, on average, found to be within the limits in the WHO guidelines of 2000. Table 3.1 shows the hourly average data of PM_{10}, SO_2, CO, NO_x, and Ozone (O_3).

TABLE 3.1

Hourly Average Ambient Concentrations of Air Pollutants in Pakistani Cities in 2000

Item	Lahore	Rawalpindi	Islamabad
PM_{10} hourly average data in µg/m³	895.00	709.00	520.00
SO_2 hourly average data in ppb	44.60	30.70	28.50
CO hourly average data in ppm	2.82	1.83	1.55
NO_x hourly average data in ppb	156.60	74.70	148.50
O_3 hourly average data in ppb	8.50	17.00	10.00

Source: Pakistan EPA/JICA, 2001.

A study investigating air quality was conducted by SUPARCO under the ENERCON/UNDP Fuel Efficiency in Road Transport Sector (FERTS) from 2003 to 2004 for the cities of Karachi, Lahore, Peshawar, Quetta, Rawalpindi, and Islamabad. Using mobile stations, data were collected usually along roadside and measured every hour on various dates in 2003 and 2004. The climatic conditions when the data were sampled are shown in Table 3.2.

Similar to those of the Pakistan EPA/JICA study conducted in 2000, the results of this study showed high levels of PM_{10} exceeding WHO 2005 guideline values (20 µg/m³) for all the cities. The highest levels were recorded in Lahore and Quetta, reaching almost 260 µg/m³ and 290 µg/m³ average hourly concentrations, respectively. Figure 3.1 shows the 48-hour averages of PM_{10} for the six cities included in this study.

TABLE 3.2

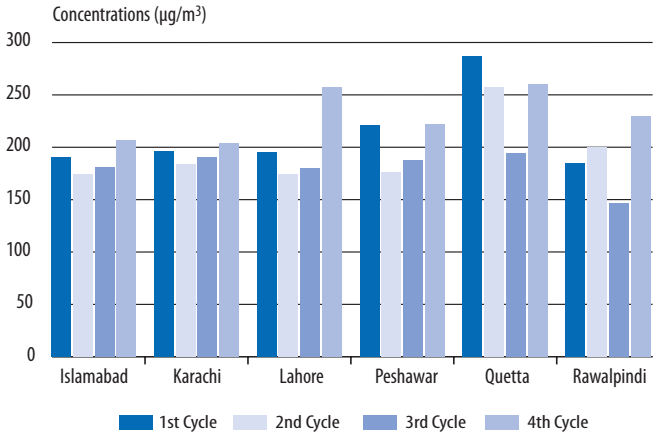
Climatic Conditions for the Four Cycles

	2003		2004	
City	1st Cycle	2nd Cycle	3rd Cycle	4th Cycle
Islamabad	Monsoon	Winter	Spring	Summer
Karachi	Postmonsoon	Winter	Spring	Summer
Lahore	Monsoon	Postmonsoon	Spring	Summer
Peshawar	Monsoon	Winter	Spring	Summer
Quetta	Summer	Postmonsoon	Winter	Spring
Rawalpindi	Monsoon	Postmonsoon	Winter	Summer

Source: Pakistan EPA/ World Bank (2006).

FIGURE 3.1

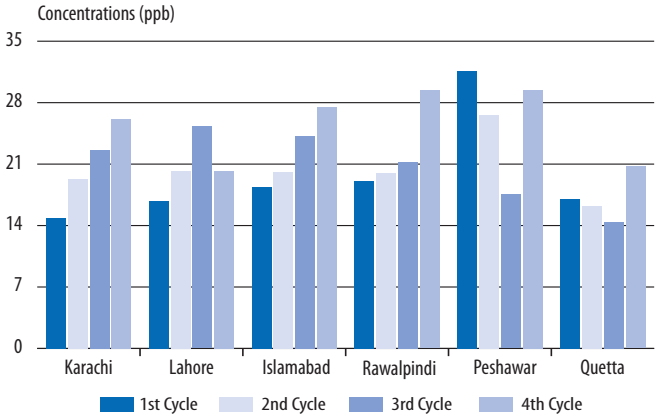
48-hour Mean of PM_{10} in Major Pakistani Cities



Source: SUPARCO (2005).

FIGURE 3.2

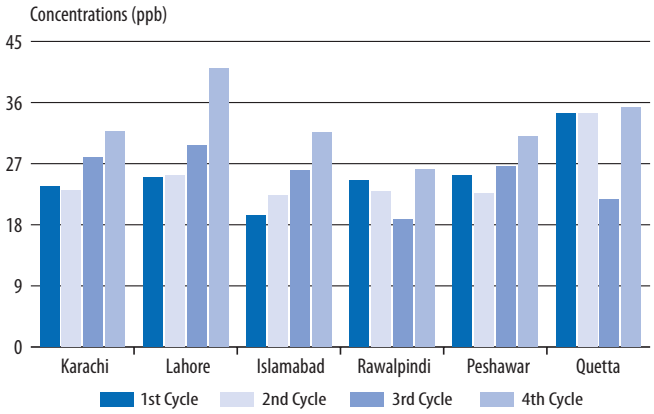
48-hour Mean of SO_2 in Major Pakistani Cities



Source: SUPARCO (2005).

FIGURE 3.3

NO_x Levels in Major Pakistani Cities



Source: SUPARCO (2005).

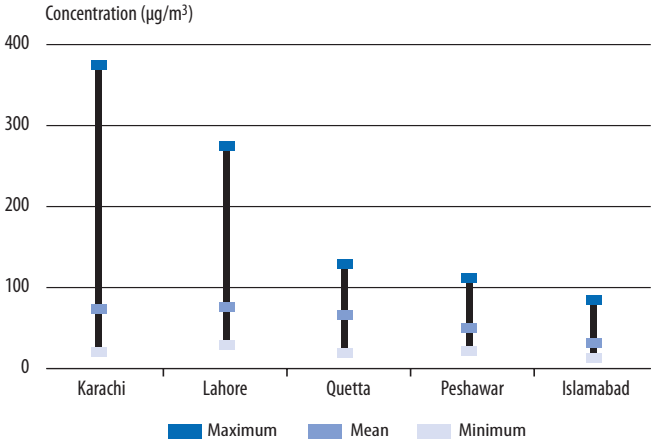
Figure 3.2 shows the ambient levels of SO_2 observed from these six cities, which were found to also exceed WHO guideline values, with Quetta posting the highest average concentrations. The new WHO guideline values (2005) specifies the limit for 1 year averaging at 20 µg/m³ or 7.56 parts per billion (ppb). Ambient levels of NO_x were also included in the study as shown in Figure 3.3. Internationally, standards are only set for Nitrogen dioxide (NO_2); hence, it is difficult to assess the seriousness of NO_2 pollution in these cities. Fortunately, in another study conducted jointly by Pakistan EPA and JICA in 2005, levels of NO_2 were included in the assessment.

The ambient concentrations of NO_2 are shown in Figure 3.4. Karachi had the highest or maximum recorded levels followed by Lahore, Quetta, Peshawar, and Islamabad. Average concentrations showed that Karachi and Lahore have similar concentrations at 76 µg/m³. The average concentrations of NO_2 in Quetta, Peshawar, and Islamabad were 69.50 µg/m³, 47.28 µg/m³, and 30.41 µg/m³, respectively. The safe level of long-term exposure to NO_2 is set by WHO at 40 µg/m³ for 1-year monitoring, while for short-term monitoring (1 hour), the threshold is set at 200 µg/m³. The lowest recorded level of NO_2 (11.65 µg/m³) was found in Islamabad in the residential area along embassy road, while the highest recorded level (399.65 µg/m³) was found at Karimabad Junction in Karachi (Lodhi 2006).

Ambient ozone (O_3) concentrations in these Pakistani cities were found to be within the standards set by WHO (as shown in Figure 3.5).

FIGURE 3.4

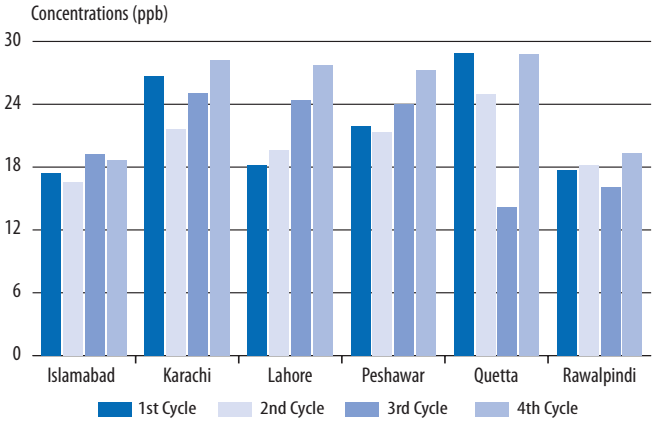
Ambient Levels of Nitrogen Dioxide in Different Cities in Pakistan



Source: Lodhi (2006).

FIGURE 3.5

O_3 Levels in Major Pakistani Cities



Source: SUPARCO (2005).

» Part Four

Impacts of Air Pollution

The most recent study on the impacts of PM on health in Pakistan conducted by the Pakistan EPA and the World Bank showed that it causes 22,000 premature deaths in adults and 700 in children annually. The total health costs is estimated between Rs62 billion to Rs65 billion (about US$1.09 billion[1]) or approximately 1% of the gross domestic product (Pakistan EPA/World Bank 2006).

In terms of annual Disability Adjusted Life Years (DALYs) lost, mortality accounted for an estimated 60%, followed by respiratory symptoms. The bulk of losses were due to adult premature mortality, which was consistent with evidence from other assessments that found adults to be more vulnerable to respiratory symptoms and in greater danger of lung cancer (Pakistan EPA/World Bank 2006).

In 2002, a medical study investigated the impact of environmental pollution on the health of nearly 1,000 traffic policemen. Results showed that about 80% of the traffic policemen had chronic ear-nose-throat (ENT) problems and 40% showed signs of lung problems (some of which developed into asthma and tuberculosis). Due to the nearly 10-hour job on the road amidst smoke and blowing horns, almost 90% showed symptoms of irritability and tension; 45% of the cases (ranging from 35 to 50 years of age) suffered from hypertension (Pakistan EPA 2005).

The incidence of the so-called "winter fog" phenomenon in Pakistan, which is a cocktail of toxic gases and particulates, has contributed to economic losses, aggravating respiratory and cardiovascular diseases, as well as increased cardiac arrest rates. One study in 2002 estimated that approximately 16.28 million people—about 40% of the total urban population in Pakistan—are exposed to this "fog" and have health implications amounting to Rs25.7 billion per year (Pakistan EPA 2005).

[1] 1 US$ = 59.73051 Pakistan rupee on average in 2005 (www.oanda.com).

Pakistan had high levels of lead in gasoline prior to its nationwide ban in 2002. Various studies conducted in Pakistani cities, such as Peshawar, Karachi, Islamabad, and Chakshahzad, in the 1990s showed high levels of lead in blood of students. In Karachi, 98% of the children studied had blood lead levels (BPbLs) of more than 20 µg/dl compared to only 32.6% in Peshawar. The higher traffic activity in Karachi and exposure of the students were identified as the main reason for this difference. In the two schools where BPbLs were investigated in Karachi, the average was 38.2 +/- 7 µg/dl and ranged from 10.4 µg/dl to 52.2 µg/dl, which was considerably higher than the acceptable 10 µg/dl BPbL. As expected, samples in Chakshahzad showed low levels and within safe limits—the average BPbL was 2.38 µg/dl and ranged from 0.2 µg/dl to 8.6 µg/dl. BPbLs in Islamabad ranged from 13 µg/dl to 32µg/dl and averaged 22.8 +/- 3.3 µg/dl (Khwaja 2003). Unfortunately, there are no studies available that investigated BPbLs after lead was completely banned in gasoline in Pakistan.

TABLE 4.1

Annual Costs of Health Impacts of Ambient Particulate Air Pollution (Billion Rs)

Health End-Points	Attributed Total Cases	Total Annual Costs
Premature mortality: adults	21,791	58–61
Mortality: children under 5	658	0.83
Chronic bronchitis	7,825	0.06
Hospital admissions	81,312	0.28
Emergency room visits/ outpatient hospital visits	1,595,080	0.80
Restricted activity days	81,541,893	2.06
Lower respiratory illness in children	4,924,148	0.84
Respiratory symptoms	706,808,732	0.00
Total		**62–65**

Source: Pakistan EPA/World Bank (2006).

» Part Five

Air Quality Management

Legal Basis and Mandate

The fundamental environmental legislation in Pakistan is the Environmental Protection Act of 1997 (PEPA), which superseded the Pakistan Environmental Protection Ordinance of 1983. The Act establishes the general conditions, prohibitions, and enforcement for the prevention and control of pollution, and the promotion of sustainable development. The Act also establishes and delineates the powers and functions of the Pakistan Environmental Protection Council (PEPC), Pakistan EPA, provincial Environmental Protection Agencies (EPAs), and Environmental Tribunals. In particular, the Act creates the authority for the delegation of environmental management functions to the provincial EPAs (Pakistan EPA/World Bank 2006).

Air quality management in Pakistan is handled at the national, provincial, and district (city) levels. At the national level, Pakistan EPA is responsible for setting air quality and emissions standards and for defining associated systems for monitoring and enforcement. However, ambient air quality standards and comprehensive vehicle emissions standards have yet to be promulgated by the Pakistan EPA. As a result, even if the four provincial environmental protection agencies have the authority to provide their own ambient air quality standards and emissions standards, these legislations have not been made.

Provincial Local Government Ordinances promulgated in 2001 have devolved administrative, legislative, and fiscal powers to City District Governments (CDG). Although the Local Government Ordinance gives CDGs wide legislative powers, these are not widely exercised to manage air quality in the municipality but focus on municipal services delivery, revenue collection, and other fiscal and administrative issues. An Environment Cell headed by the District Environment Officer has been created within the CDG Municipal Services Department in Lahore to deal with air pollution problems in the city (Ghazali 2006).

The 2001 National Environmental Action Plan (NEAP), which was approved by PEPC, included air pollution in its core programs. Some key objectives, including the introduction of unleaded gasoline and a reduction of sulfur in diesel, were achieved. However, a number of initiatives are still to be undertaken. To consolidate ongoing and proposed initiatives for the management of urban air quality, MoE has developed the Pakistan Clean Air Programme (PCAP), which highlights the four major sources of urban air pollution that need to be addressed: (i) vehicular emissions, (ii) industrial emissions, (iii) burning of solid waste, and (iv) natural dust. It incorporates a range of short- and long-term actions to be adopted by all levels of government and by a variety of agencies (Pakistan EPA/World Bank 2006). Table 5.1 shows the various measures (categorized as short- and long-term measures) and responsible agencies identified by the Pakistan EPA for the implementation of PCAP.

The cities of Lahore in Punjab Province and Karachi in Sindh Province have been at the forefront in improving urban air quality. Both cities have established Clean Air Commissions involving high-level representatives from the city and national government and other stakeholders and headed by the City mayor. Box 5.1 outlines the history and development of the Lahore Clean Air Commission and the proposed action plan.

TABLE 5.1

Proposed Measures to Address Air Pollution in Pakistan in PCAP

Short-term Measures	Responsible Agencies	Long-term Measures	Responsible Agencies
General Air Quality Management			
Baseline data collection on ambient air quality using fixed and mobile laboratories	Federal and Provincial EPAs	Creation of public awareness and education	Ministry of Environment and Provincial Environment Department
Launch of effective awareness campaign against smoke-emitting vehicles	Provincial Governments	Setting up continuous monitoring stations in cities to record pollution levels in ambient air	Ministry of Environment and Provincial Government
Reducing Emissions from Mobile Sources			
Stop import and local manufacturing of 2-stroke vehicles	Ministry of Commerce and Ministry of Industry	Improvement of energy efficiency in vehicles and industry	Ministry of Environment
Restriction on conversion of vehicles from gasoline engine to second-hand diesel engines; launch effective awareness campaign against smoke-emitting vehicles	Provincial Governments	Introduction of low-sulfur diesel and furnace oil and promotion of alternative fuels, such as CNG, LPG, and mixed fuels, in the country	Ministry of Petroleum and Natural Resources
High pollution spots in cities may be identified and control through better traffic management, such as establishment of rapid mass transit and traffic-free zones	Provincial Governments	Review Motor Vehicle Ordinance to provide for inspection of private vehicles	Federal and Provincial Governments
Capacity building of Motor Vehicle Examiners	Provincial Governments	Establish vehicle inspection centers	Ministry of Communication and Provincial Government
Regular checking of quality of fuel and lubricating oils sold in the market	Ministry of Petroleum and Natural Resources	Identify pollution control devices/ additives for vehicles and encourage their use	Ministry of Environment and Ministry of Petroleum
Phasing out of 2-stroke and diesel- run public service vehicles	Federal and Provincial Governments		
Giving tariff preference to CNG-driven buses	Ministry of Industries and Ministry of Finance		
Adoption of fiscal incentives and a financing mechanism to provide resources to transporters	Ministry of Communication and Provincial Government		
Establishment of environmental squad of traffic police in all major cities to control visible smoke	Provincial Governments		
Reducing Emissions from Stationary			
Covering of buildings/site during renovation and construction to avoid air pollution	Provincial Governments	Promotion of waste minimization, waste exchange, and pollution control technology in industries	Federal and Provincial EPAs, Federation of Pakistan Chamber of Commerce and Industries and Ministry of Industries and Production
Reducing Emissions from Area Sources (Open Burning) and Dust			
		Proper disposal of solid waste in cities/ provinces	Capital Development Authority and Provincial Governments
		Block tree plantation in cities, forestation in deserts and sand dune stabilization	Ministry of Environment and Provincial Forest Department
		Paving of shoulders along roads	Ministry of Communication and Provincial Government

Source: Adapted from Pakistan EPA, Pakistan Clean Air Program (2006); Pakistan EPA/World Bank (2006).

In 2007, continuous air quality monitoring stations will be set up in Karachi, Lahore, Peshawar, Quetta, and Islamabad with support from JICA. This is part of the agreement between the Government of Pakistan and Japan to implement the "Establishment of the Environmental Monitoring System in Pakistan" in 2003. This includes the setting up of seven air quality monitoring stations in five major cities of Pakistan (Pakistan EPA/World Bank 2006).

BOX 5.1

Lahore's Initiatives to Improve Air Quality

In 1997, some concerned residents of Lahore filed a public interest environmental litigation against the growing menace of vehicular air pollution at the Lahore High Court. After almost 6 years (in 2003), the case came out of hibernation when Mr. Justice Sair Ali of the Lahore High Court took it as a high-priority concern. The Honorable High Court, considering air pollution as an issue of public importance, formulated a consensus-based Commission to make recommendations for effective future action to bring about a meaningful change in quality of vehicular air pollution. The Commission, known as the Lahore Clean Air Commission (LCAC), was composed of lawyers, EPD, City Government, Punjab Government, City Mayor (Nazim), environmental scientists, and civil society members. LCAC was tasked to submit a report on feasible and practical long- and short-term solutions and measures for monitoring, controlling, and improving the vehicular air pollution in the city of Lahore. The Commission worked for over a year and met with a number of stakeholders. During this process, LCAC made contact with the Clean Air Initiative for Asian Cities (CAI–Asia).

CAI–Asia assisted in organizing a National Workshop for the Improvement of Urban Air Quality in Pakistan in December 2004. This brought technical expertise to Pakistan from all over the world to assist in the formulation of the solutions and measures called for by the Court. The Commission fine-tuned the draft recommendations formulated at the Conference with the approval of all the stakeholders who signed the final document and submitted these recommendations to the Lahore High Court. The recommendations proposed measures to address pollution from diesel buses, autorickshaws, ambient air quality standards, vehicular emission standards, fuel standards, proposed financial plan to implement the recommendations, proposed monitoring mechanism to monitor the progress in the implementation of the recommendations, awareness raising, and capacity building.

The Recommendations of LCAC were thoroughly tested by the Court by inviting public objections to the Recommendations through public advertisement and through notice to all the respective ministries and departments. This process took nearly a year spread over almost 15 hearings.

After approval of the recommendations, the Court directed the civil society, city government, and the Punjab Government to come up with an Action Plan.

An action plan has been developed for Lahore and its implementation is now ongoing. The recommendations of the commission include

- Introduction of Euro 2 CNG buses
- Phasing out of existing buses in 2 years
- Certification of vehicles from authorized workshops
- Gap age for buses should be 10 years
- Phase-out old wagons
- Introduction of CNG rickshaws
- Ban on the registration of 2-stroke rickshaws by January 2006
- Phase out existing rickshaws from Lahore in 1 year
- Setting own Ambient Air Quality Standards and Vehicle Emission Standards by 2006
- Proper I&M system
- Awareness-raising for CNG use

Among the important achievements of Lahore is the phase-out/banning of 2-stroke rickshaws and diesel-fueled public transport vehicles and their replacement with CNG-fueled rickshaws.

Source: Shah (2006), IUCN (2006).

Ambient Air Quality Standards

Pakistan only has standards for SO_2 and NO_x for industrial areas as stipulated in the National Environmental Quality Standards (NEQS) (1995). The SO_2 ambient standards are set for four categories of background ambient air in power plants operating on oil and coal. These categories correspond to the maximum allowable emissions of SO_2 in tons per day. Table 5.2 shows the detailed specifications of this regulation. For NO_x, the annual average concentration was pegged at 100 $\mu g/m^3$ for power plants using oil and coal and was not further categorized like the SO_2 standards.

TABLE 5.2

SO_2 Ambient Air Quality Standards for Oil and Coal Power Plants and Corresponding Emissions Limits

Categories	Annual Averaging ($\mu g/m^3$)	24-hour Averaging ($\mu g/m^3$)	Maximum SO_2 Emissions (tons per day)
Unpolluted	< 50	< 200	500
Moderately polluted (low)	50	200	500
Moderately polluted (high)	100	400	100
Very polluted	> 50	> 400	100

Source: NEQS (1995).

Though these standards were stipulated in NEQS, it is not clear how these were developed and enforced. A need to develop a comprehensive set of ambient air quality standards for criteria air pollutants in Pakistan is crucial to the development of its own air quality management system. Such standards need to be health-based and congruent with WHO guidelines.

Management of Mobile Sources

The existing vehicle emissions standards in Pakistan were notified in the 1993 National Environmental Quality Standards for Vehicle Exhaust and Noise (Annex III). These set of standards were found to be no longer sufficient to tackle the increasing problem of emissions from motor vehicles in Pakistan because these only include parameters for smoke and CO, which are comparable to pre-Euro standards for in-use vehicles (NECC 2002). In addition, the standards were set for all modes of vehicles and did not delineate between light-duty and heavy-duty vehicles, and/or motorcycles.

The NEAP 2005 and the proposed PCAP mention a number of other actions to address emissions from motor vehicles, including proposed new vehicle emissions standards and corresponding fuel quality standards for metrocities. The proposed measures by PCAP, as shown in Table 6.1, are mostly on tailpipe-oriented measures, but with some provisions for travel demand management and promotion of modal shift toward public transportation, and strengthened enforcement (Pakistan EPA/World Bank 2006).

The national workshop on air quality management in Pakistan, which was held in Lahore in 2004, discussed the adoption of Euro 2 for all types of vehicles in 2007, Euro 3 in 2010, and Euro 4 in 2013 for Pakistan's metrocities (CAI–Asia 2004). However, this has not yet been officially adopted by government regulators.

The current gasoline specifications monitored in Pakistan are research octane number (RON) at 90, lead at zero levels, and sulfur content at 0.1% (or 1,000 ppm). For diesel, it is 1.0%, with the actual levels ranging from 5,000 ppm to 10,000 ppm of sulfur. Various steps to improve the specification of petroleum products have been taken since 2000. Unleaded gasoline, introduced in the country in July 2002, has been improved to 90 RON unleaded gasoline and is now produced and marketed since 2003. Several national refineries, such as Attock Refinery Ltd, are in the process of further reducing sulfur levels in diesel (Azam 2006).

The Government has actively promoted the use of CNG to reduce the pressure on petroleum imports, to curb pollution, and to improve the environment. This is clearly stipulated in the country's Petroleum Policy of 1997 (ADB 2004). As a result, Pakistan has become the third largest country in the world with natural-gas vehicles. Most of these vehicles are private cars. Public transport auto-rickshaws have been converted to either CNG or LPG.

In addition, local notifications have also been promulgated to limit or totally ban the operations of highly-polluting vehicles, such as the ban on old and poorly maintained city buses, and the ban on 2-stroke auto-rickshaws. Such notifications have been made in Lahore and Karachi banning 2-stroke auto-rickshaws from operating in the city as mentioned in Table 6.1. In Lahore, some roads have been closed for operations of 2-stroke rickshaws: the Mall Road was closed on 17 April 2006, Jail Road on 27 September 2006, and Main Boulevard (Gulberg) on 18 October 2006. It is planned that by 20 December 2007, a complete ban of 2-stroke rickshaws will be implemented in Lahore (Khan 2006).

The country does not have an established inspection and maintenance system in order to regulate emissions from in-use vehicles. However, motor vehicle examiners, who operate within the transport departments in each state, conduct arbitrary inspections and issue a certificate of fitness for public and commercial vehicles. CDGs and the provincial traffic police are implementing a provincial motor vehicle ordinance that allows them to apprehend private and public transport vehicles emitting visible smoke, vapor, grit, sparks, ashes, cinders, or oily substances and fines them Rs500 for such violation (Ghazali 2006).

A voluntary inspection and tune-up program is included in the United Nations Development Programme-Global Environment Facility-Fuel Efficiency in Road Transport Sector (UNDP-GEF-FERTS) project and a German Agency for Technical Cooperation (GTZ)-supported project in Peshawar. According to the ENERCON component of the UNDP-GEF-FERTS project, Pakistan has plans to put up a centralized system operated by the private sector but controlled and overseen by the Government. This will handle emissions and safety issues as well, and is planned for operations in 2007 for all commercial vehicles and 2010 for all types of vehicles

(CAI–Asia 2004). Recently, the Government of Karachi has agreed to work with a Malaysian firm to set up an inspection and maintenance system in the city.

Management of Stationary Sources

The management of emissions from stationary sources is also the responsibility of the Pakistan EPA and the federal or provincial EPAs. The industries of particular concern are the (i) brick kilns, which use rubber tires for fuel; (ii) rubber, pulp, and paper mills, which emit high amounts of hydrocarbons and metallic and acidic compounds; (iii) factories using high-sulfur furnace oil; (iv) health care waste incinerators; and (v) thermal power plants.

In the NEP 2005 and PCAP, a number of measures targeting stationary sources emissions have been included, addressing PM and other criteria pollutants, and as well as a range of potentially carcinogenic pollutants, including dioxins and furans. A number of cities have industrial clusters that are located in proximity to residential areas. The proposed measures include the introduction of low-sulfur diesel and furnace oil, promotion of alternate fuels, waste minimization and energy efficiency, and pollution control technology. The relocation of polluting industrial units violating land-use regulations is also one of the stricter measures that can help reduce exposure to air pollution (Pakistan EPA/World Bank 2006).

The Pakistan EPA, in collaboration with the industry and other stakeholders, has implemented the "Self-Monitoring and Reporting System for Industry" (SMART) Program. Under the program, industries in Pakistan will systematically monitor their environmental performance and report the data to EPAs. By implementing the system, the Government is, in fact, transferring its responsibility for examining and evaluating industry's environmental performance to individual industrial facilities. This would save Pakistan EPA considerable expense, time, and effort and would enable industries to make long-term provisions for eco-friendly production (Pakistan EPA 2006b).

The Environmental Standards Committee takes into account the resources and interests of both EPAs and industries. It classifies industries into categories A, B, and C, each corresponding to a specified reporting frequency. Category A industry will report their emission levels after every month; category B industry, quarterly; and category C industry, biannually. Industrial units will get their effluent tested from a laboratory and enter the results in electronic form included in the package (software SMART – Self-Monitoring and Reporting Tool) (Pakistan EPA 2006b).

Management of Area Sources and Dust

Widespread burning of garbage in several urban areas is another critical air pollution problem in Pakistan. CDGs are charged with removing sources of pollution and exercise control over these kinds of area sources. Currently, CDGs are actively engaged in controlling emissions by prohibiting roadside incineration of municipal waste and are taking steps to introduce sustainable waste management practices (Ghazali 2006).

A comprehensive waste management program is also being considered by Pakistan EPA in order to address the issue of rampant open burning in Pakistani cities.

Public/Nongovernment Participation

Several organizations, such as the World Conservation Union (IUCN) and the World Wide Fund for Nature (WWF), have actively engaged in awareness-raising campaigns executed through electronic and print media and through workshops in collaboration with various stakeholders.

Public interest litigation has spurred government agencies to take cognizance of deteriorating air quality in Pakistani cities. A number of cases have been filed against the Government. Issues directly related to air quality as those argued by Syed Mansoor Ali Shah and Shehla Zia focused on vehicular air pollution and public health and safety issues. This has resulted in a strong and proactive participation of the Lahore City Government on improving air quality in the city.

The Pakistan Clean Air Network (PCAN) with its secretariat hosted by IUCN is actively seeking the involvement of all stakeholders in its effort to promote better air quality in Pakistani cities. It is also closely coordinating with government authorities in order to support and complement government-led initiatives.

In 2004, a national workshop on air quality management was organized by CAI–Asia in Lahore, Pakistan in partnership with City of Lahore, Lahore Clean Air Commission, National Environmental Action Plan-Support Programme, IUCN Pakistan, ADB, World Bank, and other institutions in order to catalyze air quality management efforts in Pakistan and to strengthen air quality management in the main urban areas in the country.

As a follow-up to this workshop, another National Workshop on Urban Air Quality Management was organized by IUCN Pakistan in collaboration with CAI–Asia and PCAN in September 2006. The workshop paid special attention to integrated traffic management and developing strategies for addressing air quality management issues in collaboration other partner organizations in Pakistan. The Pakistan Clean Air Program was also presented and discussed in this workshop.

The workshop further strengthened the collaboration and partnerships of various local and international institutions in Pakistan and has raised the optimism of being able to improve urban air quality in the country.

» Part Six

Conclusion

Pakistan finds itself at a critical juncture in its development trajectory. High rates of growth and industrial productivity in the traditionally agrarian economy are indicative of greater input of resources and, as such, remain inextricably linked to the emissions from the accelerated use of energy in the country. The low-quality fuels used in major industries and in the transport sector have substantially contributed to the problem, which is further aggravated by uncontrolled biomass and waste burning in the urban area. The proliferation of informal and inefficient public transportation system in major cities in Pakistan has also been one of the key factors driving the air pollution problem.

The booming economy is likely to lead to a rapid growth of personal motorization. Without adequate support and regulatory measures, this phenomenon could accelerate the worsening air quality problems in Pakistani cities.

Based on existing air quality monitoring data, PM_{10} and $PM_{2.5}$ are the main pollutants of concern. PM concentrations were found to exceed 1979 WHO guidelines by a factor of 3–4. Oxides of nitrogen are also found to exceed WHO guidelines. The establishment of a continuous air quality monitoring is urgently needed to monitor the current air quality and provide the information required to formulate appropriate measures to protect public health. It is welcoming news that Pakistan is moving forward with the establishment of continuous air quality monitoring stations in its major cities.

Although there have been few studies of the impacts of air pollution in human health and the environment, the very high concentrations of PM suggest a very heavy burden of air pollution-induced diseases in the population. This is confirmed by a recent study of the Pakistan EPA and the World Bank that estimated health costs ranging from Rs62 to Rs65 billion per year, equivalent to about 1% of GDP. This underscores the urgent need to effective implement measures to reduce PM.

Pakistan still lacks a legal framework that can address urban air pollution and provide an integrated and comprehensive air quality management policy for the country. The need for such a legal basis is important in providing the fundamental basis for air pollution control. The involvement of concerned stakeholders should be ensured in the formulation and legislation of such policies. Linkages and roles of the national, provincial, and local levels should be clearly and firmly stipulated so as to avoid overlapping of roles and ensure coordination and cooperation.

There is also a need to raise the awareness of the public in major cities in Pakistan and to ensure that relevant stakeholders are informed of the problem and are supportive of the development and implementation of action plans to mitigate air pollution.

References

Ahmad, S. 2004. INAA for the characterization of airborne particulate matter from the Nilore area of Islamabad city. Paper presented at the Thematic Planning on Monitoring Air Pollution of the International Energy Agency, Vienna, 7–11 June 2004. Available: http://www-tc.iaea.org/tcweb/abouttc/strategy/Thematic/pdf/presentations/pollution/Issues,_Trends_and_Challenges_in_Air_Pollution_in_Pakistan.pdf

Ahmed, Amin. 2006. *Urban pollution: Over 22,000 die annually: report.* Dawn, The Internet Edition. 15 June 2006. Available: http://www.dawn.com/2006/06/15/nat13.htm

Alam, Mukhtar. 2006. *KARACHI: Pollution crosses tolerable limits: Suparco airs SOS.* Dawn, The Internet Edition. 20 July 2006. Available: http://dawn.com/2006/07/20/local1.htm

Asian Development Bank (ADB). 2005. *Key Indicators 2005.*

ADB. 2006. *Key Indicators, 2006 update.*

Azam, Muhammad. 2006. Pakistan's step towards developing fuel quality roadmaps. Paper presented at the Developing Fuel Quality Roadmaps in Asia Workshop, 22-23 May 2006, ADB, Manila. Available: http://www.cleanairnet.org/caiasia/1412/article-70713.html

CAI–Asia. 2004. Draft Recommendations: National Workshop for the Improvement of Urban Air Quality in Pakistan. Clean Air Initiative for Asian Cities (CAI–Asia). Available: http://www.cleanairnet.org/caiasia/1412/article-59041.html

Ghazali, Hassaan. 2006. Personal Communication. Urban Policy Analyst, Government of Punjab, Pakistan.

Khan, Tariq Zaman. 2006. Initiative of City District Government of Lahore to Combat Air Pollution. Paper presented at the National Workshop on Urban Air Quality and Integrated Traffic Management, 13–14 September 2006. Karachi, Pakistan.

Khwaja, Mahmood. 2003. Environmental ealth: Lead exposure and its impacts on children. *Sustainable Development Policy Institute (SDPI) Research and News Bulletin*. Vol.10(2). March–April 2003.

Islam, Zia-Ul. 2006. AQM in Pakistan: The PCAP and Plans for its Implementation. Paper presented at the National Workshop on Urban Air Quality and Integrated Traffic Management, 13–14 September 2006. Karachi, Pakistan.

IUCN. 2006. National Workshop on Urban Air Quality and Integrated Traffic Management, 13–14 September 2006, Karachi, Pakistan. Draft Report.

Lodhi, Zulifikar. 2006. Ambient Air Quality in Pakistan. Available: http://www.environment.gov.pk/PRO_PDF/AmbientAirQtyPakistan.pdf

Ministry of Finance (MoF), 2006. *Pakistan Economic Survey 2005–2006.* Available: http://www.finance.gov.pk/survey/home.htm

NECC, 2002. *Study on Improving Vehicular Emission Standards in Pakistan*. Prepared by the National Energy Conservation Centre (NECC) for the UNDP/GEF/ ENERCON project on Fuel Efficiency in Road Transport Sector Project.

Pakistan EPA/ World Bank. 2006. Strategic Country Environmental Assessment: Rising to the Challenges. Draft May 2006. Available: http://www.environment.gov.pk/NEW-PDF/Pak-SCEA-May2006.pdf

Pakistan EPA, 2006a. Pakistan Clean Air Program (PCAP).

Pakistan EPA. 2006b. Self Monitoring & Reporting (SMART) Procedure. Available: http://www.environment.gov.pk/Smart.htm Accessed: October 2006

Pakistan EPA, 2005. State of the Environment Report 2005 (Draft). Available: http://www.environment.gov.pk/Publications.htm

Pakistan EPA/JICA. 2001. *Three Cities Investigation of Air and Water Quality with Analytical Comments (Lahore, Rawalpindi, and Islamabad)*. Pakistan Environmental Protection Agency and Japan International Cooperation Agency. June 2001.

Shah, Mansoor Ali. 2006. Civil Society's Response to Lahore's Air Pollution Problems. Paper presented at the National Workshop on Urban Air Quality and Integrated Traffic Management, 13–14 September 2006. Karachi, Pakistan.

Wikipedia. 2006. *Transportation in Pakistan*. Available: http://en.wikipedia.org/wiki/Transport_in_Pakistan

Wikipedia. 2006b. *Karachi*. Available: http://en.wikipedia.org/wiki/Karachi

Wikipedia. 2006c. *Lahore*. Available: http://en.wikipedia.org/wiki/Lahore

Wilcoxen, P. 2006. Website of Associate Professor Peter Wilcoxen, Maxwell School, Syracuse University, New York, USA. Available: http://wilcoxen.cp.maxwell.syr.edu/pages/137.html Accessed: August 2006

World Bank. 2000. South Asia Environment Strategy. Final Draft. South Asia Environment Unit, World Bank, Washington, D.C. Processed, 2000.

World Bank. 2006. PAKISTAN—Highways Rehabilitation Project. Project Information Document Report No. AB2170. 8 February 2006. Available: http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2006/02/15/000104615_20060215092856/Rendered/PDF/Updated0HRP0PID0Feb081006.pdf

WHO/UNEP. 1992. *Urban Air Pollution in Mega-cities of the World*. World Health Organization/United Nations Environment Programme, Blackwell, Oxford.