Urban Air Quality Management

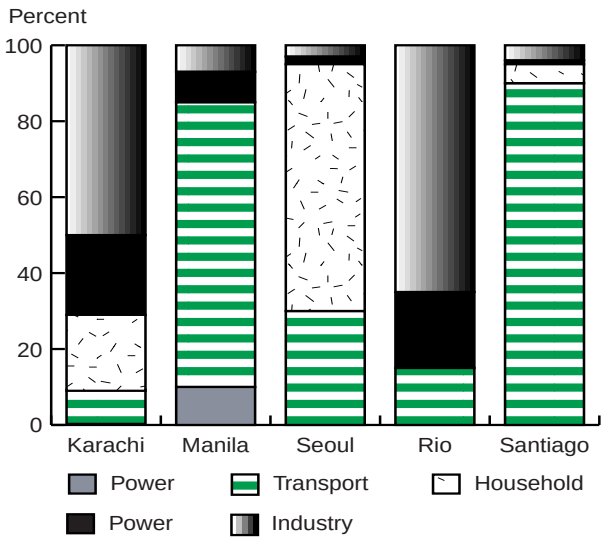
Poor air quality due to pollution is a serious environmental problem in most urban areas. The greatest burden of pollution is on human health. Urban air quality management requires an integrated approach that determines which are the most serious problems; identifies the measures that offer cost-effective and feasible solutions across a range of economic sectors and pollution sources, and builds a consensus among key stakeholders concerning environmental objectives, policies, implementation measures, and responsibilities.

Rapid urbanization, motorization and economic growth contribute to a growing air pollution problem in most large developing urban centers. Comparative risk assessment and health studies have been carried out in a number of cities (e.g., Bangkok, Cairo, Mexico City, Quito, Santiago, and cities of Central and Eastern Europe). These studies indicate that the greatest damage to human health comes from exposure to fine suspended particulates—particulate matter with an aerodynamic diameter of less than 10 microns (PM_{10} and smaller)—and to lead. Other pollutants of concern are sulfur dioxide (SO_2), to the extent it contributes to fine particulates and long-range environmental damage; ozone (O_3), mainly in warmer, sunny locations with unfavorable topographic conditions; volatile organic compounds (VOCs), some of which are known carcinogens; nitrogen oxides (NO_x), contributors to ozone formation; and carbon monoxide (CO), which is associated with global warming.

Main Sources of Pollution

Anthropogenic air pollution originates from large stationary sources (industries, power plants, and municipal incinerators); small stationary sources (households and small commercial boilers); and mobile sources (traffic); see Figure 1. Many of these sources are closely related to the production and consumption of energy, especially fossil fuels. Besides power plants and industries, domestic use of fossil fuels, especially heavy fuel oil, biomass, and brown coal, is a significant source of ambient particulates and sulfur dioxide, especially in temperate regions (e.g., in China and Eastern Europe). Traffic is a large contributor to both particulate and sulfur emissions in cities with frequent traffic congestion and with large, poorly maintained fleets of vehicles that use high-sulfur diesel fuel (e.g., in Asia). In cities where leaded gasoline is still used, traffic may contribute 80–90% of atmospheric lead concentrations. (Poorly controlled emissions from lead

Figure 1. Sources of Particulate Emissions in Selected Cities



Source: UNEP and WHO 1992; World Bank 1996.

smelters could also be significant.) The roles of natural and anthropogenic sources are equally important in the formation of ground-level ozone. Natural sources, such as biogenic emissions from plants and trees, and traffic emissions are the largest sources of atmospheric VOC. Natural, mobile, and stationary combustion sources are significant contributors to nitrogen oxide concentrations. Motor vehicles are typically responsible for the greatest part of carbon monoxide emissions.

The impact of emissions on human exposures depends on the location and dispersion of pollution: large stationary sources, often located at a distance from most densely populated city centers, disperse into higher layers of the atmosphere, while households and traffic emit near ground levels in highly populated areas. As a result, mobile and small stationary sources contribute more to ambient urban pollutant concentrations, and the resulting health effects, than their share in total emissions loads indicates.

Options for Reducing the Harmful Impacts of Pollution

Measures to mitigate the negative effects of pollution may focus on separating pollution sources and receptors, reducing the polluting activity, reducing its pollution characteristics, and controlling emissions with filtering devices. Not all of these alternatives are available for all pollutants. Changing the location of the pollution source may be an effective strategy for universally mixed pollutants with only localized health effects, such as particulates. Urban planning, zoning, and other land use regulations can influence urban air quality through microlevel decisions. However, these measures are not effective for persistent pollutants such as heavy metals and for pollutants with significant regional and global impacts such as sulfur dioxide and carbon dioxide. Opportunities for applying alternative methods of emissions reduction also vary across pollution sources (Table 1).

The impact of emissions from large stationary sources can be reduced by choosing a location away from populated areas; using clean fuels such as gas and low-sulfur or low-ash coal; applying cleaner technologies such as fluidized-bed combustion and low-NO_x burners; improving maintenance and housekeeping; and installing proper end-of-pipe control technologies such as electrostatic precipitators and baghouses.

The impacts of traffic-related emissions may be mitigated by diverting traffic away from heavily populated areas (for example, by building ring roads around cities or restricting downtown traffic); converting high-use vehicles to cleaner fuels (for example, converting buses to natural gas); improving vehicle maintenance; increasing the share of less polluting traffic modes; using more fuel-efficient vehicles; and installing catalytic control devices. Supply-side traffic management measures aimed at reducing congestion (for example, by improving road infrastructure) rarely lead to significant overall emissions reductions because they may simply increase traffic flows.

Table 1. Most Effective Pollution Abatement Options at Key Sources

	Industry and energy						*Traffic*				
	Location	*Fuels*	*Maintenance*	*Clean technology*	*End-of-pipe*	*Households: Fuels*	*Location*	*Fuels*	*Maintenance*	*Clean technology*	*End-of-pipe*
PM_{10}	x	x	x	x	x	x	x	x	x	x	
Lead			x		x			x		x	
SO_2		x	x	x	x	x		x	x	x	
VOCs							x		x	x	x
NO_x	x	x		x			x		x	x	x
CO							x		x	x	x

Note: PM_{10}, particulate matter 10 microns or less in aerodynamic diameter; SO_2, sulfur dioxide; VOCs, volatile organic compounds; NO_x, nitrogen oxides; CO, carbon monoxide.

Emissions from households and other small stationary sources can be reduced most effectively through conversion to cleaner fuels.

Policy Approaches and Instruments

Setting Priorities

Because of the many sources of emissions in an airshed, pollution abatement focused on a single sector may lead to little improvement in air quality (see Box 1). Proper air quality management requires an integrated approach consisting of:

- Use of *monitoring and modeling* to establish an emissions inventory of key pollutants and emissions sources
- Use of *dispersion modeling* to determine the impacts of the emissions on ambient concentrations
- Use of *dose-response functions and valuation techniques* to estimate the impacts of the pollutants on human health
- Identification of *technically feasible abatement options* and calculation of their costs
- Estimation of the *impacts* of these abatement alternatives on ambient air quality and human health
- Determination of *priority measures* with high benefit-cost ratios.

An integrated approach requires coordination and consensus building across sectors and among affected stakeholders to agree on priorities and adaptable measures; agreement on acceptable benchmarks for environmental performance in individual sectors; introduction of policies and instruments to support implementation; and establishment of an implementation monitoring and enforcement mechanism cutting across sectors and authorities.

Guidelines and Standards

WHO establishes guidelines for ambient pollutant concentrations at which the risk of adverse health impacts is considered negligible. (For certain pollutants with no threshold below which there are no observable effects, WHO provides exposure-effect information, illustrating the major health impacts of different levels of the pollutant.) In developing countries with heavily polluted areas, these guidelines may serve as long-term objectives; however, short-term actions should be guided by a careful analysis of the expected benefits and costs of pollution abatement

Box 1. Setting Priorities: Three Examples

The sectoral approach in São Paulo: tackling the "wrong" sources of pollution. Early World Bank projects to abate pollution did not attempt to address pollution problems in an integrated way. The São Paolo Industrial Pollution Control Project, for example, succeeded in reducing particulate emissions from industrial sources but ignored mobile sources, which were important contributors to pollution. As a consequence, the city's ambient dust levels did not improve.

An integrated approach in Slovenia. The government of Slovenia requested World Bank assistance to finance the installation of flue-gas desulfurization technology at a power plant to reduce ambient particulate and sulfur dioxide concentrations in neighboring cities. An analysis of the main pollution sources found, however, that the principal contributor to poor ambient air quality was the use of low-quality coal in households and small boilers, which could be effectively tackled by a coal-to-gas conversion program for small combustion sources. Under the Bank-financed Environment Project, an Air Pollution Abatement Fund was established to provide loans to households in eligible municipalities that adopted smoke-reduction regulations.

Integrated analysis of alternatives for reducing emissions in Santiago. A Bank study (World Bank 1994) analyzed the costs and the impacts on ambient air quality of several strategies for controlling pollution in Santiago de Chile:

- Tightening emissions standards for light-duty vehicles
- Setting more stringent emissions limits for diesel buses and trucks
- Converting buses to natural gas
- Tightening emissions limits for large stationary sources
- Converting households to clean fuels.

The study found that, on an emitted-ton basis, reductions in particulates were more than 10 times more valuable, in terms of health benefits, than reductions in any other pollutant. Of the control options analyzed, measures to reduce emissions from fixed sources and gasoline vehicles had the highest benefit-cost ratios, followed by measures to reduce emissions from diesel trucks and buses.

measures. In practical terms, this leads to interim, achievable ambient quality objectives.

The analysis of good practices for management and pollution abatement, available technologies, and the expected impacts on emissions and ambient concentrations can provide minimum requirements for pollution abatement performance (or, alternatively, maximum emissions levels) in each sector. Requirements for pollution performance at individual sources, should, however, take into account local conditions and may focus on reductions at those sources that can carry out the reductions at the least cost. Allowing intersectoral and intercompany agreements within an airshed (the bubble concept) may be a more cost-effective way of achieving the required emissions reductions than less flexible approaches.

Regulations and Incentive Instruments

In the past, pollution management most often focused on the improvement of technologies and on the addition of end-of-pipe controls relying on uniform emissions or technological standards. The limitations of this approach have directed policymakers' attention to more flexible measures that rely on improved management and pollution prevention techniques, with an increased focus on the complex effects of pollution from a variety of sources on ambient air quality and human exposures (see Box 2).

Incentive-based policy instruments increase the price of pollution, encourage the search for cleaner operations, and influence the demand for polluting activities:

- *Direct-incentive policy instruments* such as emissions charges (or, alternatively, emissions permit trading) may be best applied to large stationary sources and to pollutants (such as PM_{10}, SO_2, and NO_x) for which the abatement cost varies across pollution sources and for which monitoring is feasible. The best examples are the acid rain trading program in the United States, which contributed to a significant reduction of the overall costs of reducing sulfur dioxide emissions from large stationary sources, and the nitrogen oxide emission charge on large combustion plants in Sweden.

Box 2. "Good" and "Bad" Choices of Policy Instruments

Fuel taxes have been effectively applied in many countries to increase demand for cleaner fuels. One of the best-known examples is the differentiated taxation of gasoline according to its lead content. This measure has contributed to a significant increase in the market share of unleaded gasoline in a large number of European and other countries.

Other policy instruments have been less successful. For example, many big cities have experimented with placing various restrictions on traffic (for example, according to license plate number) to reduce air pollution from mobile sources. These programs did not fulfill policymakers' expectations of reducing overall emissions. In Mexico City, for example, the measures encouraged drivers to buy additional, typically more-polluting vehicles.

- *Indirect policy instruments* such as product charges, taxes, and deposit-refund systems are best applied to small and diffuse pollution sources that cannot be monitored easily; where the use and disposal of products are closely linked to their pollution effects; and where prices can influence producer and user behavior. Examples are fuel taxes and deposit-refund systems for batteries.

While incentive policy instruments offer potential cost savings and allow flexibility in responding to environmental requirements, the administrative costs of such measures may be high, or the feasibility of implementation may be low, requiring direct regulation. Prohibiting the use of highly toxic substances (such as lead in gasoline) and industrial processes (such as mercury cell chlor-alkali production) is a typical example.

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