Urban Air Quality Management Plan - A Framework for Development and Implementation

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Contents

List of Figures

List of Tables

References

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1. Introduction

People throughout the world are increasingly feeling the social, environmental, political, and economic impacts of rapid urbanization. In particular in developing countries, where the urbanization trend has been occurring at an extremely high rate for the last several years, there are significant changes taking place within urban areas as well as the regions surrounding them. It appears that urbanization in developing countries today is following patterns of growth similar to that which took place in Europe and North America a century ago. Unfortunately, the population in and around many cities in several developing nations is thus faced with social and environmental conditions roughly comparable to those that were experienced previously by urban residents in the developed countries.

Traditionally, cities have been economic centres, and they are still the driving forces of economic and social development. As centres of concentrated human activity, cities have a disproportionately large impact on the natural systems that support them. Cities draw upon energy and natural resources from vast areas, and have intense effects on their local environments. However, cities also provide the opportunity for humans to achieve sustainability by becoming centres of innovative planning, and models of energy and resource efficiency. By recognizing the capacity of regional environments to support urban development, and planning growth accordingly, local authorities can manage urbanization to create sustainable cities and ways of life. This type of planning is vital in the long-term, to ensure the health of people, and of the natural systems upon which the residents depend for survival.

The pace of urban development, together with the type of social and economic forces that drive it, can have profound implications for the population in and outside of urban areas. While urbanization can bring improvement to people's income and lifestyles, it also comes with negative environmental and social impacts. These negative impacts threaten our quality of life at every level, from the health of the individual citizen, to the stability of the global economy, to the long-term survival of humans and natural systems around the world. Some of the major environmental issues associated with urbanization and the corresponding increases in population density are those related to water quality, waste management, and air quality.

Before the European Industrial Revolution of the 17th century, the atmosphere had the ability to preserve the cleanliness of the air. However, as we approach the 21st century, this is no longer the case. Air pollution results from almost all human activities. Rapid growth in population, industrialization, economic activities, and motor vehicle use are contributing to emissions of air pollutants at an ever-growing rate. The rate and volume of air pollutants emitted from human activities have exceeded the natural absorption capabilities of the earth and its atmosphere.

One of the most obvious environmental impacts of a growing urban population has been the increase in air pollution. The level of air pollution in a region depends upon a number of factors ranging from the types of emission sources in and around the area to its geography and weather conditions. Generally, increased emissions of pollutants cause the quality of the regional air to get worse. Hence, people in growing urban areas are subjected to worsening air quality, and it has become a major concern worldwide.

Current scientific evidence indicates that emissions of air pollutants and gases from human activities are threatening not only human health and welfare, but also the health of global ecosystems. Ecosystems can be defined as the natural systems of interrelation between living organisms and the non-living components of their environments. All life on earth, including humans, is part of an ecosystem, and depends on the interrelations with other parts and natural systems for survival. Thus, when we threaten the health, integrity or proper functioning of ecosystems, we threaten our own human life support system.

Population growth in urban areas and the resulting environmental pressures seem at times to increase at a rate faster than that can be managed. The challenges faced by authorities in growing urban areas are those of slowing down the pace of growth and allowing the regions grow in a planned manner to reduce environmental damages. As motor vehicles are becoming the single most significant contributors to air pollution in large cities, land use patterns and transportation systems are also critical to improvement in regional air quality. Therefore, an integrated planning of land use, transportation systems, and air quality management becomes essential for the development of a healthy, livable region.

Every individual has a part to play in reducing air pollution and maintaining acceptable air quality in the cities of tomorrow. However, urban planners, and local, regional, and national governments in particular, must address air quality management as one of the most important challenges in the process of re-orienting urban growth and development to a sustainable path. In this context, it is deemed appropriate to cite the following international agreement on the responsibilities of local governments towards sustainable development.

The "Local Agenda 21"

One of the 27 basic principles adopted at the United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992 was Agenda 21. This Agenda 21 is a framework for a cooperative global action plan for environmental management and sustainable development. Towards this end, Chapter 28 of Agenda 21, "Local Authorities' Activities in Support of Agenda 21" (the so-called "Local Agenda 21") particularly encourages local initiatives on environmental matters. It provides guidance and a framework for local planning. The "Basis for Action" under Chapter 28.1 of Agenda 21 states:

> *Because so many of the problems and solutions being addressed by Agenda 21 have their roots in local activities, the participation and cooperation of local authorities will be a determining factor in fulfilling its objectives. Local authorities construct, operate, and maintain economic, social, and environmental infrastructure, oversee planning processes, establish local environmental policies and regulations, and assist in implementing national and sub-national environmental policies. As the level of governance closest to the people, they play a vital role in educating, mobilizing, and responding to the public to promote sustainable development.*

Subsequently in 1996, the International Council for Local Environmental Initiatives (ICLEI) published "The Local Agenda 21 Planning Guide", to provide step-by-step guidance for the implementation of Agenda 21, with key elements of sustainable development planning, for local authorities. Towards this end, this framework outlines the major adverse impacts of urbanization, and provides guidelines for developing a regional air quality management plan.

Contents

2. Trends in Urbanization and Urban Air Quality in Asia

Since the 1970s a massive growth in urban areas has been taking place all over the world. It is estimated that nearly two-thirds of the world's people will be living in urban areas by the year 2025. The rapid growth has been taking place mostly in developing nations, in particular in Asia. Along with increase in population and economic activities, these areas are faced with rising social and environmental problems.

2.1 Global Trends in Urban Growth

Around the globe, cities are rapidly growing as more and more of the earth's people become urban dwellers. Not only is this growth characterized by increased numbers within the existing urban populations, but is also due to in-migration to urban areas by people from rural areas. As economies, industries, and populations grow, so do the actual physical urban areas that house them, leading to larger cites world-wide, and an increasing number of "mega-cities" with more than 10 million inhabitants.

Developing countries, in particular, are currently experiencing this trend of rapid growth and urbanization. On average, urban populations in the developing world are growing at a rate of 3.5 % per year. While these rates of growth are similar to the rapid urban growth of European and North American cities a century ago, the present explosive urban growth is much larger in scale due to the sheer numbers of people involved. For example, Sao Paulo, Brazil currently has 16.4 million inhabitants, while Mumbai, India has 15 million. By the year 2015, the United Nations predicts that Mumbai will have grown to over 25 million people.1

Urbanization and Associated Problems

Traditionally, the driving forces that have characterized urban growth and development have been economic. The economy has directed human activities within urban centres, which in turn have dictated how natural resources are used, and the type of impacts that urban areas have on their natural environments. The environmental and social costs of economic activities have not generally been factored into decision-making, and many negative effects of these activities are only now being realized.

Cities around the world are facing problems of overcrowding, inadequate sanitation facilities, shortages of clean water supplies, and air pollution. In many cities, it is the urban poor who bear the brunt of environmental problems, occupying areas of high population density that lack adequate water and sanitation facilities, and with no escape from air pollution. It is estimated that more than 1.1 billion people live in urban areas where air pollution exceeds levels considered appropriate for healthy living.1

The rapid, mostly unplanned, growth and development of urban areas in recent years is straining the ability of both social and natural systems to cope with increasing demands. Urban growth is placing increasing pressure on the natural environment, degrading the very resources essential for sustenance, and threatening the health of citizens both in urban areas and in the surrounding regions. For this reason, traditional patterns of urban growth and development have been "unsustainable". The challenges and environmental problems associated with urbanization are being felt particularly acutely by developing countries, as they are currently facing much higher rates of growth, and higher absolute numbers than the developed countries.

2.2 Urban Air Quality Trends in Asian Countries

Urban air quality is one such environmental problem that is increasingly evident as a major threat to human health and the "quality of life" for urban residents. Specific air pollution concerns vary from one city to the next, and between various parts of the world. In more developed countries, some air quality problems have been addressed through strict regulation of industrial and motor vehicle emissions. However, the major threat still remains from motor vehicle use. According to a recent study of cities in Austria, France and Switzerland, air pollution from road transport kills more people than do traffic accidents. Air Pollution in these countries causes 21,000 premature deaths and health impacts of an estimated EURO 27 billion every year.2 In developing countries in Asia, both industrial and vehicular sources of air pollution are rapidly worsening, as urban growth occurs.

World Health Organization data show that ambient concentrations of particulate matter are worsening in nearly every Asian city monitored. Emissions of air pollutants such as particulate matter, sulphur dioxide and nitrogen oxides from industrial sources have grown exponentially during the past 15 years in several Asian cities. Emissions of particulate matter, unburned hydrocarbons and carbon monoxide from domestic cooking, and heating in cities in colder climates in northern India and China during winter season, are a major concern. Exposure to smoke and particulate matter dominates urban problems in Asia, and is responsible for millions of excess cases of respiratory disease and thousands of excess deaths. Respiratory illness is the leading cause of mortality in Asia for children under the age of 5. Rough estimates indicate that air pollution in urban areas in China cause nearly 320,000 excess premature deaths and

1.4 million cases of bronchitis each year. It is estimated that health costs from particulates and lead pollution in Bangkok, Kuala Lumpur and Jakarta are about 10% of the annual city income or roughly $ 5 billion (US). Ground-level ozone may also become a concern in several Asian cities as emissions of nitrogen oxides and volatile organic compounds from other stationary sources and motor vehicles continue to grow.3

While in the future large industrial sources may be better controlled, the rapid growth in the use of motor vehicles for moving goods and people is expected to further deteriorate the air quality in these regions. Improved economy is allowing the high- and middle-income residents to own four-, three- and two-wheeled motor vehicles, irrespective of their fuel efficiency or emission control ability. Enlarging cities and the lack of transportation infra-structure to cope with the number of motor vehicles on roads are all contributing, directly and indirectly, to the degradation of urban economy and environment. The urban sprawl is forcing vehicle owners to make longer trips. Every vehicle trip adds to air, water and noise pollution, and vehicle use creates solid waste such as discarded tires and vehicles.

Traffic congestion on roads forces vehicle users to cycles of frequent stop-and-go and slow speed driving. Both styles of driving cause more air pollution from vehicles. Indirectly, congested roads are also producing economic loss. As shown in Table 1, the estimated annual cost of time delay caused by congestion in 7 cities in Asia ranges from $51 to $305 million (US).

Table 1: Estimated losses due to traffic jams in selected Asian cities

City	**Anual Cost of Time Delay (million US$)**	**Percent of Regional Gross National Product**
Bangkok	272	2.1
Hong Kong	293	0.6
Jakarta	68	0.9
Kuala Lumpur	68	1.8
Manila	51	0.7
Seoul	154	0.4
Singapore	305	1.6

Source: Adapted from "World Resources 1996-97. A Guide to the Global Environment. The Urban Environment", Chapter 1, World Resources Institute, Washington, D.C. www.wri.org

The air pollution problem is compounded by factors such as old and poorly maintained vehicle fleets, increasing use of two-stroke vehicles and diesel vehicles, and use of not-so-clean fuels. For example, a two-stroke motorcycle engine can emit up to 10 times more particulates and hydrocarbons than a 4-stroke engine. Diesel vehicles emit significant quantities of smoke, fine particles and unburned hydrocarbons containing several toxic compounds. Where it is still allowed, the use of leaded gasoline is frequently the largest source of lead exposure which disproportionately affects the health of children and the poor.

Strategies for the Future

Three major impacts of rapid urban growth, namely air pollution, transportation and land-use pattern, are interlinked. Urban authorities have been following the traditional practice of addressing these issues through different agencies following their separate mandates. The traditional structures and processes of single-issue management in an isolated manner are deemed to be ineffective in dealing with the problems now faced by urban authorities. A re-orientation of these institutions appears to be a prerequisite to tackle these issues together.

Overall, a new sustainable strategy for urban growth is needed. Such a strategy will seek to reduce current negative impacts upon the environment, while preventing future environmental degradation, rather than taking measures after the fact to mitigate negative effects. Urban authorities in developing countries have a window of opportunity to overcome existing institutional barriers and to address land-use, transportation and air quality issues in an integrated manner through strong inter-agency coordination. Ultimately, the goal for all countries should be to create sustainable cities within healthy environments, hence supporting healthy people.

Key Trends in Urbanization

- More people are living in urban areas. Within the next decade, more than half the world's population (3.3 billion) will be urban dwellers.
- The fastest rate of urban growth is in developing countries and particularly where economic activities are increasing.
- Cities are being transformed into mega-cities.
- *'Urban sprawl'* is leading to *'unintended cities'* in many areas.
- Transportation management, urban sprawl and increasing use of motor vehicles are directly linked to most urban air pollution issues.
- Negative environmental and social consequences of rapid urbanization are reaching crisis points around the world.

Contents

3. The Atmosphere and Air Pollutants

> *In urban areas air pollution is a pervasive environmental problem. Air pollution damages vegetation, buildings, materials and ecosystems, but the greatest concern is that it threatens the health of human beings. Smoke coming out from industrial chimneys, domestic cooking and heating by burning solid fuels and oil, and from the exhaust pipes of cars, trucks and buses is the obvious sign of air pollution. However, there are other air pollutants which are often invisible, but which cause illnesses and death, destroy the earth-protecting layer of gas in the upper atmosphere, and contribute to the changing of the world's climate.*

As the topic of air pollution is full of scientific terms, it is appropriate to describe briefly the common terms that are used in this paper for the benefit of unfamiliar readers.

3.1 The Atmosphere

The atmosphere is defined as the whole mass of air that surrounds the earth. The air becomes gradually thinner, less dense, with altitude. The whole atmosphere extends a few hundred kilometres above the earth, and is made of four layers that surround the earth like concentric rings. These layers are called troposphere, stratosphere, chemosphere and ionosphere. However, the commonly referred to *'earth's atmosphere'* consists of the two bottom layers that are of most interest and concern to human beings. The troposphere is the nearest to the earth, and the one in which all living beings live. It extends from ground-level to about 17 km, and the one above it is the stratosphere that lies between about 17 km and 50 km above the earth's surface.

Nearly eighty-one percent of earth's atmosphere is within the troposphere. As shown in Table 2, when unpolluted by human activities, the dry air in the troposphere consists on a volume basis mainly of nitrogen (78.1%) and oxygen (20.9%), while the rest is made up of small amounts of argon, carbon dioxide, methane, nitrous oxide and other trace gases. The air in the troposphere also contains water vapour.4

Table 2: The gaseous composition of unpolluted air

Constituent	**Part per million by volume (dry basis)**
Nitrogen	780,000
Oxygen	209,400
Water	-
Argon	9,300
Carbon dioxide	315
Neon	18
Helium	5.2
Methane	1.0 - 1.2
Krypton	1.0
Nitrous oxide	0.5
Hydrogen	0.5
Xenon	0.08
Organic vapours	Ca. 0.02

Source: "Fundamentals of Air Pollution", 3rd Edition, Edited by Richard W. Boubel, Donald L. Fox, D. Bruce Turner, and Arthur C. Stern, Academic Press, California, U. S. A. , 1994.

Earth's Climate and Its Livability

The weather conditions we experience are the results of a complex interplay of the earth's atmosphere, oceans, ice caps, land mass and biosphere. The weather varies all the time, but its average pattern, called climate, remains more or less the same for centuries, unless subjected to unusual disturbances. There have been major climate changes in the past because of natural causes. However, those changes took place slowly and gradually to allow the life on earth to adapt, evolve and survive. Two critical atmospheric phenomena which make the earth habitable are the so-called "greenhouse effect" and "ozone layer".

Greenhouse Effect

Although many of the gases and water vapour present in the troposphere are in minute amounts, they play an important role like a blanket around the planet by producing the natural "greenhouse effect". The term "greenhouse" is simply described as a building made of glass which traps the sun's heat to create an inside atmosphere that is warmer than its surroundings. Much like glass, various gases in the earth's atmosphere allow the sun's radiation to pass through to its surface where some of the heat energy is absorbed, but they also trap some of the heat radiated by the earth and its lower atmosphere. This trapping of heat by the atmosphere keeps the earth warm, with an average global surface temperature of about 15° C, and moist enough for habitation. Without this heat trapped by the gases in the atmosphere, the heat radiated by the earth would escape into space leaving the earth's surface too cold for life, approximately 30° C colder than it is now.5

Ozone Layer, Useful Ozone and Harmful Ozone

Ozone (O_3) is a form of oxygen gas (O_2); one molecule of ozone contains three oxygen (O) atoms bound together. It is present throughout the atmosphere, and is formed naturally as well as from human activities. Nearly all naturally-occurring ozone is present in significant concentrations in the lower part of the stratosphere. This natural layer of ozone in the stratosphere plays an important role by filtering out most of the harmful radiation from the sun reaching the earth. All living beings on earth have evolved and adapted to this filtered amount of sun's radiation. Under natural unpolluted atmosphere, the stratospheric ozone is produced and destroyed in such amounts that its overall concentration in the layer remains more or less constant. The ozone layer varies in thickness because of earth's rotation and climate system. Normally it is thinnest over the equator and thickest around the poles, especially over the Antarctica. Because of this important role, the ozone in the stratosphere is called "useful ozone".

The natural "greenhouse effect" and the protective "ozone layer" in the stratosphere are being threatened by human activities, and have become a major global concern in recent years because of the potential impacts on the earth's climate system. This concern is described later under a section on "Global Issues".

Another type of ozone also occurs in the lower part of the troposphere. This tropospheric ozone is the 'harmful ozone"; it is commonly called "ground-level ozone", as it is formed near the earth's surface. It occurs entirely as a result of human activities, particularly in and around urban areas. It is a major component of 'smog', and is described further under the section on "Ground-level Ozone".

3.2 Ambient Air, Air Pollutants and Emission

Ambient air is the air near the earth's surface, and what people breathe. The gaseous composition of unpolluted ambient air is similar to that of the air in the troposphere, i.e, mostly nitrogen and oxygen with small quantities of other gases, as described above.

A pollutant is a substance that contaminates a medium, such as air, water or soil, and causes it to be unclean. Air pollution is defined as the presence in the ambient air of a pollutant or pollutants that substantially changes its original cleanliness. Ambient air quality standard, or simply Air quality standard, of an air pollutant is its concentration in the ambient air that is considered to be safe for human health and welfare.

Air pollutants are generally classified as Primary and Secondary pollutants. While Primary pollutants are emitted directly from emission sources, Secondary pollutants are those produced in the atmosphere. The primary pollutants or gases that react with each other in the atmosphere to form secondary pollutants are referred to as precursors of the latter.

Air emissions or Emissions refer to air pollutants that are emitted into the atmosphere from any source. An Emission standard of a pollutant from a given source is its maximum allowed quantity that can be emitted from the source.

3.3 Air Pollutants, and Their Sources, Pathways and Fate

The sources of air pollution are numerous, and include both natural and human-made. Examples of natural sources are: volcanoes, forest fires, dust storms, oceans, hot springs, saltwater lakes, and plants and trees. Nearly all human activities cause air pollution. Air pollutants are emitted from industrial, commercial and residential sources, and all mobile sources operated by burning fuels. There are five major primary air pollutants, one or more of which are emitted from the majority of sources. These are: carbon monoxide (CO), particulate matter (PM), sulphur oxides (SOx), nitrogen oxides (NOx) and volatile organic compounds (VOC). Other primary pollutants include lead and other heavy metals. Some species of VOC are hazardous or toxic substances. The major secondary pollutants of concern are ground-level ozone (O3) and fine particles (PM10). The ground-level ozone is formed in the atmosphere through reactions mainly between NOx and VOC on warm sunny days in the presence of sunlight. Fine secondary particles are formed in the atmosphere from SOx , NOx, VOC and gaseous ammonia (NH3) .

Carbon dioxide (CO2) , methane (CH4) and nitrous oxide (N2O) are the major greenhouse gases emitted from human activities. Several synthetic chemicals, or the so-called ozone-depleting substances, emitted into the atmosphere are destroying the protective ozone layer in the stratosphere. Emissions of greenhouse gases and ozone-depleting substances are of major global concern because of their potential impacts on the earth's climate.

Winds move and disperse air pollutants from an emission point to locations downwind, while mixing with ambient air and new emissions from other sources along the way. The pollutants can remain in the atmosphere from a few hours to several years, some even residing for thousands of years, and thus they can travel long distances before their deposition to earth. Some persistent air pollutants can also move up to the stratosphere. Air pollutants are thus subject to complex physical, and even chemical, processes under dynamic atmospheric conditions. Under most circumstances, new secondary pollutants are produced from some pollutants and gases already present in the atmosphere. Weather conditions and geography significantly influence the fate of air pollutants within an airshed. For example, windy conditions can blow pollutants away from the local airshed as well as bring new pollutants inside the airshed from outside; stagnant conditions can build-up air pollutants and restrict them within a valley; and rainy or snowy conditions deposit some pollutants back to the earth.

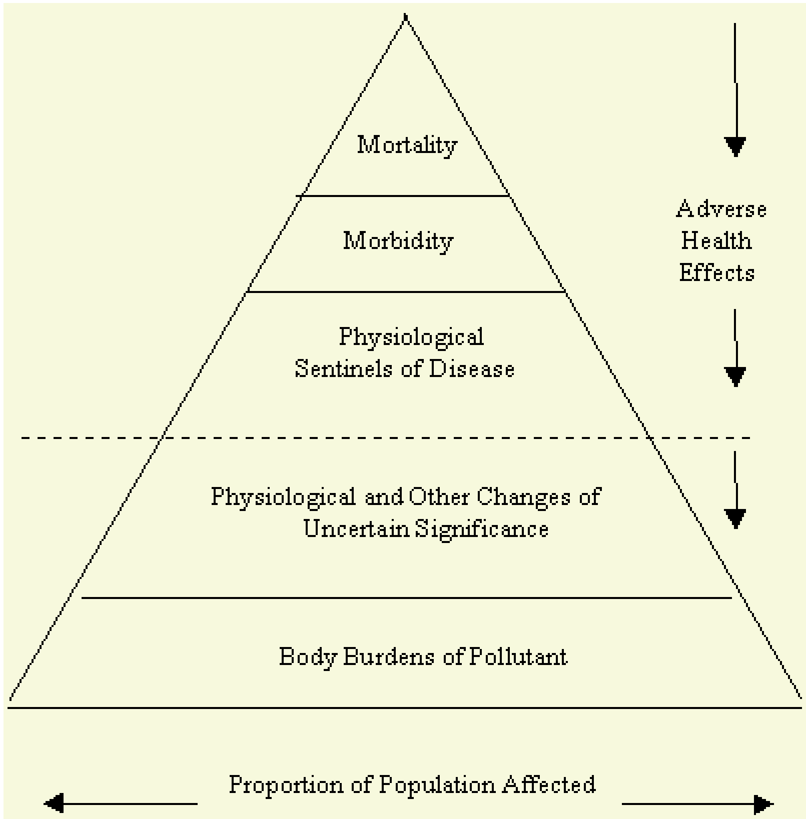
3.4 Effects of Air Pollutants on Health and Environment

Air pollutants affect human beings in adverse ways both directly and indirectly. Direct effects are caused during inhalation of air, as pollutants travel inside the respiratory system along with the air. Human health is affected indirectly through food and water consumption, as several air pollutants have adverse impacts on water, land, animals, fish and wildlife, and vegetation. These consist of five primary pollutants (sulphur oxides, suspended particulate matter, volatile organic compounds, nitrogen oxides and carbon monoxide), ground-level ozone and fine particulates.

Effects on Human Health

Different people react differently when exposed to various types of air pollutants. How an individual will react to a certain air pollutant will depend on his/her health conditions, the type and amount of air pollutant, and how long the person is exposed to it. Some groups within the population - such as children, the elderly and people with respiratory or cardiovascular conditions - may react adversely at a low level of exposure to some air pollutants. However, even healthy individuals develop symptoms of adverse health effects at high exposure levels. Air pollutants vary in their characteristics. While some air pollutants are toxic and life-threatening, there are others which cause illness and physical discomfort. The magnitude of health risk and effects also depends on the duration of exposure to air pollutants, namely acute or short-term and chronic or long-term exposure. The general relationship, as determined by World Health Organization6, between severity of health effects on the number of population exposed to air pollutants and increased frequency of exposure is shown in Figure 1. The known adverse health effects of common air pollutants are listed in Table 3.

Figure 1: Schematic spectrum of biological response to pollutant exposure



Source: World Health Organization, "Manual on Urban Air Quality management", Copenhagen Regional Office for Europe, 1976

Table 3: Adverse health effects of common air pollutants

Pollutant	Most Relevant Effects
Carbon Monoxide	Affects central nervous system, cardiovascular and lung diseases.
Particulate Matter	Fine inhalable particles initiate a variety of respiratory and cardiovascular diseases, exacerbate existing respiratory conditions, and lead to mortality in some cases. Some inhalable particles may also cause cancer.
Lead	Affects mental development and performance, blood formation, nervous, and kidney systems.
Sulphur Dioxide	Acute respiratory functions, aggravation of respiratory diseases.
Nitrogen Dioxide	Aggravation of chronic respiratory diseases and asthma, risk to pulmonary structural changes.
Ozone	Eye irritation, coughing, chest discomfort, increased asthma attacks, decrease in lung function.
Volatile Organic Compounds	Some compounds cause eye irritation, coughing and sneezing, and drowsiness. Several other compounds are toxic and known to cause cancer and affect nervous systems.

(Adapted from Reference 4)

For most air pollutants, adverse health effects are only observed when people are exposed to them above a certain "threshold" concentration of pollutants in the ambient air. However, recent studies have shown that for some pollutants, such as inhalable particulates, no known threshold concentration appears to exist. In other words, human health can be affected even when exposed to very low ambient levels of these pollutants.

Adverse effects of air pollutants on vegetation, animals and materials are summarized as follows:

Effects on Vegetation and Crops

Visible symptoms of air pollution effects are leaf discoloration, leaf necrosis, chlorosis, spottiness, glazing or silvering, and leaf dropping. Non-visible or subtle effects include reduced plant growth, alteration of biochemical and physiological processes, changes in reproductive cycle, reduction in crop yield, and reduction in total biomass.

Effects on Wildlife and Fish

Gaseous and particulate pollutants affect animals and fish directly, and indirectly through their consumption of water and vegetation. Impacts on fish can also occur by deposition of acidic air pollutants on water and alteration of its acidity or alkalinity.

Effects on Materials and Structures

Air pollutants affect metals such as iron, zinc, copper, silver and aluminium by corrosion and loss of surface material, and alteration of electrical properties. Effects of air pollution on building materials and stone sculptures include soiling and deterioration. Air pollutants cause soiling and loss of tensile strength in fabrics, and discoloration of dyes. Some air pollutants also affect paint, paper, leather, glass and rubber.

Air Pollutants and Air Quality

- There are two basic types of air pollutants - primary and secondary.
- Primary pollutants are emitted directly into the atmosphere from their sources.
- Secondary pollutants are formed in the atmosphere by interactions of certain primary pollutants and other gases.
- Air pollutants are emitted from natural sources and human activities.
- Air pollutants reside in the atmosphere from a few hours to even thousands of years.
- Weather conditions and geography of a region affect dispersion of air pollutants from their origin to destination.
- Air pollutants adversely affect human health, animals and wildlife, vegetation, materials and the ecosysytems.

Contents

4. Urban Air Quality Issues

Urbanization with growing population, development and motor vehicle use leads to increasing emissions of air pollutants, and consequently their concentrations in the ambient air are increasing too. Generally, the larger the population in an area, the more polluted is the regional ambient air.

The ambient concentrations and make-up of pollutants in an urban atmosphere depend on the mix of human-made and natural emission sources, the land use pattern, transportation system, population density, industrial and commercial activities and the climate. In addition, several physical and chemical processes influence the form and fate of pollutants moving through our atmosphere. Air pollutants do not recognize geographical boundaries and can travel hundreds or even thousands of kilometres from their origin over a variety of terrain under various weather conditions.

In recent years, our understanding of the atmospheric processes that shape the air quality in different regions has improved. Typically, the major air quality issues which are of common concern to nearly all urban areas include:

- urban 'smog';
- wet and dry deposition of acidic compounds;
- visibility impairment; and
- emissions of hazardous air pollutants or air toxics.

However, because of the regional differences in geographical features, weather conditions, growth patterns, emission sources, and other factors, each urban area faces different air quality issues. Therefore, region-specific air quality issues should be identified and addressed accordingly by each urban government. In addition, there are the global issues of climate change and depletion of the ozone layer in the earth's stratosphere which are of common concern to everyone in the world.

4.1 Urban Smog

The word *'smog'* originated in the UK. in the early 1900s to refer to the unique atmospheric condition resulting from a combination of smoke and fog. In winter the city of London usually experiences dense, stagnant fog. When coal was the main fuel for industry and for home heating in and around the city, there used to be severe episodes of air pollution during foggy days.

The term *"Photochemical smog"* came into use in the 1960s to describe the air pollution condition in Los Angeles, California, U.S.A. Although photochemical smog contains many compounds, its major constituent is ozone which is formed in the atmosphere by reactions between reactive hydrocarbons, commonly known as volatile organic compounds, and nitrogen oxides on warm sunny days.

Only recently has the term *"urban smog"* been used to describe what people see as polluted, brownish, hazy air hanging over urban areas and their vicinities. On occasion, some people in these areas find the air difficult to breathe. As it is known now, urban smog is a mixture of many air pollutants. The main components of urban smog are ozone gas and small solid and liquid particles.

Ground-level Ozone

As mentioned above, ground-level ozone is a secondary pollutant as it is formed in the atmosphere. It is produced mainly on warm sunny days through reactions among certain primary, or directly emitted, pollutants. The major ozone-forming air pollutants, or ozone precursors, are volatile organic compounds (VOCs) and nitrogen oxides (NO_x).

Sources - In urban areas, the majority of VOCs and NO_x are emitted from human activities, and contributions from natural sources are relatively small. Nitrogen oxides are produced during the combustion of fossil fuels (coal, oil and gas), and biomass (wood and wastes, including dry agricultural and animal wastes). Fuels are used in transportation, electricity generation, and industrial and commercial operations. The predominant energy source for cooking and heating is also the burning of fuels, wood and some wastes. In urban areas, motor vehicles are the major sources of NO_x emission. Some chemical manufacturing processes also generate nitrogen oxides, but these are not as widespread as fuel, wood or waste combustion.

The sources of VOC emission are numerous and widespread. Natural sources of VOC include trees and vegetation. The major human activities which generate VOC include: combustion of fuels, wood and wastes, industrial processes, evaporation of gasoline and other volatile fuels, and use of organic chemical and solvents.

Inhalable Particulate Matter

Particulate matter suspended in the atmosphere is generally less than 40 microns in diameter (one micron is one-thousandth of a millimetre). It consist of a mixture of solid and liquid materials that can include dust, smoke, soot, salt, metals and acids. Inhalable particles are very small, less than 10 microns in diameter and commonly known as PM_{10}. These sizes of particles are generally subdivided into a coarse fraction of those between 10 and 2.5 microns, and a fine fraction of particles 2.5 microns or smaller, or the so-called $PM_{2.5}$. Lately there has been an increasing concern over $PM_{2.5}$ particles because of their potential impacts on human health and environment.

Minute PM_{10} and $PM_{2.5}$ particles can bypass the body's natural defences and directly enter deep inside the lungs, and thus cause adverse health effects mentioned above. Fine particles are also responsible for much of the haziness of the atmosphere.

Sources

Primary particles arise from both natural and human activities. Natural sources include wind erosion of land and soil, sea sprays, volcanic eruption, forest fire and biological materials, such as pollen, spores and bacteria. Human activities which generate primary particles are: crushing and grinding of materials, construction and demolition, agricultural operations, road dust, and combustion of fuels, wastes, and wood and agricultural wastes.

As for the precursors of secondary particles, typical sources of NO_x and VOC are described above under "Ground-level ozone". Major sources of SO_x emission include the combustion of fuels and wastes containing sulphur, and industrial and commercial operations that process raw materials with sulphur. Ammonia gas is emitted mostly from agricultural activities, including animal husbandry. It is also discharged in small quantities from a variety of other activities such as fuel combustion, chemical industry and refrigeration.

4.2 Acidic Deposition

Acidic deposition is commonly known as acid rain. It occurs when air pollutants like oxides of sulphur and nitrogen are converted in the atmosphere into sulphuric and nitric acid droplets, and sulphate and nitrate particles. These acidic substances are deposited back to earth's surface as dry particles or with rain, fog or snow.

Sources

The sources of emission of sulphur and nitrogen oxides are mentioned above. Inhalable acidic aerosols and particles adversely affect human health.. Dry and wet deposition of acidic substances on earth's soil, water and vegetation cause changes in the acidity of the receptor and damages the delicate ecosystems of rivers, lakes and the plant life in them. Deposition of acidic pollutants damages building materials, metals, glass, stone sculptures, leather, fabrics and paper.

4.3 Atmospheric Haze and Visibility Degradation

One of the obvious signs of poor air quality in most urban areas is the haziness of the atmosphere. It sometimes occurs even during the peak hours of the daytime in some urban areas. Atmospheric haze produces poor visibility by reducing the ability of the human eye to see objects at a distance clearly. The conditions which promote haze formation are complex, and depend on weather conditions and air pollution levels. High levels of water vapour, and pollutants such as fine particles, ozone and nitrogen oxides are usually associated with haze and poor visibility.

4.4 Hazardous Air Pollutants

Hazardous air pollutants (HAPs), or the so-called air toxics, are mostly chemical substances and trace metals present in the atmosphere as gas, liquid droplets and solid particles. These pollutants are known to cause adverse health effects, including cancer, birth defects, nervous system disorders and genetic damage. HAPs also impact on other media of the environment through contamination of soil and water. Some of these HAPs are quite pervasive and persistent in the environment. HAPS can also gradually build up in the food chain and adversely affect animal and human, its consumers. People are exposed to different levels of different HAPs. Some HAPs can cause immediate adverse effects on some people even through limited exposure, while others cause health problems only after prolonged cumulative exposure over a number of years.

Sources

HAPs have come into existence since the beginning of the chemical industry. Manufacturing and use of chemicals are cornerstones of modern society, but hundreds of these chemicals of different types are released into the environment in varying quantities. HAPs are released into the atmosphere as volatile organic compounds and particles from a variety of sources. They are discharged from industries, chemical plants, motor vehicles and small- and medium-size businesses, such as gasoline service stations, metal fabrication shops, paint shops, and users of various chemical solvents. Some pesticides and herbicides are also persistent HAPs.

4.5 Global Air Quality Issues

As mentioned in a previous section, the issues of global climate change and ozone layer depletion are currently the major concern for the world. This is primarily because these issues have the potential to change the earth's climate system and thus to affect all living beings on the planet.

Global Climate Change [5, 8-11]

As mentioned previously, the earth's average temperature has been maintained by the so-called greenhouse gases (GHGs) to make it livable. These gases maintain a balance between the energy reaching the earth and that escaping into space. Human activities, particularly since the 19th century Industrial Revolution, have been upsetting the earth's energy balance by releasing more GHGs and other substances, as well as through deforestation and land use. The increased levels of these gases in the atmosphere are warming the average surface temperature of the earth by trapping more heat, as more energy is retained in the earth's atmosphere than is lost in space.

> *Several chemical compounds belonging to another group of human-made substances, the so-called ozone-depleting substances (ODS), also contribute to global climate change. As ODS are associated with stratospheric ozone depletion, another global air quality issue, these are described separately below.*

Firm evidence now exists for the global climate change over the past 100 years, particularly the warming trend of the earth's atmosphere. Direct measurements indicate that the average global surface temperature has risen by nearly 1° C during the 1860 -1998 period, and the 11 warmest years on record have occurred since 1982. In this last decade, 1998 was reportedly the warmest year, which according to some quarters was the warmest year of the last 600 years. According to the experts, if things continue on pretty much the same way, the global surface temperature could increase by 1.5° to 4.5° C by 2100. If that happens, the earth's temperature will rise at a rate more rapid than any observed during the last 10,000 years.

Sources

The most common GHGs, namely carbon dioxide, methane and nitrous oxide, are emitted from both natural and human-made sources. It should be noted that although water vapour is another GHG, human activities do not affect it directly. Carbon dioxide is the single most important greenhouse gas. Major natural sources include volcanic eruptions, forest fires, living organisms, decomposition of vegetation and animal material, and soil. The primary human-made cause of carbon dioxide emission is the burning of fossil fuels such as coal, oil and gas. Deforestation also contributes indirectly to the build-up of carbon dioxide by removing the sinks for the gas, and by the release of the carbon stored in the trees.

Other human activities which release methane, nitrous oxide, and other GHGs include: coal mining, oil and gas exploration and distribution, solid and liquid waste disposal and treatment, and agricultural practices including rice paddies, and raising cattle and livestock.

Potential Impacts

Greenhouse gases have different lifetimes in the atmosphere. For example, while methane can remain in the atmosphere for 11 years, the lifetime of some ODS ranges from 10,000 to 50,000 years. Each greenhouse gas also has a different capacity, or global warming potential (GWP), to intensify the greenhouse effect. The GWP of GHGs varies widely, and that of some gases is thousands of time greater than that of carbon dioxide.

Because of the complexity of the global climate system, it is hard to predict exactly how a rapid increase in global temperature will affect us. The consensus among scientists is that an increase in the earth's surface temperature at an unnaturally fast rate will have ramifications to be felt in every corner of the world. Although computer models used to assess climate change impacts are not advanced enough for accurate predictions, it is projected that warming of the atmosphere could affect life on earth in several ways, as listed below:

- adverse impacts on human health;
- changes in regional weather patterns;
- shifting of agricultural and forest zones;
- rise in sea levels;
- changes in the quantity and quality of water resources;
- alterations in natural ecosystems; and
- impacts on social and political structures.

Efforts to Mitigate Global Climate Change

Uncertainties still remain about the details of the problem, the extent of its impacts, and the manner in which the effects will be felt. In spite of uncertainties, the countries of the world agreed to initiate actions following the *'precautionary principle'* to address the problem through the 1992 United Nations Framework Convention on Climate Change at the Earth Summit in Rio de Janerio.

> *Subsequently in December 1997, a Protocol to the United Nations Framework Convention on Climate Change was adopted by over 160 nations in Kyoto, Japan. One of the most important provisions of the Kyoto Protocol set binding limits on emission of GHGs for 38 developed countries (Annex B Parties), which are most responsible for the current emission levels. These countries are to reduce emissions by an average of 5.2% below 1990 levels in the years 2008 - 2012. The Protocol also provides significant incentives for developing countries to control their emissions as their economies grow.*

Ozone-Depleting Substances [10, 11]

As discussed in the previous section, a layer of ozone in the stratosphere, or upper atmosphere, protects the earth by shielding it from harmful intense ultra-violet (UV) radiation. Since the 1930s the chemical industries have been producing a group of synthetic chemicals containing carbon and halogens (chlorine, bromine and fluorine). These chemicals include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), brominated fluorocarbons (halons), carbon tetrachloride, methyl bromide and methyl chloroform. In the 1970s it was

discovered that intense ultraviolet radiation from the sun in the stratosphere could break loose chlorine and bromine atoms from these chemicals. The loose chlorine and bromine atoms then could attack and destroy the ozone layer. Further evidence since then, in particular the discovery of the depleted ozone layer or so-called *"ozone hole"* over Antarctica, has confirmed the destructive potential of these chemicals. Because of their ability to deplete the ozone, these chemicals are commonly called ozone-depleting substances or ODS.
The ozone-depleting substances (ODS) are extremely stable, and some of them could remain in the atmosphere for several hundreds of years and move up to the stratosphere. That means, one of these substances discharged into the atmosphere now may still float in the stratosphere and destroy the ozone layer hundreds of years in the future.

Sources
The ozone depleting substances have been used widely for a variety of purposes - as a cooling agent in refrigerators and air conditioners in houses and cars, as a foaming agent for manufacturing insulation and paddings, as propellants in aerosol spray cans, as solvents and cleaning fluids, as a sterilant in hospitals, and as a fire-extinguishing agent.

Potential Impacts
The destruction of stratospheric ozone by ODS has a complex role in the global climate change phenomena. The depleted ozone layer allows increased ultra-violet (UV) radiation from the sun to reach the earth, and thus it warms the troposphere. In different ways, increased UV radiation can affect almost everything on earth, namely human health, animals, vegetation, marine and freshwater organisms and fish, and materials.
The decrease in ozone concentration also leads to some cooling of the stratosphere, as a result of its reduced ability to absorb solar energy. Moreover, it is now recognized that some ODS, in particular CFCs and HCFCs, are powerful greenhouse gases in their own right. Since the stratospheric ozone layer protects the earth, the resultant impacts of its thinning or disappearance are to be felt globally one way or another.

Phasing out of ODS
Because of this global concern, the use of major ODS is being phased out worldwide under the international agreement known as 1987 Montreal Protocol and subsequent amendments to it signed in London (1990), Copenhagen (1992) and Nairobi (1994).

Key Trends in Urban Air Quality

- More than 1.1 billion people worldwide live in urban areas with unhealthy air quality.
- Air quality issues facing an urban area depend upon the region's geography, weather and sources of air pollution.
- Typical air quality issues common to most urban areas include: urban smog, acidic deposition, visibility deterioration and toxic air pollutants.
- Increasing local emissions of air pollutants are contributing to global issues of concern.

Contents

5. Air Quality Management Plan Development Process

Faced with rapid growth and deteriorating air quality, urban areas require re-examination of the situation and fresh approaches to addressing the need for air quality improvement. Urban air quality issues have thus far been often overlooked, or not considered as a priority, in several jurisdictions, particularly in the metropolitan areas in developing countries. However, considering the importance of clean air from both local and global perspectives, it is not too soon to address urban air quality issues by developing and implementing an Air Quality Management Plan.

An AQMP describes the present state of the urban air quality and how it has been changing in recent years, and what could be done to ensure clean air quality in the region. It provides goals and objectives for the urban region, and prescribes both short- and long-term policies and control strategies for improving air quality in the region.

What is an Air Quality Management Plan (AQMP)?

- An AQMP sets a course of action that will result in the attainment of air quality goals in an airshed or airbasin. It will require actions by the government, business, industry, and the population at large, as its success will depend on cooperation of all segments of the society.

A framework for development and implementation of an urban Air Quality Management Plan, which is often referred to as AQMP or Plan in the rest of the report, is provided in the following sections. The framework provides general guidelines and brief descriptions of their key elements. The guidelines could be followed sequentially as listed below. However, in order to conform to regional requirements, a particular urban authority may design a different sequence of Plan development.

- development of AQMP policies, goals and objectives
- determination of jurisdictional roles in the Plan development
- selection of air pollution control strategy options for an AQMP
- identification of air quality issues
- development of emission reduction strategies and measures
- implementation of the Plan and tracking of its progress
- assumption of an environmental stewardship role by the local air pollution control agency, and
- allocation of resources for AQMP development and implementation.

Involvement of the public and stakeholders in the development and implementation of an AQMP is considered to be an important part of the whole process. Their input should be sought at different stages of the process, as deemed necessary by the urban authority. An outline of the public consultation and participation process is provided in a separate section in this report.

5.1 AQMP Goals, Policies and Objectives

Recognizing that an urban airshed is a limited natural resource shared by all, sound development policies and decisions to achieve sustainable solutions should reflect environmental, economic, social and cultural values. Air pollution in an urban area is relatively a more difficult problem to control than management of water or land contamination. Atmosphere is a highly dynamic and variable system influenced by the sun's radiation, the earth's gravity and its spin. Continuous emissions of pollutants into the atmosphere from natural sources and human activities, atmospheric dispersion and transformation of pollutants, and their transport over long distances are the major factors which make air quality management problematic. In addition, several air pollution-related policy initiatives at other levels of government, and some international initiatives, have broadened the scope that regional authorities need to address.

In various countries, the overall goals and the basic principles of environmental management are set out through legislative means. Such goals and principles could be used as guidance by the local authorities to formulate their own set of goals and policies for regional air quality management plan development. Based on a review of several recently developed regional AQMP, a list of possible criteria for setting policies and goals is presented below as a general guide. All these criteria may not be applicable everywhere, but several of them can be adapted to address unique air quality problems in a region and to conform to specific legal and socio-economic situations:

- protection of human health and environment, ·taking local actions to address global climate change issue,

- cleaning up of dirty areas first and maintaining areas with clean air by prevention of any further deterioration of air quality,
- attainment of ambient air quality standards for all pollutants or pollutants of concern only,
- attainment of ambient air quality standards in selected areas of the region,
- application of the best available technology to reduce emissions of all or selected pollutants from all or selected sources, irrespective of costs,
- application of the best available technology economically achievable to reduce emissions of all or selected pollutants from all or selected sources,
- reduction of greenhouse gas emissions uniformly across the region or from selected sources only,
- virtual elimination of emission of hazardous air pollutants from all sources,
- reduction of hazardous air pollutants from all sources through maximum achievable control technology,
- achievement of desired air quality goals irrespective of costs,
- equalization of emission reduction costs and social benefits,
- achievement of net benefit to the society through improvement of regional air quality and reduction in emissions of greenhouse gases.

AQMP Objectives

The objectives of an AQMP should be to put in practice the stated policies and goals set by the regional policy-makers. Their formulation is the initial step towards development of an overall emission control strategy. The AQMP objectives will largely depend on the policies and goals set by the local authority. Typically, an AQMP should be:

- effective - in achieving the desired air quality goals
- efficient - in both technical and economic terms
- fair and just - fair allocation of emission reduction responsibilities to all sources
- flexible - allowing for uncertainties in the Plan and mid-course revisions, if required
- transparent - easily understandable by all
- supportable - has the support of all stakeholders including agencies, elected officials, and the public
- implementable - control strategies can be put in place in a timely and efficient manner.

5.2 Jurisdictional Roles

In many countries, traditionally local authorities have been set up for the primary purpose of administering social and community matters within their designated political boundaries. However, air pollution by nature does not remain confined within a politically bounded area. The sources of air pollution and their receptors are also not necessarily situated within the jurisdiction of a traditional local authority. Because of the regional geography and weather conditions, air pollutants can be carried by wind across jurisdictional boundaries, a phenomenon commonly called as trans-boundary pollution. Therefore, regional management of air pollution is best done on an airshed or airbasin basis, which is defined as the geographical area which experiences similar air quality issues caused by local and regional sources of air pollution. Depending on the location, an airshed could encompass land areas governed by several local authorities.

In most cases, the responsibilities for different air pollution sources within an airshed lie with local, regional and national agencies. Within a local government, different agencies are usually responsible for functions such as air quality management, transportation and land use planning, which have impacts on local air pollution problems. All these agencies under different authorities may operate from fundamentally different *perspectives, depending on their mandate and t he training of their personnel. In addition, each agency has its specific mandate, which may overlap, complement, or even on occasions contradict that of the others.*

Because of involvement of multiple organizations, a partnership approach to regional air quality management would be desirable. Through a joint planning effort the authorities will be able to address common regional air quality related issues and concerns. A partnership approach will provide opportunities for the authorities to consolidate their resources in developing an appropriate regional air quality management plan. Cooperation and coordination among agencies are essential, but not necessarily a simple task. Where jurisdictional overlaps and conflicts arise, efforts must be made to overcome and proceed with AQMP development and its subsequent implementation. The potential lack of coordination among these various authorities may inhibit development of a coherent and effective air quality management plan.

In view of the above, establishment of a good institutional relationship during early stages of AQMP development is considered essential. It will also ensure that the needs and concerns of the parties involved are properly identified and resolved. An initial step in the AQMP development process should be to identify lead agencies to coordinate and manage distinct tasks of the project. If a selected lead agency does not have the authority to act on certain matters related to the task, institutional barriers should be removed to empower the agency to fulfill its responsibility. The multi-agency partnership approach will also be helpful in building support during subsequent implementation of the Plan.

5.3 Emission Control Strategy Options

Because of the recent advancement in knowledge about environmental protection, several new innovative approaches to urban air quality management programs, growth management and transportation strategies are being applied to reduce air pollution in several jurisdictions around the world. Experience to date in Europe and North America indicates that when a traditional regulatory approach is combined with alternative approaches, it can achieve emission reductions and air quality goals in a cost-effective manner in several instances.

For an effective long-term air quality management strategy, one or more of these alternative approaches to emission control should be considered along with conventional regulatory tools. Therefore, a window of opportunity exists for urban policy-makers to formulate a policy on consideration of alternative approaches to emission control during development of regional air quality management plans.

5.3.1 Traditional Emission Control Strategy

Traditional air pollution control approaches have been to rely entirely on enforceable *'command and control'* rules and regulations based on technology to limit emissions from sources. The control technology is usually aimed at reducing emissions at the *'end-of-pipe'*, after the pollutants have been generated. It can ensure that industry and business implement necessary control measures to comply with regulatory requirements for emission reductions within a short-term scheduled period. Where they have been applied to date, such technology-forced solutions have achieved significant emission reductions from various sources and improved regional air quality.

However, such *'command-and-control'* approach also has its limitations, and in instances can produce unintentional negative impacts. In many cases it has been costly, contentious, and often even ineffective as a long-term strategy. During the past few years it has also been recognized that regulatory approaches hardly provide any incentive to the regulated sectors for reducing any more emissions than required by the authority. These methods of emission control also appear to inhibit development of advanced control techniques or innovative approaches to reduce emissions.

Another potential negative result of the *'command-and-control'* approach could occur when there is a need for continued reduction of emissions from major emission sources. Once the easily controllable emissions are reduced, any additional emission reduction from the same sources becomes increasingly costly. Besides, there are various small sources that are either under-regulated or unregulated because of social and political reasons.

5.3.2 Alternative Emission Control Strategies

Needless to mention that the *'command-and-control'* method has its place in air pollution control. However, there are alternative strategies to emission control that should be explored for application in an urban air quality management program. Some of these approaches include:

- integrated air quality management
- application of economic instruments
- provision of operational flexibility to source operators
- implementation of pollution prevention measures and clean technology, and
- adoption of a precautionary principle or proactive approach

Integrated Air Quality Management

Until recently, efforts to improve urban air quality have generally been restricted to a single issue such as smoke, particulate matter, ground-level ozone or acidic deposition. However, the present understanding of the regional, and global, air quality issues strongly favours an integrated air quality management approach to address a number of issues together. There are several common important factors, such as contributing pollutant characteristics, sources of their emissions, and similar health and environmental impacts, which contribute to a number of air quality issues.

Common Characteristics of Pollutants

The inter-relationship of contributing pollutants and precursor gases to these air quality issues is illustrated in Table 4, and highlighted below:

- five common air pollutants give rise to most local air quality issues;
- nitrogen oxides and volatile organic compounds are precursors of both inhalable particulates and ground-level ozone;
- nitrogen oxides and sulphur oxides are major constituents of acidic deposition;
- sulphur oxides contribute to inhalable particulates;
- fine particles and sulphur dioxide have impacts on visibility deterioration and global climate change; and
- all pollutants and gases cause health and environmental effects, directly and indirectly.

Table 4: Air pollutants contributing to air quality issues and impacts

Air Quality Issue or Impact	**Pollutant and Gas**									
	CO	VOC	NO_x	SO_x	PM	NH_3	CO_2	CH_4	N_2O	CFCs
Smog Ground-level ozone Inhalable particulates	 * 	 + +	 + & - +	 +	 +	 +				
Visibility degradation		+	+	+	+	+				
Acidic deposition			+	+						
Hazardous air pollutants		+			+					
Global climate change	+	+	+	-	-	-	+	+	+	+
Stratospheric ozone depletion										+
Health impacts	+	+	+	+	+	+	+	+	+	+
Environmental impacts		+	+	+	+	+	+	+	+	+

• minor contribution
+ positive impact (direct and indirect)
- negative impact (direct and indirect)

•

CO -	carbon monoxide	VOC -	volatile organic compounds
NO_x -	nitrogen oxides	SO_x -	sulphur oxides
PM -	particulate matter	NH_3 –	ammonia
CO_2 –	carbon dioxide	CH_4 –	methane
N_2O –	nitrous oxide	CFCs –	chlorofluorocarbons

Common Pollutant Sources

As shown in Table 5, several common categories of sources contribute to most air quality issues through emission of common air pollutants. It is evident from the table that the pollutants which contribute to most air quality issues are emitted mainly from combustion-related sources. Common sources can be controlled through similar control techniques to reduce emissions of these pollutants. Development of control strategies for more than one pollutant from a particular source sector would reduce emissions to address several air quality issues, and it may be cost-effective in the long run.

Table 5: Air pollutant emission sources contributing to air quality issues

Air Quality Issue Contributing Source of Air Pollutant Emission

Air Quality Issue	**Contributing Source of Air Pollutant Emission**						
	Industry and Utilities	*Trans-portation*	*Agri-cultural*	*Waste disposal*	*Residential/ Institutional*	*Fugitive*/ Natural*	*Long-range transport*
Smog Ground-level ozone Inhalable particulates	yes yes	yes yes	yes yes	yes yes	yes yes	yes yes	yes yes

Visibility degradation	yes	yes	yes	yes	yes	yes	yes
Acidic deposition	yes	yes		yes	yes		yes
Hazardous air pollutants	yes	yes	yes	yes	yes		yes
Global climate change	yes	yes	yes	yes	yes	yes	yes
Stratospheric ozone depletion	yes	yes	yes		yes		yes

* including road dust re-entrained by motor vehicles

Because of these similarities, it is logical to pursue an integrated multi-effect/multi-pollutant comprehensive strategy for effective management of urban air pollution problems. Such an approach will also ensure that a chosen solution for one air quality issue will not create negative consequences for another air quality issue. A coordinated evaluation of several air quality issues together can lead to the development of integrated management policies. It will avoid separate regulations to address different issues. It will also require reduced efforts by emission source operators to comply with regulations.

Economic Instruments

Economic instruments, or market-based economic incentives, for air pollution control include emission fees, emission reduction credits, tradable permits and tax incentives. However, application of the appropriate instrument has to be determined for each specific situation and for the each source category. When used together with conventional regulatory methods, economic instruments provide the affected sources with incentive and flexibility to decide how to attain the overall emission reduction goal in a cost-effective manner. Thus the economic impact of emission reduction from the source is reduced without affecting the overall environmental objectives.

Operational Flexibility

Examples of operational measures include provisions for limiting emissions on a facility-wide basis and requirements for spatial and temporal emission reduction programs. A facility-wide emission, also known as emission bubble or cap, approach provides a particular facility some flexibility to comply with regulatory requirements. Under the traditional approach, an emission source with several emission points within the facility is required to control and comply with permitted emission from each point individually. The emission bubble approach places a conceptual dome over the facility and treats it as one point source with maximum emission limits for different pollutants from the entire facility. The facility operator is authorized to use the most cost-effective mix of control techniques to comply with permitted emission requirements. This allows the operator to decide which emission points need to be controlled and how without incurring unnecessary control costs.

Spatial and temporal emission reduction programs also offer a potentially viable method of reducing overall emissions within the airshed. By identifying emission *'hot spots'* within the airshed, special efforts can be made to reduce emissions from particular sources in those areas, thus narrowing the degree of control in the entire urban area. Similarly, ambient air quality levels of pollutants in an urban area are not uniform throughout the year. The concentrations of different pollutants typically show seasonal, and even daily or hourly, variations. An opportunity, therefore, exists for flexible requirements for emission reduction at selected sources at different times.

Pollution Prevention and Clean Technology

Pollution prevention methods are primarily preventative environmental management tools. As opposed to the traditional and reactive *'end-of-pipe'* control techniques, these approaches are geared towards controlling generation and emission of air pollutants proactively during production. There is an inherent danger of misunderstanding of the word *prevention* within an environmental context, as in most cases these measures do not necessarily prevent pollution *per se*. Rather these actions minimize generation and subsequent discharge of pollutants through a combination of changes in raw materials, production techniques, reuse of waste materials and good housekeeping practices. New production technologies, or the so-called clean technologies, have also been developed to replace old processing and manufacturing practices. The primary objectives of these techniques are to produce goods in a cost-effective manner with minimum discharges of pollutants and less consumption of energy and raw materials. In recent years, several air pollution control agencies have also initiated technology or equipment certification programs. The equipment or technology is developed to produce minimum emissions, and certified accordingly by the agency before installation and use within the jurisdiction.

Precautionary Principle Strategy

As mentioned above, the prevalent strategy for emission control to date has mostly been reactive, that allows some emission of air pollutants from sources, irrespective of any long-term impacts of the residuals on health and environment. There are instances where emission of pollutants has been allowed to continue even after some evidence of environmental damage has been identified, because there were uncertainties about the direct proof of a cause-and-effect linkage between particular pollutants and observed damages. However, there is ample evidence of the presence in the atmosphere of several toxic and persistent pollutants which are continuing to be emitted as a result of human activities.

The concept of the precautionary principle is a policy that could be considered as a preventative approach in developing a long-term strategy for addressing urban air quality and global climate change issues. This approach is based on *'better-safe-than-sorry'* principle, and it proactively prevents emission of pollutants at the source, when there is reason to believe that harmful effects or environmental damages are likely to be caused by them. Because of this premise and the economic realities, the precautionary approach is still somewhat controversial among the scientific community and policy-makers.

Strategy for Timing of Emission Reduction

The timing of emission reductions has a significant impact on control costs and the benefits of improved air quality. In some instances, postponing emission reduction measures may save some money, because the cost per tonne of emission reduced is likely to go down with time. This is mainly based on the assumption that the costs of current control technologies will go down or improved techniques at similar costs will become available in the near future. However, the trade-off of such a delay in implementing control measures would be to live with the consequences of worsening air quality and the resulting direct and indirect costs of adverse human health and environmental effects in the region.

5.4 Problem Definition or Identification of Air Quality Issues

The prevalent air quality issues within an airshed are identified by assessment of existing air quality monitoring results and the emissions of air pollutants from all sources in the region. The potential future air quality can be determined by application of an air quality model and emission forecasts data.

5.4.1 Air Quality Monitoring Data Assessment

In order to determine the quality of the ambient air in the region, it is necessary to carry out a detailed analysis of the regional air quality monitoring data. The results of such analysis indicate whether the concentrations of the pollutants monitored are below or above the applicable ambient air quality standards. As a reference, a summary of World Health Organization Air Quality Guidelines12 for several pollutants is shown in Table 6. Depending on how many pollutants have been monitored, number of monitoring locations and over how many years they have been monitored, the results will also provide information on the trends in the levels of air pollutants that have been monitored. Such assessment of air quality monitoring data also identifies the deficiencies in the existing monitoring program and the areas for improvement.

Table 6: A summary of World Health Organization Air Quality Guidelines

Pollutant	**Time-weighted Average**	**Averaging Time**
Sulphur dioxide	500	10 minutes
	350	1 hour
	100 – 150 [1]	24 hours
	40 – 60 [1]	1 year
Carbon monoxide	30	1 hour
	10	8 hours
Nitrogen dioxide	400	1 hour
	150	24 hours
Ozone	150 - 200	1 hour
	100 - 120	8 hours
Suspended particulate matter Measurement method		
Black smoke	100 – 150 [1]	24 hours
	40 – 60 [1]	1 year
Total suspended particulates	150 – 230 [1]	24 hours
	60 – 90 [1]	1 year
Thoracic particles (PM_{10})	70 [1]	24 hours
Lead	0.5 - 1	1 year

All units are in micrograms per cubic metre, except for Carbon monoxide which are in milligrams per cubic metre.

1 Guideline values for combined exposure to sulphur dioxide and suspended particulate matter (they may not apply to situations where only one of the components is present).

Source: "Urban Air Pollution in Megacities of the World", World Health Organization, London: Blackwell Reference Publishing, 1992.

5.4.2 Emission Inventory

An emission inventory is an accounting of all air pollution sources within a geographical area. It serves as a repository of information on:

- type and number of emission sources
- source location
- source activity rate
- air pollution control technology used at each source
- quantity of pollutants emitted from each source.

Typically, it is common practice to include all stationary and mobile sources, as well as natural sources of air pollution in an emission inventory. Stationary sources are usually divided into two major categories: point and area sources. In general, large industrial sources (e.g. petroleum refineries, power plants) fall into the point source category, although in some local jurisdictions all sources that operate under a permit from the authority are classified as point sources. Area sources generally include all other stationary sources (e.g. gasoline service stations, printing shops) which are spread all over the region. Individually, area sources are small emitters of pollutants, but collectively emissions from some area sources can be significant. Mobile sources are also classified into two categories: on-road motor vehicles (e.g. cars, buses, trucks, motorcycles) and off-road sources (e.g. railways, aircraft, ships and boats).

Traditionally, emissions estimates have been made for five common air pollutants, namely carbon monoxide, sulphur oxides, nitrogen oxides, volatile organic compounds and particulate matter. Lately, however, several agencies are also doing emission estimates for different sizes of particulate matter, different species of volatile organic compounds, and for greenhouse gases.

An inventory system can be designed for any desired spatial and temporal resolution. Emissions can be estimated and reported for all sources within (i) an entire airshed, (ii) an urban administrative region, (iii) each municipality within an urban area, or (iv) gridded areas covering the whole region, for example grids of 10 km long and 10 km wide. While an inventory is usually done on an annual basis for a calendar year, it can be designed to provide emission estimates for shorter periods, say on a seasonal, monthly, daily or even hourly basis. An AQMP is developed based on an emission inventory for a "baseline year", which is defined as a reference year for emissions against which past and future emission changes can be compared.

An emission inventory is one of the cornerstones of a regional air quality management plan development. It is also used for later tracking of progress in implementation of the AQMP. Therefore, the quality of an inventory, in terms of source types and accuracy of emission estimates, is very important. Without a detailed and accurate emission inventory, it is difficult to develop an effective air quality management plan.

5.4.3 Air Quality Modelling

Broadly speaking, an air quality model is a mathematical technique that produces an estimation of ambient air quality characteristics of an air pollutant at a desired location within a region. As mentioned in an earlier section, there is a wide variety of emission sources - small and large, stationary and mobile, and fugitive sources. Types of pollutants also vary depending on the sources, and they are emitted at different levels ranging from high up in the air from tall stacks to ground level from motor vehicle exhaust pipes. Once pollutants are emitted into the atmosphere, local weather conditions play an important role in the dispersion of pollutants within the region.

In a very complex fashion, all these factors determine the pathway and fate of air pollutants from their origins of emissions to their destinations. Monitoring of ambient air quality concentration of a pollutant provides only, more or less, its final state in the atmosphere near the monitoring site. The monitoring results do not provide any information on the source of its emission or other influencing factors.

Ideally, measurements of ambient concentrations of air pollutants are the best means of evaluating the state of the air quality in an urban area. In reality, however, monitoring of air pollutants at all locations within a large area is impractical. Therefore, air quality models are designed to simulate ambient concentrations of air pollutants monitored at different locations within the region. These models are then used to estimate ambient levels of air pollutants at any desired location within the airshed. An air quality model can be either simple or complex, depending on how its results would be used. The credibility of a model is determined by comparing its results with actual air quality monitoring data, and it depends on how good and reliable are the model input data. The most important model input data required are those for regional emissions and weather conditions.

Currently, several types of air quality models are available for different pollutants. However, as most regional airsheds have unique meteorological conditions, physical features and emission sources, region-specific air quality models must be developed using local data. Development of a reliable regional airshed model is a time-consuming exercise, and requires considerable resources. However, once a model is developed, its further application becomes relatively cheap.

Air quality models are essential for assessment of emission reduction strategies to determine their impacts on ambient concentrations of air pollutants within an airshed. Therefore, they are important tools for decision-making, policy formulation and air quality management plan development.

5.4.4 Forecasts of Urban Growth, Emissions and Air Quality

A regional air quality management plan is usually developed for a certain period in the future from a current baseline or reference year. Typically, a 10-year Plan is initially developed to achieve the desired goals. In order to determine what the future air quality situation will be in the region during the lifetime of the plan, it is essential to have information on projections of several factors.

The major factors which influence the regional air quality include projected growth in urban population, industrial and economic activities, motor vehicle use, and emissions of pollutants. Based on the above information, forecasts of emissions from the baseline emission inventory results are made. These projected emissions will represent the *'business-as-usual'* scenario of air pollution within the regional airshed. Under this scenario, it is assumed that no extraordinary emission reduction measures will be implemented other than those required under the existing regulations.

Emissions forecast data are used as input to the regional air quality models for prediction of future concentrations of pollutants in the ambient air at various locations within the airshed. The model results of future air quality under the *'business-as-usual'* scenario are assessed to determine the extent of emission reductions that would be necessary to achieve the AQMP goals.

5.5 Regional Air Quality Issues and Their Priorities

Air quality monitoring data and emission inventory results identify the current air quality issues facing an airshed. Forecasts of emissions and air quality indicate the issues that are likely to be faced in the future. On the basis of current scientific information, each issue is assessed as to its potential impacts on human health and welfare, vegetation, material, aesthetic matters and global climate change. A common set of criteria allows determination of the relative severity of impacts of air quality issues currently facing the airshed, or anticipated in the future. Air quality issues are thus ranked or prioritized for addressing by the local authority.

Not all air quality issues may have the same severity in the airshed, and it is usually beyond the ability of an urban authority to simultaneously address all of them within the period scheduled for the AQMP development. Therefore, it is up to the decision-makers to determine which air quality issues are to be dealt with and when. After considering relevant matters, including input from stakeholders and the public, they can decide on the schedule for addressing the regional priority air quality issues.

5.6 Development of Emission Reduction Measures

Once a decision on the priority air quality issues to be addressed is made, the focus of planning should be turned to the task of identifying which pollutants are contributing to these issues and what are their emission sources. Such identification of particular pollutants and their sources will narrow the scope of the task of assessment and selection of emission reduction measures.

5.6.1 Pollutants to be Controlled

As some air quality issues are due to secondary pollutants, both primary pollutants and precursors of secondary pollutants need to be identified for control. Where the issue of inhalable particulates needs addressing, the precursor gas ammonia should also be a candidate for control. In order to address the global climate change issue, reductions in emissions of greenhouse gases and ozone-depleting substances would be necessary.

5.6.2 Emission Sources to be Controlled

For obvious reasons, natural sources of emissions in an urban area are uncontrollable. Therefore, to start with, all emission sources of human activities, both stationary and mobile, are to be targeted for control. The definitions of stationary and mobile sources and examples of different categories of these sources are provided earlier under "Emission Inventory".

As the types of stationary emission sources vary from one region to another, the particular sources that are to be controlled will have to be determined primarily on the basis of the regional emission inventory and the emission reduction goals for the AQMP. A common set of criteria should then be used to assess these sources to determine their candidacy for control. The guidelines for the process of selection and prioritization of emission sources for control are provided in a later section.

Off-road sources such as railways, aircraft, ships, and motorized barges and boats usually come under national jurisdiction. Therefore, local authorities need to work jointly with national agencies to control emissions from these sources. In order to reduce emissions from aircraft and ships, international cooperation is also necessary.

Because of the increasing significance of motor vehicle emissions in growing urban areas, emission reduction measures for motor vehicles are described below in a separate section.

5.6.3 Strategies for Selection of Emission Control Measures

As discussed in an earlier section, besides the traditional "command-and-control" approach, there are several alternative control strategies available for reduction of emissions of pollutants. The feasibility of application of some of these alternative approaches should be considered as a long-term strategy for emission reduction from certain types of sources. Other strategies may be applied in conjunction with the traditional approach for effective implementation of emission reduction measures. The "command-and-control" approach is still regarded as the basic premise of short-term and medium-term strategies for choosing emission reduction measures (ERMs) to achieve the AQMP goals.

The availability of emission control technology is the most important factor in designing a strategy for ERMs. Generally, control technologies can be grouped in three categories: (1) well-proven and readily available commercial technologies, (2) technologies currently under demonstration, and (3) those still in the research and development stage. Based on the control technology development status, ERMs could be considered for application as short-, medium- or long-term measures. Generally, other important factors which influence selection of ERMs are listed below.

- should all types of sources, stationary and mobile, be considered for emission reduction?
- should all categories of stationary sources, irrespective of size and age, be controlled?
- should all stationary sources of the same category, be it new or old and large or small, be controlled to the same degree?
- should emissions from all motor vehicles be controlled or restricted to cars only?

- should emissions from off-road sources, such as railway locomotives, construction and agricultural equipment be controlled?
- should all selected sources belonging to the same category be required to implement control measures at the same time or at different times?
- is there a need for *'contingency'* emission reduction measures for quick implementation by selected sources, in order to meet the AQMP goals?

5.6.4 Selection of Emission Sources for Control

An iterative process, as shown schematically in Figure 2, can be used to select emission sources and emission control measures for implementation to achieve AQMP goals. Based on the strategies determined for selection of emission sources to be controlled, the regional emission inventory should be reviewed to prepare an initial list of sources. Assessment of emission control measures for these sources is to be done on the basis of pre-selected criteria, as outlined below.

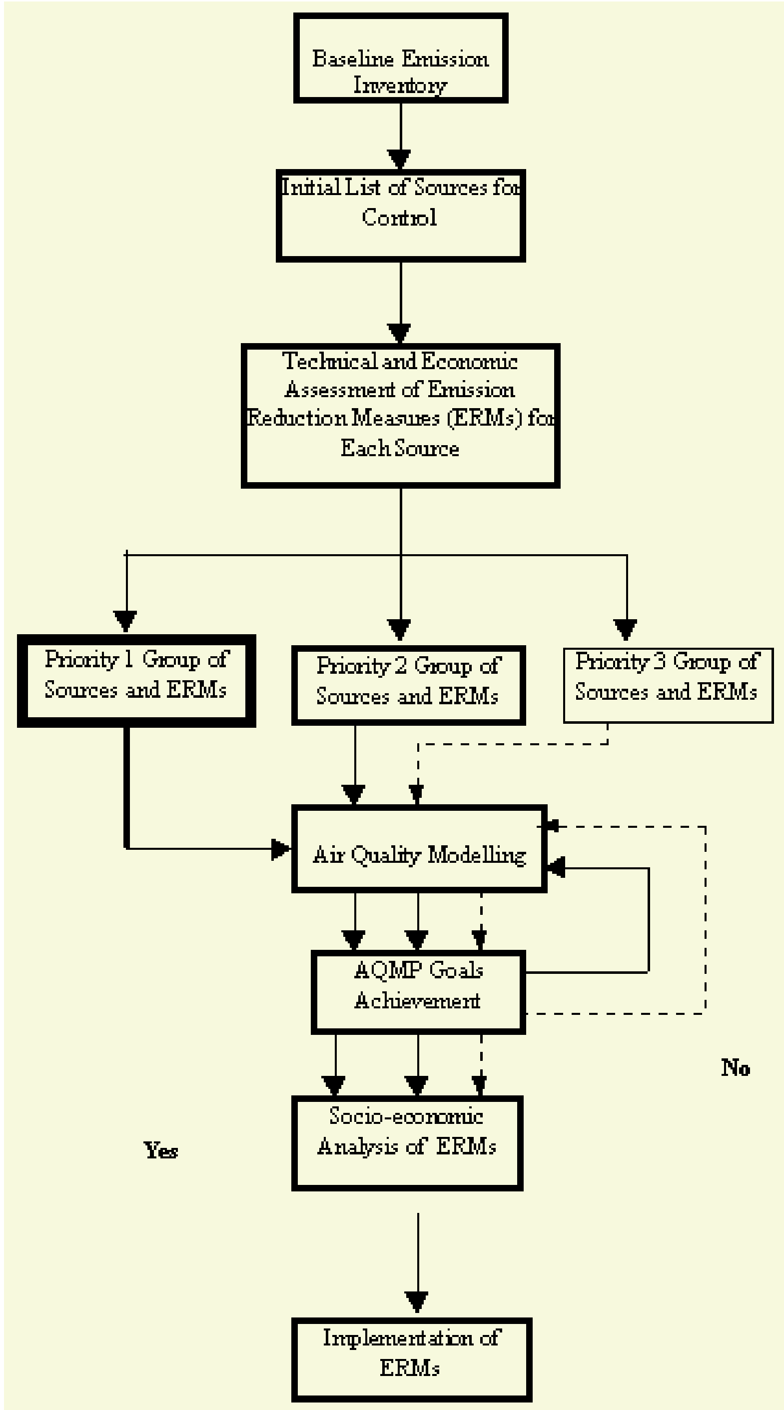


Figure 2: Schematic of an iterative process of development of emission reduction measures

Assessment of Emission Reduction Measures

As mentioned above, a set of common criteria should be developed in order to assess the relative merits of alternative reduction measures for each selected emission source. Application of the same criteria to assess different emission reduction measures for a variety of sources would render a fair and unbiased selection of control measure. The following list of criteria is usually considered for assessment of an emission reduction measure (ERM); however, additional region-specific criteria should also be taken into account.

- Pollutants - which pollutants will be reduced by the ERM?
- Quantity of emission reduction - how much emission of each pollutant will be reduced? Will the emission reduction potential change over time?
- Ease of technology availability and applicability - what is the availability status of the control technology? Is it readily applicable to new and existing emission sources?
- Impacts on health, environment and global climate change - to what extent will the ERM impact on health and environment? Will its application impact on emission of greenhouse gases?
- Impacts on other media - will the ERM transfer pollution to any other media such as water and land?
- Regulatory tools - do the necessary regulations exist to implement the ERM or would amendments to existing regulations or enactment of new regulations be required?
- Effects on other ERMs - will implementation of this particular ERM enhance or reduce the effectiveness of other ERMs?
- Cost-effectiveness - what will be the estimated initial start-up, short-term and on-going operational costs of the ERM? What is the cost-effectiveness of the control measure in terms of cost per tonne of pollutant reduced?

Cost-effectiveness of Emission Reduction Measure

There are several methods of estimating the cost-effectiveness of an ERM. The regulatory authority should prescribe a common method of estimation of cost-effectiveness for a fair assessment of all ERMs. The term *'cost-effectiveness'* typically means the economic efficiency of a particular emission control measure. It is defined as the total costs of controlling a unit quantity of emission reduction, e.g. $/tonne of emission reduced. The total costs of an ERM include its initial capital cost and annual operating cost.

Prioritization of Emission Reduction Measures

Once the potential ERMs for the initial list of sources are determined, they should be prioritized into groups for potential implementation. As illustrated in Figure 3, the iterative process utilizes air quality modelling to sequentially determine the impacts of the first priority group of ERMs on the ambient air quality concentrations of designated pollutants. If the results indicate that this group of ERMs will achieve the AQMP goals, then their implementation can proceed. In the event of falling short of achieving the AQMP goals, the second priority group of ERMs should be added to the first group and air quality modelling should be repeated. By means of this iterative process, a list of candidate emission sources and ERMs should be determined to attain the goals for the Plan. The final selection of sources could be made after completion of a socio-economic impact analysis of all proposed emission reduction measures. The methods for socio-economic analysis are discussed in a later section under "Costs and Benefits of Air Quality Management Plan".

5.6.5 Emission Reduction Measures for Motor Vehicles

Motor vehicles already contribute significantly to the pollution load in many urban areas in both developed and developing countries, as evident from Table 7. The increasing air pollution from cars, trucks and other motorized vehicles is the leading cause of deterioration of air quality in most urban areas. Control of emissions from motor vehicles poses one of the most challenging tasks facing urban regions around the world. It is a particularly daunting task in rapidly growing cities.

Table 7: Motor vehicle contribution to emissions of air pollutants in urban areas in selected cities during 1980s and 1990s

City	**Year**	**Percent Contribution of Motor Vehicles**				
		Carbon Monoxide	*Hydrocarbons*	*Nitrogen Oxides*	*Sulphur Dioxide*	*Particulate Matter*
Athens	1990	100	79[a]	76	8	13[b]
Beijing	1989	39	75	46	-	-
Budapest	1987	81	75	57	12	-
Cochin	1993	70	95	77	-	-
Colombo	1992	100	100	82	94	88
Delhi	1987	90	85	59	13	37
Lagos[c,d]	1988	91	20	62	27	69
Los Angeles	1990	98	62	84	68	11[e]
Mexico City	1990	97	53	75	22	35
Mumbai	1992	-	-	52	5	24
Santiago	1993	95	69	85	14	11
Sao Paulo	1990	94	89	92	64	39

Notes: a) Applies to road transport only, values represent volatile organic compounds;
b) Includes smoke;
c) Percent shares apply to all transportation modes;
d) Does not include biomass;
e) Primary particulates less than 10 microns in diameter; - Data not available

Source: "A Guide to the Global Environment 1996-97. The Urban Environment", Chapter 4, World Resources Institute.

Land Use - Transportation - Air Quality

Urban air quality, land-use pattern and transportation systems are interlinked; thus the planning of air quality management, transportation and land use should be coordinated to develop a set of integrated comprehensive strategies to reduce emissions from motor vehicles. While vehicle-related measures such as the use of clean fuels and fuel efficient, clean vehicles can reduce emissions from vehicles, there is also a need to discourage car use through measures related to land-use and transportation systems. Emissions from motor vehicles can be reduced effectively by considering a package of measures which fall into four general categories:

- Land use planning
- Transportation control measures
- Cleaner vehicles
- Cleaner fuels

It should be noted that the following outlines of each of the above categories of measures are presented here as typical only, and not as a prescription for all urban areas. Each urban area is unique in its characteristics as regards its size and layout, zoning regulations, population density, number and type of motor vehicles on roads, and the state of its existing transportation infrastructure and mass transit system. Therefore, each urban area will require its own combination of strategies to address its own transportation problems.

Land Use Planning

An integrated land use and transportation plan can govern the pattern and modal choice of travel by the residents within the region, and thus can reduce reliance on the car. Through appropriate planning, new growth within the urban region can be directed towards designated areas that have high residential and employment density and a good choice of transit service. Land use planning can be used to promote compact communities of mixed uses that would increase accessibility of various amenities to its residents, and thus would reduce the need for single-occupant vehicle trips for daily activities.

Transportation Control Measures (TCMs)

This category of measures can be classified into three sub-categories, namely shifting to energy-efficient transport modes, transport infrastructure improvement and transportation demand management. However, some measures could fall into more than one sub-category, and there are several which are complementary to others. During the past two decades a number of TCMs have been implemented in several developed and developing countries.

TCM Examples - A shift towards energy efficient travel modes would mean moving people in and out of an urban area with the minimum possible fuel consumption, and thus air pollution, per person. Examples include provision of adequate mass transit, incentives for ridesharing in motor vehicles, and promotion of non-motorized transport modes, such as bicycling and walking.

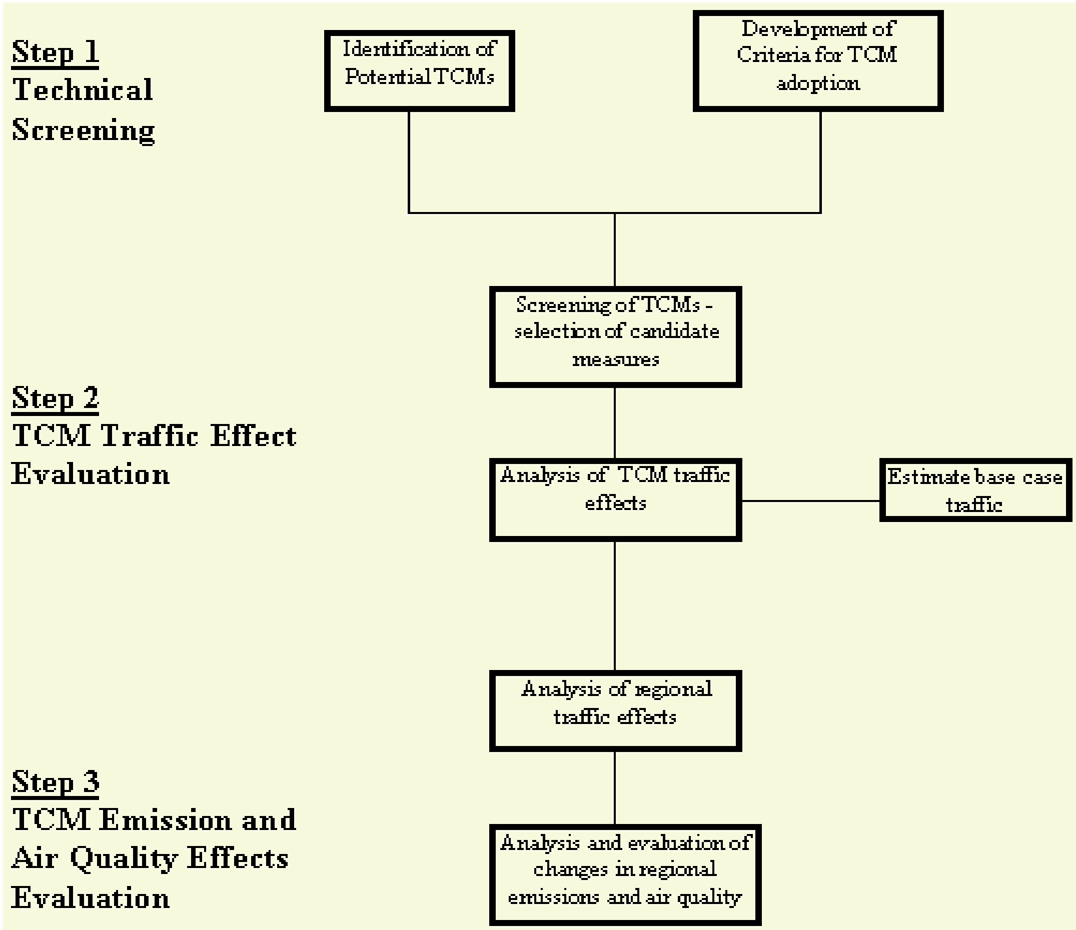
Many growing urban areas, particularly in developing countries, are faced with worsening traffic congestion. This leads to prolonged stop-and-go traffic patterns, which in turn result in increased emission of air pollutants. These areas require significant improvement, and possibly expansion, of the existing transportation infrastructure to cope with the increasing traffic congestion. The measures in this TCM category include provision of one-way streets, exclusive lanes for high-occupancy vehicles such as buses and car or vanpools, and construction of bypass or ring roads to divert traffic away from congested core business areas. Other traffic congestion management measures that should be considered are traffic signal synchronization, separate routes for trucks, parking restrictions, bicycle lanes and pedestrian pathways.

Transportation Demand Management - In simple terms, transportation demand management (TDM) is comprised of a range of relatively low-cost measures to make a transportation system more efficient by managing urban traffic within the constraints of the existing infrastructure. Besides improvements to traffic flow through measures mentioned above, there are other measures that can be categorized as *'carrots'* and *'sticks'*.

Examples of *'carrots'* include incentives to change the (i) amount of travel (e.g. by telecommuting), (ii) time of travel (e.g. staggered work time, peak vs off-peak hours), and (iii) mode of travel (e.g. car or vanpool, transit, cycle, walk). Disincentives and penalties, such as parking charges, fuel and vehicle taxes, road tolls, fuel rationing and mandatory no-drive days, are examples of *'sticks'* that can be used to discourage vehicle use.

Implementation of a number of the above mentioned TCMs should help to reduce motor vehicle travel demand in urban areas. However, to meet the travel demand in many fast growing urban areas, there is still a considerable need for expansion of existing public transit systems. Presently, several mass transportation systems are available for consideration by local authorities. The criteria for selection and development of a public transit system should include effective land use (persons per hour per lane), and emission of air pollutants and total costs in terms of per passenger per kilometre.

Because of the large number of TCMs that are worthy of consideration and since some may not be applicable to a given urban region, a screening method can be used to select the measures which would benefit the region most. A schematic flowchart of a typical screening procedure is



shown in Figure 3.

Figure 3: Simplified outline of technical analysis of Transportation Control Measures

Typically, the following three-stage approach is taken to assess TCM effectiveness in reducing use of motor vehicles.

1. Technical screening of TCMs - This process assesses the existing traffic situation, identifies problems, reviews existing TCMs in place, and develops criteria for applicability of additional TCMs in the particular region.
2. Evaluation of TCM effects on traffic - Planning resources and models are used to determine effectiveness of screened TCMs in reducing traffic problems.
3. Evaluation of TCM effects on air pollution - The potential impacts of screened TCMs and the consequent traffic changes on vehicle emissions and regional air quality are assessed at this stage.

Cleaner Vehicles

New Vehicles

Significant advancement in vehicle technology has been made during the past three decades to make vehicles more energy efficient and cleaner burning. Today's vehicles emit considerably less air pollutants than those of past years. For example, on a gram per kilometre travel basis, today's motor vehicles can generate 90 to 98% less carbon monoxide, hydrocarbons and nitrogen oxides than those manufactured in the 1960s. Vehicles are also designed to be more fuel efficient, i.e. less fuel is burned to travel a unit distance and thus generate less air pollution.

Vehicle Emission Inspection and Maintenance

Motor vehicles are manufactured to meet certain emission standards during their use over the vehicle warranty period. Proper maintenance of vehicles is necessary to ensure emission levels remain below those standards. However, as a vehicle is used, its emission characteristics gradually deteriorate, even when it is properly maintained. In a typical urban vehicle fleet, older vehicles generate disproportionately more air pollutants than the newer vehicles. A poorly maintained older vehicle can emit one hundred times more pollutants than a properly cared for modern vehicle. Therefore, implementation of an appropriate vehicle emission inspection and maintenance program is an effective measure to ensure efficient operation of vehicles. In developing countries, where older vehicles constitute much of the urban fleet, this kind of program can reduce motor vehicle pollution significantly.

Old Vehicle Scrapping

In order to reduce the number of old polluting vehicles in the urban fleet, a vehicle scrapping program could be introduced. Under such a program, the owners of old vehicles could be given an incentive, either as money or public transit pass, in exchange for giving up the vehicle for scrapping by the agency responsible. The reusable parts from a scrapped vehicle should be recycled, and the rest should be disposed of as waste.

Electric Vehicles

Mass production of electric and hybrid vehicles for urban driving, using conventional fuel and electricity, is anticipated to be a reality in the near future. This new generation of vehicles generates little or no pollution; but presently the costs of these vehicles are high. However, consideration should be given to a mandatory requirement of such vehicles in the future, as they become commercially available and less costly.

Cleaner Fuels

Conventional Fuels

Gasoline and diesel oil have long been the primary transportation fuels, and they continue to be so throughout the world.. In recent years, considerable improvement in petroleum refining techniques has been made to produce fuels much cleaner than before. Unleaded and reformulated gasoline of less volatile types with reduced sulphur and toxic constituents are commercially available; and so is low-sulphur diesel fuel. Clean fuels are necessary to operate the new low-emission vehicles properly. For example, besides being a health threat, lead in the gasoline affects vehicles equipped with catalytic converters to reduce exhaust emissions, by reducing the efficiency of the catalysts to convert air pollutants.

Alternative Fuels

Alternative transportation fuels such as natural gas, propane, ethanol, methanol and bio-diesel are also available, and their use is increasing in many countries. When properly designed for these fuels, new vehicles can produce less pollutants than by using conventional fuels. Appropriate techniques for conversion of older vehicles to run on alternative fuels are also available. This is an area where local governments can provide environmental stewardship by:

- encouraging responsible agencies to enact necessary regulations for tax incentives to promote use of alternative fuels, and for developing infra-structure for supply and delivery of these fuels;

- promoting the use and procurement of cleaner technology vehicles and fuels for their own vehicle fleets; and
- encouraging other vehicle fleet owners and operators in the region to switch to these fuels and vehicles.

Each urban area has its unique set of transportation related problems. Therefore, an appropriate mix of control measures has to be evaluated for each urban area. The measures identified above are not the panacea for addressing air pollution from every urban motor vehicle fleet, nor are they exclusive of any other strategies that could be implemented.

Public Awareness Program

The success of the above emission reduction measures depends largely on public acceptance and support for them. Basically these measures to reduce air pollution from motor vehicles are aimed at changing existing behaviours of every resident in the region. Generally, people are not so forthcoming in responding to any new measures or techniques that will require changing of their lifestyle, despite the claim of ultimate good for the urban air quality.

Based on the experience of several regional agencies, it is essential that a public outreach program should form a vital component of a successful implementation of various emission reduction measures related to urban transportation. Local authorities must therefore launch a public awareness and education program about air pollution from motor vehicles, its effects on health and environment, how the proposed measures are aimed at reducing pollution, and how individual and collective actions can alleviate the existing situation.

A number of different techniques that have been used successfully in several jurisdictions to inform and raise awareness of the public include: written materials (question-and-answer fact sheets, brochures and newsletters), mass media (radio, television and newspaper), public forum, and community focus groups. Local authorities should decide which of these techniques will be effective in such a campaign, after taking into consideration the social and cultural aspects of the urban area. Another component of a public awareness program that should not be underestimated is the evaluation of its success through periodic review and revisions, if necessary.

Key Measures for Motor Vehicle Emission Control

- Coordinated planning of land-use, transportation and air quality management
- Development of less polluting means of transportation
- Introduction of measures to reduce vehicle use, in particular single-occupant vehicle trips
- Implementation of transportation control measures
- Introduction of stringent vehicle emission standards
- Implementation of vehicle emission testing and compliance program
- Old vehicle scrapping
- Promotion of the use of cleaner and alternative fuels
- Public awareness program

5.6.6 Urban Initiatives for Addressing Global Issues

As mentioned in a previous section, many countries have signed and ratified the international protocols on global climate change and phasing-out of the production and use of major ozone depleting substances. These countries are committed to the articles in the protocol. The local governments have a responsibility to support the national efforts by adopting policies and implementing actions to meet those commitments.

Emission Reduction Measures for Greenhouse Gases

A number of emission reduction measures to address priority regional air quality issues will contribute, directly and indirectly, to reduction in emission of greenhouse gases (GHG). In particular, the energy conservation measures to reduce emissions from the combustion of fossil fuels will have significant impacts on the reduction of GHG emissions.

Urban governments can consider the following additional measures for greenhouse gas emission management at the local level. As not all of these measures may be applicable to all areas, some measures may have to be adjusted to suit the local situation.

- Adoption of energy efficiency measures in infrastructure, buildings, equipment, industrial and commercial processes
- Encouraging national agencies to implement fuel efficiency standards for motor vehicles
- Use of clean and renewable energy
- Solid waste landfill management
- Protection of green space and urban afforestation
- Public awareness program about global climate change - its causes, measures for its mitigation, potential impacts and the need for adapting to changed climate.

Emission Reduction Measures for Ozone-Depleting Substances

Depending on the extent of the local use of ozone-depleting substances (ODS), an urban authority should consider the following measures to prevent further use and discharge of these substances into the atmosphere:

- Initiate programs for: (i) immediate repair of any leakage of ODS from equipment that is still in use, (ii) safe removal of ODS from any equipment before its disposal; and (iii) subsidized or free collection of refrigerators, freezers and air conditioners from their owners and safe disposal of the ODS from them.
- Start a public awareness program about ODS, their potential impacts on global climate and life on earth, and what individuals could do prevent their use and discharge to the atmosphere.

5.6.7 Costs and Benefits of Air Quality Management Plan

Improvement in urban air quality through implementation of an air quality management plan will incur costs as well as yield benefits to the region. The extent of the costs and who will bear them will depend on the sources targeted for emission reduction. Typically, an AQMP recommends ERMs for a variety of large, medium and small sources involving all segments of the society. Therefore, the costs of implementation of ERMs have to be borne, directly or indirectly, by all citizens in the region. The principal benefits of emission reductions will be to the society through improved air quality, which will result in improvements in health and welfare of the people, environment as a whole, and economic productivity in the region.

Increase in direct costs of complying with additional emission reduction measures for industry, business, and the public is a general concern in many urban areas. This is mainly because of the lack of awareness among the parties concerned about the "hidden costs" of uncontrolled air pollution, and the potential economic benefits of clean air. To ensure the reasonableness of any additional regulatory measures for the management of urban air quality issues, a socio-economic analysis of the measures proposed in an AQMP will be necessary.

Socio-economic analysis forms an integral component of an AQMP development, as it evaluates the costs and benefits of the measures proposed in the Plan. Such analysis plays a particularly important role in determining whether implementation of an ERM makes economic sense for the urban scenario concerned.

Although there are several methods available for economic analysis, each method has its limitations. When applied to the same case, different methods can yield different results, and the estimates of costs and benefits could vary even by an order-of-magnitude. The primary reason for wide variations in estimates lies in the difficulty of assigning realistic monetary values to various costs and benefits associated with implementation of the AQMP measures.

Several important environmental effects cannot be measured in economic terms. Many potentially adverse health effects of air pollution cannot be fully quantified, as there are both direct and indirect costs and benefits related to the state of human health. For example, an absence from work, resulting in loss of productivity and an economic cost, can be due to ill health that is not necessarily caused by air pollution only. Moreover, it is difficult to assign monetary values to reduced adverse health effects and the risk of mortality because of improvement in air quality. It is also somewhat controversial, because assumptions are made about the value of a human life. Another difficulty arises when estimating, in monetary terms, the intangible impacts of urban air pollution on the surrounding environment, such as visibility degradation and damage to ecosystems.

Despite this drawback, a socio-economic analysis of the costs and benefits of reducing air pollution can assist the policy-makers to decide on the ERMs recommended in an AQMP. It allows them to make decisions on the ERMs that are to be implemented and on a schedule for their implementation to meet the AQMP goals.

5.6.8 Planning Resources and Schedule

Development of a regional air quality management plan is a complex process involving several local authorities, industry, business and the public. The analysis and assessment of information have to be done by technical experts in several areas, such as air pollution engineers, air quality scientists, urban and transportation planners, economists, and outside consultants for special studies. However, an inter-agency cooperation will provide opportunities to share responsibilities and technical resources.

In order to complete an AQMP development on time, a strategic plan for the whole project and detailed individual task plans should be drawn up at the beginning. A project manager and task leaders should be assigned to ensure coordination of activities and meeting the schedules.

An AQMP development takes a few years to complete. In order to proceed effectively with the development, timely allocation of adequate resources by the agencies is considered essential.

Key Elements of an Air Quality Management Plan (AQMP)

- Development of AQMP goals, policies and objectives.
- Determination of roles of different agencies.
- Selection of air pollution control strategy options.
- Defining of local air quality issues.
- Assessment and development of emission reduction measures to address local and global air quality issues.
- Evaluation of costs and benefits of the proposed emission reduction measures.
- Allocation of resources for AQMP development and implementation.
- Implementation of AQMP and tracking of its progress.

Contents

6. Public Consultation and Participation

As mentioned earlier, public consultation should be an integral part of the AQMP development process, and it should be a policy of the regulatory agency. The population as a whole has a stake in the quality of the air they breathe. It is each citizen's right and responsibility to be involved in the protection and enhancement of air quality for the benefit of present and future generations. An AQMP is to be developed, and later implemented, based on input from numerous individuals and groups. Local authorities should, therefore, promote and foster citizen participation throughout the process.

Public consultation is a two-way process. An informed public makes useful contributions to the development of a regional air quality management plan. Active public participation allows exploration of new and alternative, and sometime innovative, ideas about AQMP development. It may also enable early detection of potential problems with AQMP implementation. Therefore, it is important that the public consultation takes place from the start of the AQMP development process.

A public consultation program consists of a series of activities that provide opportunities for participants to be knowledgeable about urban air quality issues and options for solution, and to express their views. The process of consultation should be designed to reflect the particular circumstances at hand. Each situation needs to be tailored accordingly. Consequently, the key steps involved in designing a consultation plan and a few major principles of the process are outlined below as a guide for the local agencies.

6.1 Steps in Consultation Planning

Generally, a plan for public consultation is designed to expedite the process and obtain useful input from stakeholders to different elements of an AQMP. Typical steps in designing such a plan are outlined in the box below.

Key Steps in the Public Consultation Planning Process

- Identify the extent of public consultation necessary
- Develop an initial plan to establish objectives, identify potential participants and decide on consultation topics
- Develop a detailed plan by determining the methods of consultation, types of information materials needed, and schedules for consultation
- Hold consultation and obtain input
- Analyze and consolidate input and prepare report
- Seek post-consultation feedback from participants.

6.2 Principles of a Public Consultation Process

The most important principle behind public consultation should be to maximize public involvement. Other key principles and features which need to be considered are as follows.

Fair and Equitable

In order to be fair and equitable, a consultation process should seek ways to reach diverse constituents in the society, including non-traditional groups who are sometimes overlooked. Every effort should be made to communicate with as wide a public as possible. Different needs of various groups and cultures should be recognized and supported.

Efficient and Timely

Efforts should be made to raise public awareness about urban air pollution and its impacts on human health and environment, through distribution of information as widely as possible. For this purpose, appropriate channels need to be developed for providing the public with technical information, public education materials, solicitation of input, and invitation to participate in structured public meetings and workshops. Local authorities should be open to using several means of communication to involve unorganized communities and individuals.

The goals and objectives of the consultation process should be clearly defined and communicated to the public at the outset of AQMP development. The public should be provided with documents, reports and notifications of events in a timely manner for review, active participation and meaningful input. Records of all public meetings should be maintained and reports produced on a timely basis.

Transparent, Accountable and Accessible

A trusting relationship between the local agencies and stakeholders is an essential feature of a successful public consultation program. Therefore, urban authorities need to conduct their activities in an open and accountable fashion. To complement the transparency of the public consultation, an accountability procedure should also be designed. Additional background information should be provided to interested stakeholders upon request.

In certain circumstances, it may be necessary for the sake of efficiency and effectiveness to consult with experts on a particular subject matter, rather than with the public-at-large. However, the public should be given clear context and rationale for such a decision.

Consultation Output and Feedback

The information obtained during the consultation process is to be regarded as stakeholder advice to the local agencies. Therefore, the input from the public should be reviewed and duly considered prior to decision-making, and as a feedback, participants should be apprised of the decisions.

Consultation Resources

Public consultation requires preparation of documents and communication materials, and holding of public meetings. Adequate funding should be allocated for this purpose. In addition, due to financial constraints not all interested participants may be able to attend consultation meetings. Provisions for possible financial assistance to such participants should be duly considered.

In order to facilitate and expedite the AQMP development with public input, local agencies may also consider the following means of achieving the overall objectives of public consultation:

A Task Force could be formed to oversee the development of the AQMP. The Task Force should have representations from industry, business, government, academia, environmental organizations, and traditionally marginalized social groups.

Usually, the task of compilation and analysis of important scientific and technical data in support of the AQMP development is undertaken by the agency staff and subsequently peer reviewed. Alternatively, it could be carried out by several Working Groups of experts for specific subject areas, and Focus Groups could be set up for public input.

An Advisory Group, consisting of a cross-section of non-government stakeholders, can be established to support the agencies involved in AQMP development. It can provide advance input and reaction to draft AQMP issues and proposals. This group can assist in preparation of public consultation materials for relevance, effectiveness and transparency, and thus can expedite the consultation process.

Major Elements of Public Consultation

- Equitable representation of all segments of society - including marginalized groups
- Transparent and accountable role of planning agencies and local government authorities
- Open, two-way dialogue between public and planning agencies
- Early involvement of public in planning process, to allow for an active role in shaping subsequent decisions
- Provision of adequate resources for multiple opportunities and methods to involve public.

Contents

7. Implementation

Implementation of an AQMP is a complicated exercise. No one person or organization has jurisdictional authority or responsibility for putting in place the actions and emission reduction measures recommended in the Plan. In most cases, responsibilities for different emission sources lie with local, regional and national agencies. Each agency has its specific mandate, which may overlap, complement, or even contradict those of the others. Cooperation and coordination among and between agencies are essential, but not necessarily a simple task. Besides coordination of actions among the regulatory agencies, the successful implementation of some measures will require working together with a number of private sector representatives and the general public.

In view of the above, establishment of a good institutional relationship during the early stages of AQMP implementation is considered essential. It can be helpful in building support for the implementation of various control measures. It will also ensure that the needs and concerns of the parties involved are properly identified and resolved. Therefore, an initial step should be to identify a lead agency or party to coordinate and manage the implementation of each control measure. If a selected lead agency does not have the authority to implement a particular measure, institutional barriers should be removed to empower the agency to fulfill its responsibility.

7.1 Implementation Priority

In order to determine the order of implementation of the emission reduction measures recommended in the Plan, it is appropriate to develop some criteria for prioritization of these measures. The main objective for priority ranking of emission reduction measures should be their overall effectiveness in achieving the goals of the Plan. As a general guide, the so-called "low-hanging fruits", i. e. those measures that could be implemented relatively easily and cheaply, could be picked for priority implementation. Caution should be exercised, however, in choosing easy-to-implement measures first, as that would leave some difficult, but often necessary, measures for implementation later. Moreover, implementation of all easy measures may not achieve the overall emission reduction goals of the AQMP. Therefore, prioritization of ERMs for implementation should ultimately remain focused on reaching the emission reduction target of the Plan.

7.2 Resource Allocation

A successful implementation program will require adequate resources, both in terms of staff and funding. As the development of an AQMP involves expertise from different areas - such as air quality scientists, engineers, urban and transportation planners - continuation of their input during its implementation will be necessary and particularly helpful.

7.3 Tracking of AQMP Implementation

Achievement of urban air quality objectives can be a long-term process. Stakeholder involvement during the implementation of an AQMP is as important as it is during the development of the Plan. Therefore, it is essential to ensure continuity of the coordinated activities of the parties involved during implementation of the policies and measures recommended in the AQMP. To assess the success, or failure, of the Plan, progress reports on the status of its implementation should be prepared on a regular schedule. Such reports should provide an up-to-date account of implementation of the emission reduction measures recommended in the Plan.

In measuring the progress of implementation, indicators such as how well the inter-agency cooperation, industry and government partnership, and public participation are working should be reviewed. The progress in legislative actions towards development and enactment of recommended regulations should also be tracked. Actual progress in meeting the AQMP goals of emission reduction and air quality improvement should be determined on the basis of ongoing ambient air quality monitoring data, updated emission inventory results, and a regional air quality model. A simplified schematic of an AQMP implementation tracking program is shown in Figure 4.

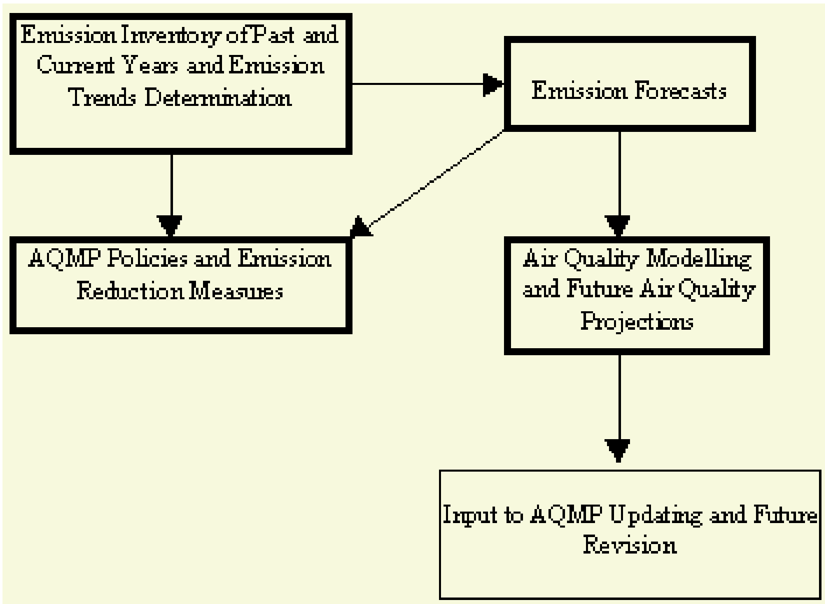


Figure 4: Key elements of air quality management plan implementation tracking program

Periodically, the air quality model should be used to assess the potential impacts of revised emission inventory forecasts on the future regional air quality situation. The results from such assessment could form the basis for any mid-course revisions to the Plan, and for strategy development for a future AQMP update.

7.4 Role of Local Authorities

In addressing the urban air quality issues, and at the same time the global climate change issue, local authorities have a unique role to play. Traditionally, in many countries, local authorities have been set up for the primary purpose of administering social and community matters within their designated political boundaries. An airshed boundary, however, can be shared by more than one local administrative jurisdiction. Therefore, the responsibility for management of air quality within such an airshed has to be shared by all local authorities concerned.

Moreover, as the responsibility for implementation of several recommended emission reduction measures may lie with multiple levels of government, local authorities should encourage the parties responsible for action. Where necessary, existing institutional barriers may also have to be removed. Local institutions should be strengthened so that they have authority to enact regulatory tools for implementation measures recommended in the Plan. In order to support their expanding role, local governments could consider principles such as "polluter pays" or "user charges" to generate revenue exclusively for capacity building in the areas of air quality monitoring, research projects, and administration of the air quality management program.

Ideally, once an AQMP is developed, a single airshed management agency should have the responsibility and authority to implement the recommended measures affecting emission sources, transportation system and land use. In the future, such an agency will be in the best position to ensure integrated and effective air quality, transportation and land use planning, as well as the administration of rules and regulations for air pollution control.

7.5 Innovative Management and Environmental Stewardship

Lately, the responsibility of local governments for management of environmental matters is shifting from the role of a regulator to a leader and partner. These agencies have the opportunity to set a good example by taking practical actions to reduce air pollution discharge from their own activities. Examples can be set by implementing "green" measures that replace the use of wasteful methods of energy, raw materials and products in public works and offices. Actions in these areas by local authorities will result in emission reduction of pollutants responsible for local air quality issues. These efforts will also put into practice the maxim "think globally and act locally" through reductions in emissions of greenhouse gases which cause global climate changes.

In order to reduce motor vehicle use, local authorities could launch vehicle trip reduction programs for their employees. The strategy for such programs focuses on increasing public transit use and discouraging single occupant vehicle use by the employees for commuting to work. Employers could consider offering incentives such as discounted fares for transit users and assistance to employees living in the same community to rideshare in carpools and vanpools. Other large private employers in the urban area should be encouraged to introduce such vehicle trip reduction measures for their employees. Well-maintained motor vehicles produce much less pollution than when they are maintained poorly. Local agencies should introduce a regular maintenance program for their vehicle fleets. Where clean and alternative fuel vehicles are available, a program to purchase such vehicles should be considered at the time of buying new vehicles.

Partnerships can be established by working together with all stakeholders through sharing information, and conducting joint research projects specific to regional air quality. Local authorities could provide technical assistance, and initiate joint demonstration projects with local businesses to modernize and "cleanup" polluting facilities. In this regard, particular focus should be given to assisting small- and medium-size facilities and informal sectors in reducing emissions from their activities. Collectively, emissions from the activities of these groups may be significant in certain urban areas, while these groups tend to lack both the technical know-how and the financial resources to control emissions from their activities.

Key Elements and Indicators of AQMP Implementation Progress

- Air quality monitoring - continue ambient air quality monitoring and data to determine the status of air pollutant levels in the region.
- Emission inventory - use currently available methods to update estimates of emissions from regional sources, revise previous emission inventories, prepare new emission forecasts, and determine emission trends.
- Future air quality - determine future air quality levels in the region, using emission forecasts data and air quality models.
- Implementation status report - prepare a progress report of the AQMP implementation on a regular basis.
- Environmental leadership - local authorities to initiate actions to reduce air pollution from own activities, and assist others.

Contents

8. Concluding Remarks

Global Trends in Urbanization

The increasingly rapid pace of urbanization throughout the world is raising new challenges for planning agencies and urban authorities. In many large cities around the world, air quality is poor and deteriorating. In one way or another, environmental problems are shared by urban areas around the globe. In Europe and North America, the challenge for higher-income cities is to reduce their excessive draw on global resources. Meanwhile, the challenges of resource and environmental management are particularly acute for governing agencies in developing countries. However, urban and industrial growth do not necessarily have to be wasteful, and activities that improve human welfare do not need to be unsustainable.

Achieving Sustainability
In order to create urban areas that provide a safe, healthy, sustainable environment for this generation and those that follow, action must be taken now to address these issues. Authorities should seek not only to address the immediate problems, but also to take a preventative approach to planning and management, to avoid future intensification of these problems. Thus, in terms of managing air pollution, the challenge for urban authorities is to direct growth and development activities in such a manner as to reduce current air pollution levels, pave the way for reduction of future emissions, and operate efficiently and sustainably in the long-term.

Institutional Challenges
Cities are growing into mega-cities by encroaching into nearby suburban and rural areas. In most cases, this is happening without adequate land-use and transportation planning. At the same time, growing human activities of all sorts, particularly more and more use of motor vehicles, are worsening regional air pollution problems. An integrated approach to air quality management, transportation and land-use planning is necessary to effectively address all the related issues. The new approach to development should strive to achieve a balance among social, economic and environmental needs, and creating a *'win-win'* situation.

Most local governments are set up to deal with land-use planning, transportation systems and environmental matters separately through different agencies with different mandates. There are inherent institutional obstacles to the necessary changes in governing methods. First, traditional, centralized management structures in governments have an ingrown inertia to preserve the status quo. These top-down management methods serve as a disincentive to innovation and the exploration of alternative approaches. Effective urban air quality management will involve transfer of authority from higher to lower levels of government. Also to be recognized, is the necessity of public and stakeholder participation in the planning and management of urban environmental matters in order for them to be successful in the long-term.

Second, the conventional approach of dealing with individual issues by separate government departments is a barrier to effective coordination of management resources. Urban air quality is one of the most complex examples of a pollution problem that crosses physical, administrative and jurisdictional boundaries. Its management in isolation is not likely to succeed.

Third, and finally, the traditional emphasis on "command-and-control" type of air pollution control through rules and regulations does not appear to be the most effective. A combination of this traditional method and new means, such as economic instruments and pollution prevention, should be explored for building sustainable, healthy cities of the future.

Air Quality Management Plan Benefits
An air quality management plan is a document that lays out in detail the various air quality problems an urban area is facing. It recommends strategies for improvement of air quality to ensure the future livability of the region. It also describes how these strategies are developed and can be implemented, and identifies areas of responsibilities of the government, industry, business and the general public.

Although each urban area has its own unique features, there are several common sources of air pollution in all urban areas and similar control techniques can be applied to deal with them. Therefore, there is no need to *'re-invent the wheel'* to address many issues in urban regions of the developing nations. Benefits can be achieved by learning from the experience of the developed countries, but *not by repeating their mistakes*.

The urban air quality management planning process should not be considered as a one-time prescription to address air quality issues, which ends after its implementation. Rather it is a *process* that continuously focuses on the long-term goal of enhancing air quality of the urban region, and maintaining a healthy environment. This requires routine tracking of the Plan implementation, identification of new air quality issues, evaluation of the shortcomings of the current Plan, and development of additional emission control measures for consideration during the next updating of the Plan.

In summary, the process of developing an urban air quality management plan could provide the following benefits:

- Development of long-term strategies, an integrated planning process and implementation tools for enhancing urban air quality;
- Formulation of appropriate policies, regulations, and techniques to address local and global air quality issues, taking into consideration the geography, weather, land-use, social, cultural and environmental conditions of a particular urban area;
- Removal of institutional barriers, streamlining of agencies involved in land-use, transportation systems and environmental matters, and channeling of available human and financial resources to deal with priority air quality issues in a region; and
- Coordination of local agencies, and initiation of a partnership approach among stakeholders and public to work for the urban community.

Local authorities should take an environmental stewardship role in reducing air pollution by implementing appropriate measures within their own institutions and initiating joint actions with others. Not only do such examples raise public awareness about the urban air quality situation, but they usually produce a *'ripple'* or *'trickle-down'* effect on citizens' own daily practices. Adoption of the AQMP will affect urban residents' lives in many ways, and despite the costs, will yield many benefits for all people in the region. However, to implement it effectively, every citizen must do his or her part, and support the agencies responsible for implementation. Today's actions to reduce air pollution and enhance urban air quality will benefit every resident in the area, and around the globe, now and in the future.