CHAPTER 12

URBAN BIOGEOCHEMICAL PROVINCES

Urban biogeochemical provinces are formed by extensive urbanization, which is a process that leads to permanent increase of urban areas and population, transformation of rural population living style to the urban one, enhancement of cities' role in social and economic development, as well as formation of urban animal and plant population with very specific features. This urbanization process includes also development of urban landscapes as a specific sphere of land use organization in the urban agglomeration areas (Kurbatova et al., 2004). An integral part of urban development is increasing environmental pollution and relevant ecological risks for human and ecosystem health due to disturbance of biogeochemical food webs (Bashkin, 2002).

1. CRITERIA OF URBAN AREAS CLASSIFICATION

One of the most usable approaches to distinguishing urban areas from other populated ones is the formal approach of population number. This approach is in wide usage in many countries, for example, in Denmark, where the area with a compact population of more than 250 people is considered as a town. However the functional approach, taking into account the labor types of the local population is also applied. For instance, in Russia the urban status requires that 75% of the local population should be employed in non-agricultural labor activity and the number of people should not be less than 12 thousand.

Nevertheless, a common approach is absent in spite of UN recommendations to consider as a city any area with compact population more than 20 thousand. Sometimes city status has historical roots and this is often found in Europe. For example, Vereya city was a large and important place during the historical development of Russia, however at present its role has been lost and its population has decreased up to a few thousand but still maintains city status.

2. ECOLOGICAL PROBLEMS OF URBANIZATION

Urbanization is the most important global process. At present the World's urban population is about 3 billion or very close to 50% of all global inhabitants. During

Table 1. Urban population growth (Golubev, 1999).

	Population, million			Urban population rate, %		
Continent	1975	1995	2025	1975	1995	2025
Africa	104	250	804	25	34	54
Europe	454	535	598	67	74	83
North and Central America	235	332	508	57	68	79
South America	138	249	406	64	78	88
Asia	592	1,198	2,718	25	35	55
Oceania	15	20	31	72	70	75
Global	1,538	2,584	5,065	38	45	61

the 1990s the urban population growth was 2.5% whereas the rural one, is 0.8%. In developing countries the daily increment of urban population is about 150 thousand.

The main reasons for urban population growth are related: (a) local migrations from rural areas as well as from other countries, and (b) urban population growth due to higher birth rates in comparison to mortality (Golubev, 1999).

Both retrospective and prospective planning are also impressive (Table 1).

The ecological problems of urbanization are different in developing and developed countries. The extremely high urban growth in the poorest countries is accompanied by intensive anthropogenic loading of the environment. All life supporting municipal systems become overloaded and their enhancement rates are much less than the rate of urban population increase. These systems include water supply, drainage and canalization, waste collection and treatment as well as education, health and social service. As a result the urban environments have become dangerous for local population life. Based on UN statistics, more than 300 million city-dwellers have no suitable drinking water supply, and more than 500 billion have no access to even primitive toilets. In developing countries from 30 to 70% of municipal waste are not treated. This waste is currently accumulated especially in the poorest population urban areas. These areas are very far from traditional urban territories but the most part of the new urban population in developing countries is living in the given conditions, which can be very relatively termed as the urban ones (ESCAP, 2000; Bashkin, 2003).

In the developed countries some the most important urban ecological problems have been solved due to massive financial investments. It is known that the successful ecological solutions require 3–5% from total municipal budget. During last decades the air and water quality was improved in many developed cities. For instance, in 1960s the police officers in Tokyo had to use the oxygen masks and at present the improvement is very distinguishing. The similar improvement is shown in other urban agglomerations of the World however the ecological risk from air pollution is still the most significant in the global scale.

3. URBAN BIOGEOCHEMISTRY

At present most cities are powerful sources of technogenic materials, which influence environmental pollution not only in the urban areas but also in the suburbs and surrounding regions. Many urban areas represent technogenic and biogeochemical provinces (anomalies) with high ranks of soil, air, plant, and water pollution. Urban industrial agglomerations are centers both of huge populations and tremendous masses of pollutants entering urban areas with industrial, transport and municipal wastes and wastewaters. These pollutants form biogeochemical anomalies, which enhance the regional migration fluxes and increase the area of pollution around the agglomerations.

As a rule the anthropogenic loading in large cities is owing to the extremely high concentration of industrial production, rapid growth of transport vehicle numbers, lack of resource saving and inadequate waste technologies as well as many other economic and social forces combine to negatively influence the urban environment and human health.

These peculiarities of urban area development led to the technogenic biogeochemical provinces, i.e., the areas with local increase of pollutants in different components of urban ecosystems such as soils, grounds, surface and ground waters, plants, atmosphere. These pollutants create ecological risk to human and ecosystem health by their accumulation in the biogeochemical food webs (food stuffs and water).

As a whole, biogeochemical conditions in urban territories depend on the ratio between natural and technogenic factors of urban development. Accordingly, the analyses of biogeochemical cycling of pollutants in urban ecosystems should be based on geochemical background including the characteristic of pollution species migration and self-purification.

There are two different types of biogeochemical cycling transformation in the urban areas. The first type is connected with an accumulation of pollutants in these biogeochemical cycles, for instance, accumulation of heavy metals in various links of biogeochemical food webs, due to both natural and anthropogenic conditions. These conditions may be related to: (a) placing of cities in depressions like Novgorod city in the bank of the Ilmen lake in Russia; (b) heavy granulometric composition of soils and grounds that immobilize the metals dissolved in the infiltrating waters; (c) local geochemical background with high content of heavy metals; (d) formation of anthropogenic and natural barriers like the carbonate barrier in steppe soils. The second type is connected with the anthropogenic increase of pollutants migration, like acid deposition enhancing migration due to environmental acidification.

4. MODERN APPROACHES TO EXPOSURE ASSESSMENT IN URBAN AREAS

The concept of urban air pollution has changed significantly during the past several decades. Thirty or fifty years ago, air pollution was only associated with smoke, soot, and odor. At present, we should suggest the following definition that encompasses the concentration of many chemical species in urban air. *Air pollution is the presence of any substance in the atmosphere at a concentration high enough to produce an objectionable effect on humans, animals, vegetation, or materials, or to alter the natural biogeochemical cycling of various elements and their mass balance*. These substances can be solids, liquids, or gases, and can be produced by anthropogenic activities or natural sources. In this chapter, however, only non-biological materials will be considered. Airborne pathogens and pollens, molds, and spores will not be discussed. Airborne radioactive contaminants will not be discussed either. The natural urban air pollution due to forest fires and corresponding haze problem have been considered earlier (Bashkin, 2003).

Air pollution in cities can be considered to have three components: sources, transport and transformations in the troposphere, and receptors. The sources are processes, devices, or activities that emits airborne substances. When the substances are released, they are transported through the atmosphere, and are transformed into different substances. Air pollutants that are emitted directly to the atmosphere are called *primary pollutants*. Pollutants that are formed in the atmosphere as a result of transformations are called *secondary pollutants*. The reactants that undergo the transformation are referred to as *precursors*. An example of a secondary pollutant is troposphere ozone, O_3, and its precursors are nitrogen oxides ($NO_x = NO + NO_2$) and non-methane hydrocarbons, NMHC. The receptors are the person, animal, plant, material, or urban ecosystems affected by the emissions (Wolff, 1999).

5. CASE STUDIES OF URBAN AIR POLLUTION IN ASIA

5.1. Outdoor Pollution

The rapid growth of cities, has, together with associated industry and transport systems, resulted in an equally rapid increase in urban air pollution in the Asian region. Air pollution is principally generated by fossil fuel combustion in the energy, industrial and transportation systems. Use of poor quality fuel (e.g., coal with high sulfur content and leaded gasoline), inefficient methods of energy production and use, poor condition of automobiles and roads, traffic congestion and inappropriate mining methods in developing countries are major causes of increasing airborne emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), suspended particulate matter (SPM), lead (Pb), carbon monoxide (CO) and ozone O_3). Predominant outdoor pollutants are shown in Table 2.

Air quality is worsening in virtually all Asian cities, except perhaps in Singapore, South Korea and Japan. Air pollutants, mainly in the form of suspended particulate and sulfur dioxide is most common in the cities of the developing countries. Among mega-cities in the region and in the world for that matter, Beijing and Bangkok are the two most polluted cities. In general, cities in high-income countries like Tokyo, Osaka, and Seoul, have relatively lower levels of SPM and SO_2 in the air than cities in the developing countries, for instance, Shenyang, New Delhi, Tehran and Jakarta, where WHO Guidelines for these species are invariably exceeded. Air pollution by nitrogen oxides is one of the major problems in the cities of developed countries like Japan (see Bashkin, 2003). In China, the annual average concentration of SO_2 is

Table 2. Predominant outdoor pollutants and their sources.

Pollutants	Sources
Sulfur oxides	Coal and oil combustion, smelters
Ozone	Photochemical reactions
Lead, manganese	Automobiles, smelters
Calcium, chlorine, silicon, cadmium	Soil particulate and industrial emissions
Organic substances	Petrochemical solvents, unburned fuel

66 μg/m^3, nitrogen oxide, 45 μg /m^3, and total SPM, 291 μg/m^3. In New Delhi, air pollution is so heavy, that one day of breathing is comparable to smoking 10 to 20 cigarettes a day (ESCAP, 2000). You can see these data in comparison with WHO Guidelines in Figures 1–3.

The deterioration of air quality in urban areas is mainly the results of increases in industrial and manufacturing activities and in the number of motor vehicles. Motor vehicles normally concentrate in the urban areas and contribute significantly to the production of various types of air pollutants, including carbon monoxide, hydrocarbons, nitrogen oxides and particulates. For example, it is estimated that around 56 tons of CO, 18 tons of hydrocarbons, 7 tons of NO_x, and less than one ton each of SO_2 and particulate matter are discharged daily through the tile pipes of vehicles in Kathmandu alone. In Shanghai, the contribution of CO, hydrocarbon, and NO_x emission by automobiles to the air was over 75, 93 and 44%, respectively. These figures are estimated to increase further to 94% for NO_x, 98% for hydrocarbons, and 75%

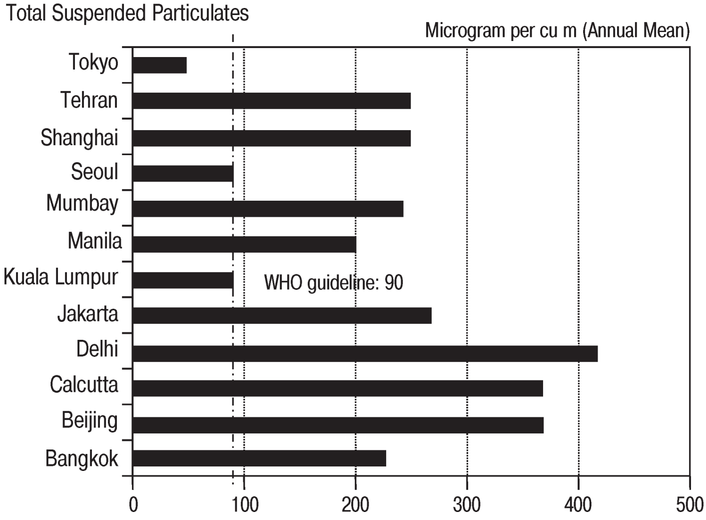

Figure 1. Ambient levels of TSP in Asian cities (ESCAP, 2000).

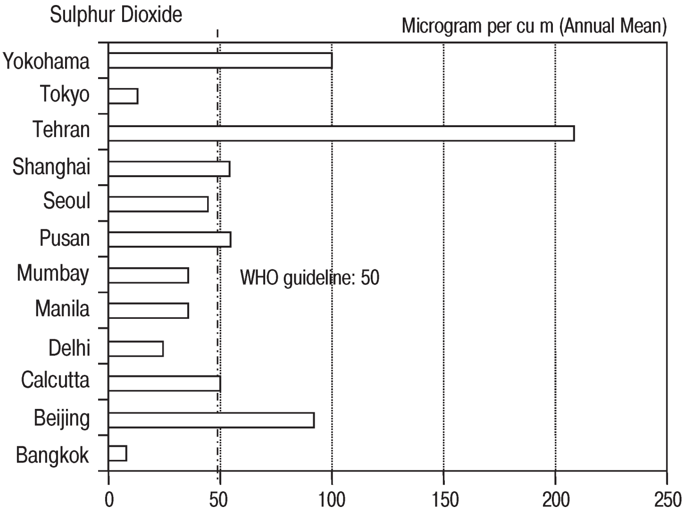

Figure 2. Ambient levels of SO_2 in Asian cities (ESCAP, 2000).

for NO_x by 2010. In Delhi, vehicles already account for 70% of the total emissions of nitrogen oxides, not to mention the amount of lead pollution from using leaded gas.

In the wake of growing numbers of motor vehicles, the problem is likely to become more acute in the future. Many Asian cities within the more prosperous economics had already tripled or quadrupled in the number of passenger cars over the last 10–15 years. In Bangkok, for example, the number of road vehicles grew more than sevenfold between 1970 and 1990 and more than 300,000 new vehicles are added to the streets of this city every year. In China, it is projected that by 2015, there will be

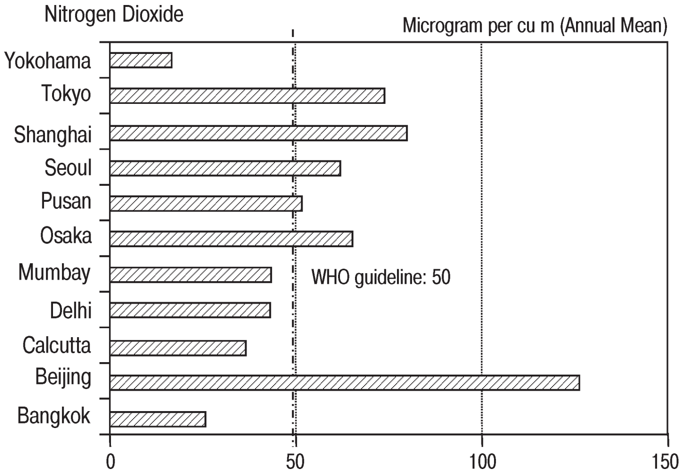

Figure 3. Ambient levels of NO_x in Asian cities (ESCAP, 2000).

30 million trucks and 100 million cars, and that the scope for future growth will still be huge. The forces driving this level of growth in vehicle numbers in the region range from demographic factors (urbanization, increasing population, and smaller households), to economic factors (higher incomes and declining car prices), to social factors (increased leisure time and the status associated with vehicle ownership), to political factors (powerful lobbies and governments that view the automobile industry as an important generator of economic growth).

Most of the growth in motor vehicle fleets in the developing countries is concentrated in large urban areas. Primary cities draw the largest concentration of vehicles. For instance, in Iran, South Korea and Thailand, about half of these countries automobiles' are in the capital cities. In Shanghai, the number of automobiles doubled between 1985 and 1990, and at present, is more than half a million. However, the growth in the vehicle fleet results primarily from increases in the number of motorized two-wheel and three-wheel vehicles, which are more affordable than cars for large segments of the population and often serve as a stepping-stone to car ownership. In Thailand, Malaysia and Indonesia, for instance, two- and three-wheelers make up over half of motor vehicles. The number of two- and three-wheel vehicles is expected to grow most rapidly in China, India and in other densely populated low-income countries. In China, it is projected that there will be 70 million motorcycles by 2015. Production of motorcycles and cars in India is also increasingly 20% annually, outstripping that for buses, which grow at three percent per year. In Nepal, the registered motor vehicles as of 1998 totals to over 200,000, with more than half comprised of two wheelers. Over half of these are concentrated in Katmandu.

Owning to the tremendous rise in the number of vehicles in several countries of the region, the increase in per capita energy consumption has also been quite dramatic. It is projected that energy use in the region will double between 1990 and 2010. In kilograms oil equivalent, it has increased from 91 to 219 in Indonesia, 80 to 343 in Thailand, 312 to 826 in Malaysia, and 670 to 2,165 in Singapore. In urban areas, high-energy use contributes to local air pollution. Cars consume about five times more energy, and produce six times more pollutants than buses. Another environmental impact of this development besides the related air pollution is the depletion of non-renewable natural resources. Like the air pollution problem, the depletion of non-renewable sources of energy also has global implications.

The mounting cost of pollution in the cities of the developing Asian countries is a waste of human and physical resources. In Bangkok, Jakarta and Kuala Lampur, the annual cost from dust and lead pollution is estimated at US$ 5 billion, or about 10% of combined city income (Bashkin, 2003). Air pollution also pushes up the incidence and severity of respiratory-related diseases. Mortality due to cardiovascular disease, particularly of the aged (over 65 years) population, increases with air pollution because labored breathing strains the heart. Studies in China revealed that air pollution, along with smoking, also greatly increases the risk of lung cancer.

The more developed nations in the region have exhibited improvement in air quality in recent years due to a number of measures taken to mitigate air pollution problems. For instance, in South Korea, levels of sulfur dioxide and total suspended particulates have been declining in Seoul and Pusan since 1990. However, slight increases in concentration of other pollutants such as nitrogen oxides, ozone and carbon dioxide in major cities of South Korea has been recorded. In Hong Kong, SO_2, NO_2 and TSP levels averaged 80 $\mu g/m^3$ in 1998. Air quality in Singapore has also significantly improved with the adoption of various strategies to prevent air pollution at its source. Several countries of the region are now promoting the use of unleaded gas. China is planning to convert fully to unleaded gas in 2010 (ESCAP, 2000).

Physical Description of Photosmog

Physical characteristics of photosmog include a yellow-brown haze, which reduces visibility, and the presence of substances which irritate the respiratory tract and cause eye-watering. The yellowish color is owed to NO_2, whilst the irritant substances include ozone, aliphatic aldehydes, and organic nitrates. The four conditions necessary before photosmog can develop are:

- sunlight;
- hydrocarbons;
- nitrogen oxides;
- temperatures above 18 °C.

Sunlight is needed for the formation of OH radicals and initiation of the photochemical reactions of nitrogen oxides in the troposphere. Nitrogen dioxide, NO_2, is important as the only tropospheric gas with appreciable absorption in the visible region of the spectrum. The chemical reactions of photosmog involve the attack of a hydroxyl radical on organic substances. The temperature being above 18 °C gives an idea of the temperature-dependent reactions that increase production of obnoxious by-products to build up to the levels associated with urban air pollution.

The reader can easily estimate whether or not the local conditions in his/her region are suitable for photochemical smog formation.

Photochemical smog was recognized as an urban air pollution problem in Los Angeles, California, USA, in 1949. From that time this phenomenon has been documented in many other sunny locations in the United States and elsewhere in the world like Sao Paulo, Brazil; Mexico City, Mexico; Metro Manila, Philippines; Bangkok, Thailand; New Delhi, India; Shanghai, China and in many other Asian cities with urban pollution from automobile transport. As long ago as the 1950s the automobile was identified as the leading contributor to photochemical smog. Los Angeles was the first major American city to build an extensive freeway system and to rely principally on private automobiles rather than public facilities for transportation. At present this is common in many Asian cities (Bashkin, 2003).

The evidence against the automobile is illustrated in Figure 4, which can be interpreted as follows. Early in the morning pollution levels are low. Nitrogen oxide

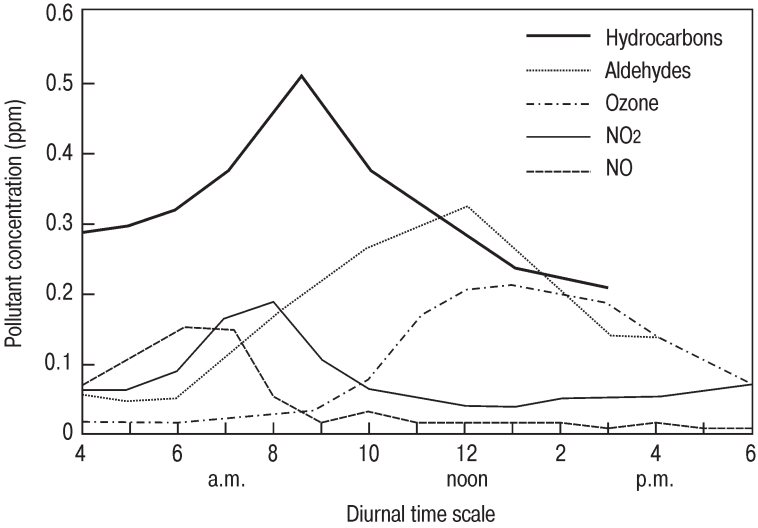

Figure 4. Sketch of the diurnal variation in the concentrations of nitrogen oxides, hydrocarbons, ozone and aldehydes under conditions of photosmog (Manahan, 1994).

and unburned hydrocarbon concentrations rise as people drive to work. As the sun rises higher in the sky, NO is converted to NO_2, and subsequently levels of ozone and aldehydes increase. The latter maximize towards midday, when the solar intensity is highest. Notice that the concentration of NO_x falls after about 10 a.m. and does not rise again during the evening rush hours. There is no second peak at the evening rush hour, because by then the free radical chain reactions are already fully under way.

Automobile emissions cause elevated concentrations of NO, which is oxidized to NO_2. Nitrogen dioxide is photolyzed in sunlight, and this reaction proceeds faster the higher the photon intensity. Tropospheric ground level (as opposed to stratospheric ozone) ozone is formed, and its photolysis leads to the formation of OH. Automobile emissions also provide the organic substances (substrates) for reaction with OH; intermediates and by-products—such as aldehydes and organic nitrates—of the oxidation of these substrates to CO_2 and H_2O are the irritating compounds of the smog. Many of these reactions are temperature-dependent, and so photochemical smog becomes increasingly noticeable the hotter the weather.

All four conditions for photochemical smog must be met simultaneously; consequently, the location and the seasons where this phenomenon is likely to be observed may be predicted. Since automobiles provide the NO_x and HC, photosmog is a big city phenomenon. Sunlight and high temperatures are needed. Other factors contributing to photosmog include orografic features, which may hinder the dispersal of the pollutant plume; this is a factor in the Los Angeles district, where mountains to the east tend to trap the air close to the city. Temperature inversions and lack of wind both serve to localize the pollutant plume and hinder its dispersal. Thus this type of urban air pollution is called photochemical smog of Los Angeles type. This air pollution phenomenon is very frequent in many Asian cities, especially those in subtropical and tropical zone.

5.2. Indoor Air Quality

Indoor air pollution in urban centers occurs both at the home and in the workplace. It can often pose a greater threat to human health than outdoor air pollution, both in developed and developing countries of the Asian region. In particular, women and young children from low-income households are often at significant risk from exposure to high concentrations of pollutants from cooking in poorly ventilated houses.

In Ahmedabad, India, mean values of SPM during cooking were as high as 25,000 $\mu g\, m^{-3}$ in coal-burning households, and 15,000–20,000 $\mu g\, m^{-3}$ where wood and dung were used. This is 130 times higher than the threshold set by US safety standards, not to be exceeded more than once a year. In addition, mean levels for the carcinogen, benz(a)pyrene, BaP, were as high as 9,000 ng m^{-3} during cooking: some 45 times higher than US standards for occupational (8 h) exposure (ESCAP, 1995).

Another example is the high concentrations of SPM, SO_2, CO and BaP, which have been recorded in coal-burning households in many Chinese cities. In Shenyang, lung cancer risk is thought to be 50–70% higher among those who spend most of their lives indoors.

A study on indoor air pollution abatement through household fuel switching in three cities—Pune, India, Beijing, China, and Bangkok, Thailand—revealed that moving up the “energy ladder”, from biomass to kerosene, leads to substantial reductions in health damaging emissions (Tables 3 and 4). Similar effects were noticed shifting from kerosene to LPG, and from coal (vented) to gas (Smith et al., 1994).

Table 3. Estimated daily exposures from cooking fuel among energy ladder in Pune, India (Smith et al., 1994).

	Estimated daily exposure, mg h/m^3	
Fuel	PM_{10}	NO_2
Biomass	17–26	0.22–0.66
Kerosene	2.4–3.6	0.08–0.11
LPG	0.4	0.05
Indian standards	0.98	0.28
WHO recommendation	0.56	0.70

Table 4. Estimated daily exposure from household fuel use along the energy ladder in Beijing (Smith et al., 1994).

	Estimated daily exposure, mg h/m^3		
Fuel	PM_{10}	NO_2	CO
Coal (vented)	2.3–3.5	0.31–0.51	310–430
Gas	1.4	0.15	60
Chinese standards	0.7	0.7	56
WHO recommendation	0.56	0.70	140

5.3. Urban Air Pollution and Health Effects

The high exposure to both indoor and outdoor ambient air pollution has been associated with a number of illnesses, including:

- acute respiratory infections (particularly in children);
- chronic lung disease, such as asthma, tuberculosis, and associated heart diseases;
- pregnancy stillbirths; and
- cancer.

Since urban air is generally more polluted, the incidence of related diseases is more common in cities. For example, lung cancer mortality is higher in Chinese cities than in the nation as a whole; and 60% of Calcutta residents, India, suffer from respiratory diseases, compared to the national average of 3%. Furthermore, it has been estimated in Bangkok that SPM could cause up to 1,400 deaths in the city per year, and that lead pollution could cause 200,000–500,000 causes of hypertension, 300–900 cases of heart attack and stroke, and 200–400 deaths per year (ESCAP, 1995). In spite of significant reduction of lead concentration in the Bangkok urban air due to lead–gasoline phasing out during the second part of the 1990s, some studies indicate that the long-time effects of lead poisoning on children in Bangkok could cause an average loss of 3.5 IQ points per child before the age of seven, i.e., an estimated total loss of 400,000–700,000 IQ points per year.

Acute Respiratory Infections

Acute Respiratory Infection (ARI), as pneumonia, is one of the biggest causes of death for young children in the Asian region. ARI is also responsible for more episodes of illness than any other disease, with the exception of diarrhoea, and it is well known that ARI is aggravated by exposure to pollutants and indoor environmental tobacco smoke (ETS).

Table 5. Tuberculosis notification in selected countries of Asia, notification rate per 100,000 population (ESCAP, 1995).

	All forms		Smear positive, of total reported	
Country	Number	Rate	Percent	Rate
Bangladesh	56,052	47.2	35	16.5
Bhutan	996	169.6	30	50.9
India	1,555,353	182.5	22	40.6
Indonesia	469,832	245.4	16	39.6
Maldives	380	172.4	31	53.4
Mongolia	1,611	71.6	7	5.0
Myanmar	16,440	38.3	72	27.9
Nepal	8,993	45.8	47	21.5
Sri Lanka	6,174	35.4	54	19.1
Thailand	50,185	88.7	76	66.5

According to WHO estimates, Bangladesh, India, Indonesia and Nepal together account for about 40% of global mortality in young children caused by pneumonia, with infant mortality rates above 40.0 per 1,000 live births. The case-fatality rates due to pneumonia among hospitalized children are between 4.2 and 18.3%. Furthermore, a study in Nepal (Pandey et al., 1989) involving a weekly examination of 240 children under 2 years of age over a six-month period, for ARI incidence and severity, demonstrated a strong relationship between the number of hours per day the children spent indoor by fire, and the incidence of moderate and severe ARI cases.

Chronic Obstructive Lung Disease (COLD) and Cor pulmonale

COLD is known to be an outcome of chronic air pollution exposure. Although tobacco smoke is known to be the major risk factor, studies in India and Nepal have found that non-smoking women who regularly cook on biomass stoves exhibit a higher prevalence of COLD than would be expected, or which appears in women who use them less frequently. Indeed, due to indoor exposure, nearly 15% of non-smoking women in Nepal (20 years and older) had chronic bronchitis; a very high rate for nonsmokers (ESCAP, 1995).

In China, COLD was associated with long term exposure to indoor coal smoke (Chen et al., 1998), and in India, Cor pulmonale (heart disease secondary to chronic lung disease) has been found to be more prevalent, and on average to develop earlier, in non-smoking women who cook with biomass fuels than those do not.

Tuberculosis

Tuberculosis, which continues to be a serious public health problem in the region, is also aggravated by air pollution. In 1991, more than 2,000 000 cases were reported in India and Indonesia alone (Table 5), and just 10 countries in the Asian region accounted for over one million deaths.

Around 40% of the population in South and South-East Asia were infected with HIV and M. Tuberculosis, which is extremely high in the region, the number of cases of active tuberculosis may rise by a factor of seven during the coming decade. Furthermore, the age group, which is economically most productive (15–59 years) is particularly vulnerable to the disease. As shown in Table 5, notification rates per 100,000 population were particularly high for all forms of the disease in Indonesia, India, Maldives, and for smear-positive cases were above 50 per 100,000 in Thailand, Maldives and Bhutan. Also of note is the extremely low smear-positive rate in Mongolia (5 per 100,000) where the level of urban air pollution is minimal among Asian countries.

Pregnancy Stillbirths

A study in India found that pregnant women who cook over open biomass stoves have almost 50% greater chance of stillbirth, although there was no measured increase in neonatal death rates (Mavalankar et al., 1991). The main threat to pregnancy appears to come from carbon monoxide, which enters the blood in substantial amounts during cooking.

Table 6. Probability of dying from cancer and cardiovascular diseases between ages 15 and 60 years for males and females in China and India, in percent (Murray and Lopez, 1994).

	China		India	
Disease	Male	Female	Male	Female
Stomach cancer	1.06	0.58	0.37	0.21
Colorectal cancer	0.25	0.23	0.12	0.1
Liver cancer	1.81	0.59	0.14	0.1
Lung cancer	0.65	0.34	0.38	0.1
Diabetes mellitus	0.14	0.17	0.49	0.65
Rheumatic heart disease	0.39	0.64	0.35	0.86
Ischaemic heart disease	0.87	0.45	2.61	1.09
Cerebrovascular disease	2.06	1.75	1.08	1.32
Inflammatory cardiac disease	0.20	0.17	2.31	1.48

Table 7. Ambient air quality standards in some Asian countries, all concentrations in $\mu g\ m^{-3}$, except CO in $mg\ m^{-3}$ (Radojevic and Bashkin, 1999).

Pollutant	Averaging time	Malaysia	Thailand	Indonesia	Philippines	Singapore	Japan
SO_2	10 min	500	–	–	–	–	–
	1 h	350	–	900	850	–	285
	24 h	105	300	300	370	365	114
	Annual	–	100	60	–	80	–
NO_2	30 min	–	–	–	300	–	
	1 h	320	320	–	–	–	205
	24 h						102
	Annual	–	–	100	–	100	–
CO	1 h	35	50	30	35	40	25
	8 h	10	20	10	10	10	–
	24 h	–	–	–	–	–	12
O_3	30 min	–	–	–	200	–	–
	1 h	200	200	160	–	235	128
	8 h	120	–	–	–	–	–
SPM	24 h	260	330	230	180	260	200
	Annual	90	100	90	–	75	100
Lead	24 h	–	10	2	–	–	–
	3 months	1.5	–	–	20	1.5	–

Cancer

Air pollution has also resulted in an increased incidence of lung and other cancers in the Asian region. One study in Japan (Subue, 1990), found that women who reported cooking with straw or wood fuel when they were 30 years of age, subsequently had an 80% increased chance of developing lung cancer in later life. We know that cancer, like chronic lung disease, takes many years to develop after exposure. Furthermore, there is mounting evidence that lung cancer can also be associated with exposure to coal smoke. The corresponding statistical assessments have been shown in China (Chen et al., 1998).

Current knowledge suggests that social habits and diet are as much a cause of cancer and cardiovascular diseases, as are exposure to environmental hazards such as carcinogens and viruses. Apart from the obvious activities of smoking and hard drinking, other examples of ways in which diet can increase the risk of cancer include preserving food through salting, smoking and pickling, which have been shown to increase the risk of oral and stomach cancer.

Indoor and outdoor exposure to many chemical substances (formaldehyde, asbestos, PVC, many metals, like Cr, As, Be, Ti, V, pesticides and nitrosoamines) can also spur the development of cancer. Here we can only state that the International Agency for Research of cancer has identified 60 environmental agents that can aggravate cancer for humans during exposure to polluted urban air (Misch, 1994).

The probabilities of cancer development in urban environments of two of the most polluted Asian countries are shown in Table 6.

The development of all above-mentioned diseases is related to exceeding the air quality standards in many cities of the Asian regions. These standards for the most frequent pollutants are shown in Table 7. The readers can compare the air quality monitoring results in his/her cities with environmental standards.