Country Synthesis Report on Urban Air Quality Management

Nepal

Discussion Draft, December 2006

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

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Abbreviations

$\mu g/m^3$	micrograms per cubic meter
ADB	Asian Development Bank
AQ	air quality
ARI	acute respiratory infection
CEN	Clean Energy Nepal
CO	Carbon monoxide
COPD	cardiovascular obstructive pulmonary disease
DANIDA	Danish International Development Assistance
EIA	environmental impact assessment
ENPHO	Environment and Public Health Organization
IEE	Initial Environmental Examination
EPA	Environmental Protection Act
EPR	Environmental Protection Rules
ESPS	Environment Sector Programme Support
EVAN	Electric Vehicle Association of Nepal
FY	fiscal year
GDP	gross domestic product
HMG	His Majesty's Government
HSU	Hartridge Smoke Unit
ICIMOD	International Centre for Integrated Mountain Development
LPG	liquefied petroleum gas
m	meters
mm	millimeters
MOEST	Ministry of Environment, Science and Technology
MOICS	Ministry of Industry, Commerce and Supplies
MOPE	Ministry of Population and Environment
NERI	National Environmental Research Institute
NGOs	nongovernment organizations
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxide/s
PM_{10}	particulate matter with a diameter of not more than 10 microns
$PM_{2.5}$	particulate matter with a diameter of not more than 2.5 microns
SO_2	Sulfur dioxide
SO_x	Sulfur oxide/s
TSP	total suspended particulates
URBAIR	Urban Air Quality Management Strategy in Asia Project
VSBK	vertical shaft brick kiln
WECS	Water and Energy Commission Secretariat
WHO	World Health Organization

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

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» Part One

General Information

Geography and Climate

Nepal is a landlocked country sandwiched in between two very large countries and economies—India on three sides and the People's Republic of China on the northern side. The country's shape is roughly rectangular, with landmass stretching 885 kilometers (km) from east to west and a nonuniform distance of 193 km from north to south, and comprises a total of 147,181 square kilometers (km^2) of land. Nepal's geography and topography are diverse, consisting of plains (*terais*) and mountainous and hilly regions, but generally the entire country is elevated. The plains itself are situated about 300 meters (m) above sea level, and the country is known for its 8,848-m high Mount Everest, the highest peak in the world. Valleys are also abundant in between hills and mountain ranges.

Owing to its wide physical diversity, and enormous range of altitude within short north–south distances, the country has a great deal of variation in climate. Although only a small country, Nepal has five climatic zones—tropical and subtropical zone (below 1,200 m altitude); the cool, temperate zone (1,200–2,400 m altitude); the cold zone (2,400–3,600 m altitude); the sub-arctic climatic zone (3,600–4,400 m altitude); and the arctic zone (above 4,400 m altitude) (US Country Studies, 2005). The temperature and precipitation patterns are highly dependent on the altitude. Generally, the temperature in the country is decreasing from the south to north regions since the elevation increases from the south to north. Consequently, annual rainfall distribution in Nepal is also affected by the changes in altitude. In addition to latitudinal variation in rainfall, the amount of rainfall generally decreases from east to west during the summer monsoon (from June to September)—eastern Nepal receives approximately 2,500 millimiters (mm) of rainfall annually; the Kathmandu area, about 1,420 mm; and western Nepal, only about 1,000 mm (US Country Studies, 2005).

Nepal's capital, Kathmandu City, also sits on a valley in the mid-hills of the country. The valley floor is elevated 1,350 m above sea level and is relatively flat but is surrounded by hills that rise up to almost 2,000 m. This bowl-like topography of the valley leads to the occurrence of calm, low wind-speed conditions and the formation of temperature inversions (cold air flowing from mountains is trapped under a layer of warmer air and acts as a lid), especially in winter (from December to May). These meteorological conditions retain the pollutants in the atmosphere leading to high levels of ambient concentrations, as supported by air quality monitoring data (Shrestha and Raut, 2002).

Some casual observations have indicated that Nepal's climate is changing. News reports and local observations include warmer summers and less cold winters in Kathmandu Valley, as well as persistent fogs until late mornings in the Terai plains (ADB, 2005a). A change in the climate will affect air pollution levels in Nepal, especially the Kathmandu Valley, since rainfall reduces levels of particulate matter in ambient air while increased wind and storms may also lead to increased transboundary pollutants.

Urbanization and Population

Nepal is one of the least urbanized countries in the world, and urbanization has not occurred evenly throughout the country. Kathmandu city is located next to four municipal towns also located in the valley, namely, Lalitpur, Bhaktapur, Kirtipur, and Madhyapur-Thimi. The capital and the four municipalities constitute the major urban area of Nepal. The Valley is the main center of economic, political, and administrative activities in the country.

In Nepal, the municipalities, as designated by the Ministry of Local Development, are the areas defined as urban. Currently, there are one metropolitan city (Kathmandu, with a population of more than 500,000); four submetropolitan cities (Biratnagar, Lalitpur, Pokhara, and Birguni, with population of more than

100,000); and 53 municipalities. Most of the country's urban areas will most likely not exceed the 300,000 population in the next 10–15 years. Areas have been classified, declassified, and reclassified as municipalities over the decades, apparently based on political interests. As a result, some areas classified as municipalities may not actually have characteristics of an urban area, while some small towns not formally defined may actually exhibit urban character.

The population of Nepal, as of mid-2004, stood at 24.7 million (projected from 2001 census) and this had increased at an annual rate of 2.3% from 2000 to 2004. Kathmandu Valley is growing at annual rate of 4.83%, more than twice the national growth rate. Population growth in Kathmandu has been critical because of centralization and migration of rural people to the capital for employment opportunities and access to facilities and services that only Kathmandu can offer. According to the last census (2001), 44.1% of people living in Kathmandu are first-generation migrants (CEN/ENPHO, 2003).

As of 2003, 15% of the population in Nepal lived in urban areas, a low share compared with that of its neighboring countries in the South Asia region (ADB, 2005b). It is projected that by year 2020, the urban population share of Nepal will be 33.7% of the estimated 34.7 million total population (MOEST, 2006). Kathmandu Valley is the most densely populated urban area in Nepal while most of the other urban areas are not very densely populated. Population densities of small towns are even higher than some areas classified as municipalities.

Economy and Industry

The gross domestic product (GDP) growth per year of Nepal is low compared with that of its neighboring countries in the South Asia region. From 2002 to 2004, Nepal's GDP growth rates of only 3.4% were the yearly lowest in South Asia. In 2002, GDP also encountered a negative growth (-0.4%) (ADB, 2005b).

The tertiary industry (or the services sector) contributes the largest to the Nepal GDP. In 2004, the contribution was 40.4% while that of the primary (agriculture) sector was a close 38.7%. In terms of annual per sector growth, in 2004, the agriculture sector experienced a 3.9% growth (the highest growth in the South Asia region), industry sector at a very low 1.0%, and the services sector an average 4.3% growth. The manufacturing industry sector in the country is relatively small, as it contributes only 7.7% to the national GDP (ADB, 2005b). The development of the manufacturing sector is hindered by Indian competition, poor infrastructure, low local market demand, and lack of sea port/access (MOEST, 2006).

A large chunk of the industries (37.7%) especially construction industry, however, is located in Kathmandu. The heaviest polluting of all the industries in Nepal are the brick kilns, most of which were also located in the valley. The presence of brick kiln industries in a vicinity leads to very high levels of pollutants—three times higher than in areas without brick kilns. Prior to the ban of old brick kiln technology and the introduction of the cleaner Vertical Shaft Brick Kiln (VSBK) technology, there were about 125 brick kilns operating in the valley (Tuladhar and Raut, 2002). With the introduction of improved brick kiln technology, it is expected that the emissions from this sector will further improve.

The services sector has traditionally been dominated by the tourism sector. Although trade, restaurants, and hotels still contribute a substantial 10.9% of GDP (fiscal year [FY]2002), this has declined by 15% from FY1998 (MOEST, 2006).

Energy

Nepal's per capita energy consumption (347 kilograms [kg] of oil equivalent) is among the lowest in South Asia region and in the world, and is reflective of the current level of development in the country (CBS, 2004). There are three primary sources of energy in the country—traditional (biomass), conventional (fossil fuels, such as coal and oil), and alternative energy (mostly renewable). Historically, Nepalese society relied solely on biomass—in the form of fuelwood, agricultural residues, and animal waste—to supply their energy needs. This was especially true for people in the rural areas who did not have to pay for the freely abundant biomass (which was also a by-product of their agricultural activities). Although currently biomass is increasingly becoming scarce, people in the rural areas of Nepal still continue to use biomass for lack of other options. As a landlocked country and no known exploitable reserves for fossil fuels, Nepal relies on imports from neighboring India to supply their conventional fuel needs.

Energy sources, such as biomass, hydroelectricity, wind, and sunlight, are estimated to potentially produce annually 1,970 million gigajoules (GJ) of energy, 75% of which would be from water resources and 12% from forests (WECS, 1996). If tapped, this indigenous energy can potentially cover up to even 15 times the total energy consumption of the country. Nepal's total energy demand was 8,883 thousand tons of oil equivalent in 2002 (ADB, 2005a).

Between 1993 and 2002, energy consumption in the country increased at an annual rate of 2.5%, almost the same rate as the increase in population (2.3%). The residential sector consumed 90.6% of energy resources in the country, followed by transport (3.9%) and industries (3.4%) (see Table 1.1).

TABLE 1.1

Share of Energy Consumption by Sector (%)

Sector/Year	1994	2003
Residential	93.1	90.6
Industrial	3.4	3.4
Commercial	0.8	1.2
Transport	2.4	3.9
Agriculture	0.2	0.8
Others	0.1	0.1

Source: Water and Energy Commission Secretariat, Kathmandu (2005), unpublished data file.

Since 98% of the residential sector relies mostly on traditional energy (especially for cooking), it is not surprising to see that traditional biomass energy sources contribute 87% of the total energy consumption. Ironically, although indigenous to Nepal, alternative energy sources only contribute 0.5% to the country's energy demand (ADB, 2005a).

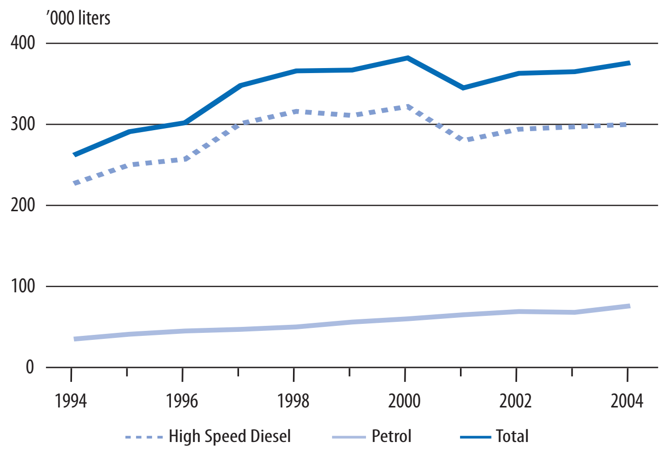
Transport

As a landlocked and mountainous country, Nepal relies highly on road transport and air transport for travel. Mobility in the urban areas, however, relies only on road transport. There are no existing light-rail transit systems in Nepal.

The existing vehicle fleet is 472,795 in FY2004, which is three times its number from the previous decade (FY1994). The annual growth rate in the number of vehicles during this period varied from between 10% and 16%. The vehicle fleet in Nepal is further characterized by increasing share of two-wheelers (43% in 1989 and 63% in 2004), and old, poorly maintained vehicles. In Nepal, more than half of the total registered vehicles (56%) are also found in Kathmandu Valley. The increase in the number of vehicles is associated with the increase in the demand for vehicle fuel (Figure 1.1).

FIGURE 1.1

Vehicle Fuel Import for Fiscal Years 1994–2004



Source: MOEST (2006).

Urban traffic in Nepal is a mix of automobiles, cycle rickshaws (manual three-wheelers), bicycles, and even animal-drawn carts. In Nepal, three-wheelers are known as *tempos*; diesel three-wheelers as *vikrams*; and electric three-wheelers as *safa tempos*. The character of the mix varies from one municipality to another; but in Kathmandu, cars and motorcycles make up about half of the mix. Roads in Nepal are either paved with blacktop, graveled, or earthen. Of the total road length of 2,051 km in 2000, 45% were blacktopped, 30% was graveled, and the remaining 25% was earthen (ADB, 2005a). The increase in the number of vehicles has not been matched by expansion and upgrading of road infrastructures, leading to increased traffic congestion especially in Kathmandu (where traffic density is 300 vehicles per km compared with the national average of 14 vehicles per km). Urbanization is clearly taking place without transport planning considerations. Roads are most often crooked and narrow, and poorly networked with each other. In addition to poor road infrastructure and increased number of vehicles, poor parking facilities and roadside trading all lead up to longer travel times, higher air pollution levels, and inefficient fuel consumption (ADB, 2005a).

Another growing problem in the country is increased emissions and vehicle breakdown due to adulteration of fuel, where low-cost kerosene is added to petroleum or diesel to extract more profits. This problem is more evident in motorbikes than in four-wheelers. In some service centers, more than 80% of maintenance work is related to adulterated fuel. Surveys indicate that fuel adulteration is about 35% in petrol and 75% in diesel (Sharma, Milan Mani, 2006). There is still no study in Nepal, however, to indicate the direct correlation of fuel adulteration on vehicle emissions.

Electric vehicles, which are also common especially in Kathmandu, started with the trolley bus system in 1975. In its initial days of service, the trolley bus provided efficient movement of travelers (88%) between Bhaktapur and Kathmandu. The trolley bus system operated profitably until 1990 but closed in 2001.

Sources of Air Pollution

Emissions inventory, which determines the contribution of different sources of air pollution, is not routinely conducted in Nepal or in its major urban areas. Inventory of emissions are conducted on a project basis, most of which are either for Kathmandu City or for the Kathmandu Valley only. To date, only two comprehensive emissions inventories have been conducted in the Kathmandu Valley (in 1993 and 2001). Source apportionment of particulate matter using advanced nuclear techniques has never been conducted in Nepal or in Kathmandu.

A comprehensive inventory conducted through the Urban Air Quality Management Strategy in Asia Project (URBAIR) of the World Bank included emissions from energy, as well as nonenergy sources (road dust, etc.) for the base year 1993. The World Bank study showed that mobile sources at that time contributed only a small percentage of emissions compared to the then-existing Himal Cement Plant and the highly-polluting old brick kiln technology. This emissions inventory, however, had a disclaimer that the emissions factor used for mobile sources may have been underestimated (2 grams per kilometer [g/km] which was later updated in another emissions inventory to 8g/km).

The 1993 emissions inventory showed that the Himal Cement Plant was the biggest source of pollutants (36% of total suspended particulates [TSP], 17% of particulate matter with a diameter of not more than 10 microns [PM_{10}]); brick kilns (31% of TSP, 28% of PM_{10}), domestic fuel burning (14% of TSP, 25% of PM_{10}), and road dust (9% of TSP, 9% of PM_{10}).

After the closure of the Himal Cement Plant and the improvement of the brick kiln technology, another emissions inventory was conducted by the Danish International Development Assistance (DANIDA)-funded Environment Sector Programme Support (ESPS) project. This 2001 emissions inventory indicated a different scenario. Mobile sources were now the main sources of pollution in Kathmandu Valley, accounting for 43% of PM_{10} and 10% of TSP. See Table 2.1 for a comparison of the two emissions inventories.

TABLE 2.1

Comparison of Emissions Inventories in 1993 and 2001 (tons/year)

	TSP			PM_{10}		
Sources	**1993**	**2001**	**% increase**	**1993**	**2001**	**% increase**
Mobile Sources						
Vehicle Exhaust	570	1,971	245	570	3,259	471
Road Resuspension	1,530	7,008	358	400	1,822	356
Subtotal	**2,100**	**8,979**	**328**	**970**	**5,081**	**424**
Stationary Sources						
Industrial/commercial fuel	582			292		
Domestic fuel combustion	2,328			1,166		
Brick kilns	5,180	6,676	29	1,295	1,688	30
Himal Cement Plant	6,000	3,612	-40	800	455	-43
Industrial boilers		28			15	
Refuse burning	385	687	78	190	339	78
Subtotal	**14,475**	**10,904**	**-25**	**3,472**	**2,498**	**-28**
Total	**16,575**	**19,884**	**20**	**4,712**	**7,580**	**61**

TSP = total suspended particulates, PM_{10} = particulate matter with a diameter of not more than 10 microns.
Note: The 1993 study was conducted by the World Bank, URBAIR Project. The 2001 study was conducted by the Environment Sector Programme Support (ESPS).
Source: MOEST (2005).

» Part Three

Status of Air Quality

Air Quality Monitoring

Prior to the creation of the Ministry of Population and Environment (MOPE) in 1995, no agency was assigned to monitor the quality of air in Nepal. Monitoring at that time was conducted on an ad hoc or project basis in Kathmandu, as well as in neighboring municipalities. To date, routine AQ monitoring is only available for the Kathmandu Valley area. Air quality monitoring outside the Kathmandu Valley is still conducted only on project basis.

With support from DANIDA, MOPE established an air quality monitoring system in Kathmandu consisting of six monitoring stations within the Kathmandu Valley. Objectives include monitoring compliance with air quality standards, assisting in air quality research and management, and raising public awareness. Once completed, all six monitoring stations will monitor a wide number of pollutants (PM_{10}, particulate matter with a diameter of not more than 2.5 microns [$PM_{2.5}$], TSP, Carbon monoxide [CO], Nitrogen dioxide [NO_2], Sulfur dioxide [SO_2], and Benzene). Currently, however, only PM monitoring is fully operational.

The six monitoring stations are installed in various locations to appropriately represent the concentrations in urban traffic areas (Putali Sadak and Patan Hospital), residential (Thamel), urban background (Bhaktapur and Kirtipur), and a valley background (Matsyagaon). All six stations have been monitoring PM_{10} since November 2002; the Thamel station also monitors $PM_{2.5}$.

A separate station to collect meteorological information has also been constructed in December 2004 as part of the AQ monitoring program in Kathmandu. This station is located at the premises of the Royal Nepal Academy of Science and Technology (RONAST) and is operated by the Department of Hydrology and Meteorology (DHM). Once this meteorological station becomes fully operational, resulting data will be correlated with those collected from the six AQ monitoring stations (MOEST, 2005).

The Ministry of Environment, Science and Technology (MOEST) is responsible for the management of the monitoring program, including quality assurance and control. The operation of the monitoring activities is performed on a contract basis by joint venture of private laboratories located in Kathmandu (Gautam et al., 2004; CEN/ENPHO, 2003). Quality assurance audit is being undertaken regularly by international experts in Denmark as part of the ESPS program. Similarly, intralaboratory comparison is also undertaken every 6 months with a laboratory in Denmark (Gautam et al., 2004).

The study of urban air quality is not continuous and systematic outside Kathmandu Valley. Some studies have been conducted outside Kathmandu Valley on an ad hoc basis by various organizations. In the past, MOPE, with the help of Krishna Engineering Consultant, monitored air pollution at nine sites of Pokhara and Biratnagar during May–June 1999. Similarly, the Consortium of Consultants and Gaurav Engineering Consultant monitored air quality at 12 sites of Kathmandu, Pokhara, Birgunj, and Biratnagar during June 1999. Both of the studies monitored 8-hour average concentrations of TSP, PM_{10}, SO_2, NO_2, CO, and Lead.

To determine the status of air pollution in urban centers outside Kathmandu Valley, air quality monitoring (covering TSP, PM_{10}, SO_2, NO_2, CO, and Lead) was also conducted in selected urban areas in November–December 2000. The nine study sites included Nepal's major urban centers outside Kathmandu Valley—Biratnagar, Janakpur, Birgunj, Narayanghat, Pokhara, Butwal, Bhairahawa, Nepalgunj, and Mahendranagar (IUCN, 2004). The monitoring was conducted to obtain 8-hour average concentrations of pollutants for a particular day in each site.

Aside from ambient AQ monitoring, MOEST has also initiated, along with the International Centre for Integrated Mountain Development (ICIMOD) and support from the United Nations Environmental Programme (UNEP), monitoring transboundary air pollution. This monitoring has also been in support of Nepal's commitment under the Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia. A monitoring station has been set up at the Institute of Agriculture and Animal Sciences (IAAS), Rampur, Chitwan to monitor both air quality and rainwater chemistry (TSP, PM_{10}, SO_2, and NO_x) and rainwater analysis for pH, electrical conductivity, and concentration of anions (e.g. NO_3^-, SO_4^-) and cations (e.g. Ca^{2+} Mg^{2+}, K^+, Na^+). Another ICIMOD activity is with the global initiative, named as Project Atmospheric Brown Cloud (ABC), which focuses on the impact of radiation and aerosol on agriculture, water budget and health. Radiation measurement is conducted at the ICIMOD headquarters, which is also known as Nepal Climate Observatory. Various instruments for aerosol measurement are placed at the Godavari Training and Demonstration of ICIMOD. Although some data has been collected, more are still required for meaningful interpretation.

Air Quality Data

The length of time that the AQ monitoring system in Kathmandu has been in operation may not be sufficient to allow a long-term analysis (10 years or more) of the air quality in Kathmandu. The length of its operation is enough, however, to collect sufficient information to evaluate seasonal trends of air pollution in the valley.

Total Suspended Particulates (TSP). In Kathmandu Valley, TSP is being monitored once a week for 24-hour average values in the two roadside stations, Putalisadak and Patan, since 2003. Figure 3.1 shows the high levels of TSP in both stations (there is no annual ambient standard for TSP in Nepal, only a daily limit of 230 μg/m^3). A seasonal trend can also be observed: air pollution is highest from December to May.

Air quality in nine urban areas outside the Kathmandu Valley also exhibited very high TSP levels ranging from 658 to 1,529 μg/m3 (see Table 3.1). These air quality monitoring information clearly indicate that TSP is a major problem in urban areas in Nepal.

TABLE 3.1

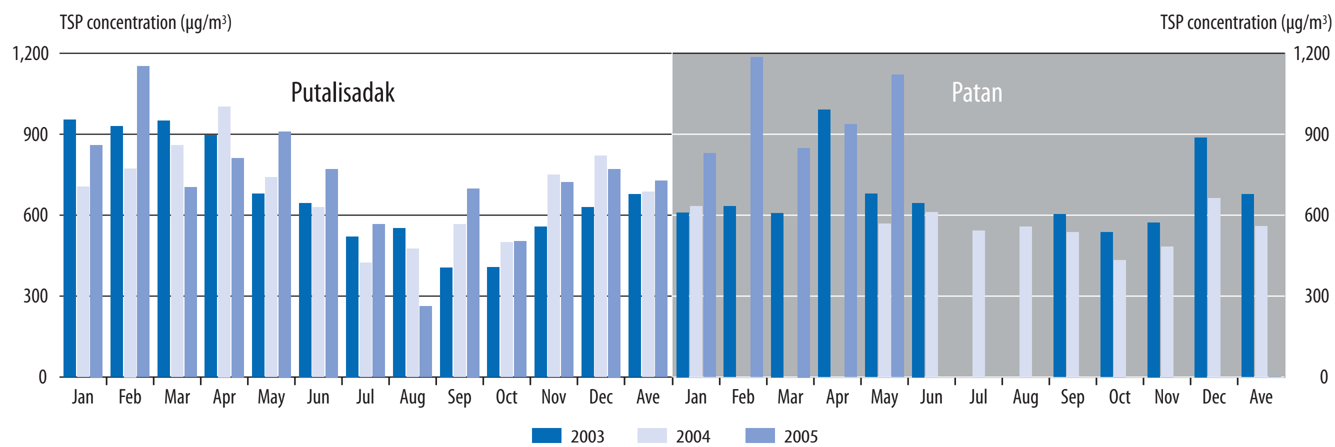
TSP Concentrations in Nine Urban Areas Outside Kathmandu Valley (μg/m^3)

City	TSP
Pokhara	874.4
Birgunj	705.86
Biratnagar	723.06
Janakpur	1,406.1
Narayanghat	658.5
Butwal	1,158.83
Bhairahawa	840.76
Nepalgunj	1,529.21
Mahendra Nagar	736.25

Note: The values are 8-hour average concentrations.
Source: IUCN (2004).

FIGURE 3.1

Monthly and Annual Average TSP at Putalisadak and Patan Stations, 2003–2005



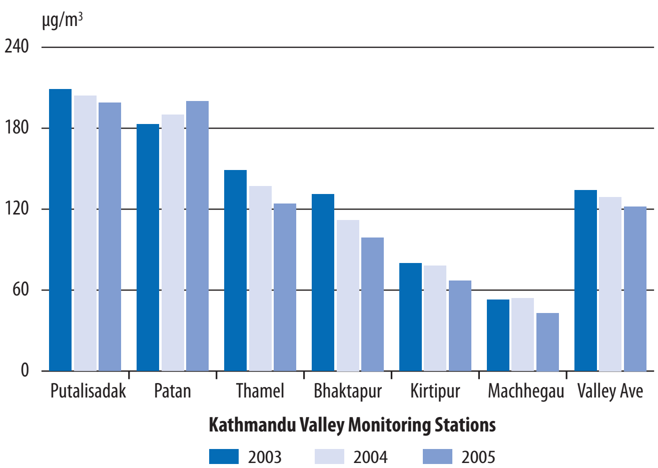
Source: MOEST (2006).

PM_{10}. The data for PM_{10} in Kathmandu Valley from 2003 to 2005 indicate that the average ambient concentration of PM_{10} has slightly improved. It continues, however, to exceed the WHO annual guidelines for PM_{10}. Nepal does not have any annual standards for PM_{10} but even its 24-hour standard of 120 µg /m^3 is also exceeded by the annual average concentrations from 2003–2005. The PM_{10} concentrations are also highest in the urban traffic areas of Patan and Putalisadak—almost double that of the values obtained in the urban background stations in Bhaktapur and Kirtipur and four times higher than the valley background values (Figure 3.2). PM_{10} concentrations in urban areas outside the valley are also very high, exceeding Nepal's daily PM_{10} limit (120 µg/m^3) by as much as 11 times (Table 3.2). Compared with new annual guidelines for PM_{10} set by WHO (of 20 µg/m^3) (WHO, 2005), the PM_{10} in urban areas in Nepal exceed the WHO guidelines by as much as 72 times. As with TSP, PM_{10} is also a major pollutant of concern in the urban areas of Nepal.

$PM_{2.5}$. The Thamel station in the Kathmandu Valley monitors both PM_{10} and $PM_{2.5}$. Figure 3.3 shows the monthly average of PM_{10} and $PM_{2.5}$ monitored parallel at Thamel residential station; the ratio seems to vary from about 0.50 to 0.75. The ratio is clearly higher during the dry season and falls gradually during the wet season, with a minimum of about 0.5 during the month of July.

FIGURE 3.2

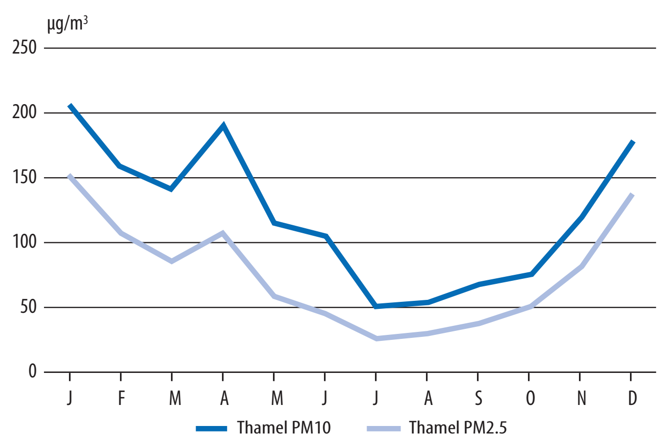
PM_{10} Concentrations in Kathmandu Valley



Source: MOEST (2006).

FIGURE 3.3

$PM_{2.5}$ and PM_{10} in Kathmandu Valley



Source: MOEST.

TABLE 3.2

PM_{10} Concentrations in Nine Other Urban Areas Outside[a] Kathmandu Valley (µg/m^3)

City	PM10
Pokhara	839.9
Birgunj	664.5
Biratnagar	661.46
Janakpur	1,298.06
Narayanghat	572.93
Butwal	1,066.89
Bhairahawa	776.59
Nepalgunj	1,448.20
Mahendra Nagar	687.5

[a] The values of monitoring in urban areas outside Kathmandu are 8-hour average concentrations.
Source: IUCN (2004).

Sulfur dioxide (SO_2). SO_2 was monitored in September 2004 in Kathmandu Valley using diffusive samplers that were later analyzed by NERI in Denmark. SO_2 levels in Kathmandu and in other urban areas in Nepal are shown in Table 3.3. SO_2 levels in the Kathmandu Valley area are much lower than those in their other urban counterparts in Nepal. Since Nepal has an annual and 24-hour standards for SO_2, these weekly and 8-hour averages are not directly comparable to Nepal's standards.

Nitrogen dioxide (NO_2). NO_2 was monitored, using passive samplers, at the six stations in the Kathmandu Valley**.** Because of difference in averaging periods, however, these weekly and 8-hour average readings of NO_2 cannot be directly correlated with Nepal standards for annual and 24-hour NO_2 standards (Table 3.4).

TABLE 3.3

SO_2 Concentrations in Kathmandu and in Other Urban Areas in Nepal (μg/m^3)

Location	Sampling Date	SO_2	Remarks
Patan (KV)	Week starting 8 Sep 2004	0.85	Weekly sample Sep 2004
Patan (KV)	Week starting 14 Sep 2004	4.47	Weekly sample Sep 2004
Thamel (KV)	Week starting 8 Sep 2004	0.50	Weekly sample Sep 2004
Thamel (KV)	Week starting 14 Sep 2004	0.13	Weekly sample Sep 2004
Kirtipur (KV)	Week starting 8 Sep 2004	5.31	Weekly sample Sep 2004
Kirtipur (KV)	Week starting 14 Sep 2004	0.14	Weekly sample Sep 2004
Pokhara	26 Nov 2000	98.23	8-hour averaging time
Birgunj	30 Nov 2000	85.13	8-hour averaging time
Biratnagar	4 Dec 2000	55.08	8-hour averaging time
Janakpur	7 Nov 2000	71.7	8-hour averaging time
Narayanghat	10 Dec 2000	81.02	8-hour averaging time
Butwal	19 Dec 2000	133.1	8-hour averaging time
Bhairahawa	22 Dec 2000	106.8	8-hour averaging time
Nepalgunj	26 Dec 2000	68.19	8-hour averaging time
Mahendra Nagar	29 Dec 2000	59.66	8-hour averaging time

Sources: MOEST, (2006) and IUCN (2004).

Carbon Monoxide (CO) and Lead (Pb). Ambient concentrations of CO and Pb in urban areas, based on an 8-hour averaging time, are shown in Table 3.5. CO values then have exceeded standards in some sites. Because of difference in averaging times, Pb concentrations cannot be compared with ambient standards.

TABLE 3.5

CO and Pb Concentrations in Urban Areas in Nepal (μg/m^3)

City	CO	Pb
Pokhara	1097.75	0.14
Birgunj	1,494.85	0.32
Biratnagar	620.466	0.22
Janakpur	427.6333	0.81
Narayanghat	1,050.02	0.11
Butwal	515.4633	0.26
Bhairahawa	849.56	0.16
Nepalgunj	801.86	0.35
Mahendra Nagar	85.90	0.13

Source: LEADERS Nepal (2000). Transport Sector Air Pollution Survey in Nine Major Urban Cities of Nepal. A report submitted to IUCN/Nepal, Kathmandu.

TABLE 3.4

NO_2 Concentrations in Kathmandu and in OtherUrban Areas in Nepal (μg/m^3)

Location	Sampling Date	NO_2	Remarks
Patan and Putalisadak (Urban Roadside KV)	Nov 2003 to March 2004	27.00	Average
Patan and Putalisadak (Urban Roadside KV)	Nov 2004 to March 2005	31.00	Average
Thamel (Urban Residential KV)	Nov 2003 to March 2004	27.00	Average
Thamel (Urban Residential KV)	Nov 2004 to March 2005	27.00	Average
Bhaktapur and TU? (Urban Background KV)	Nov 2003 to March 2004	13.00	Average
Bhaktapur and TU? (Urban Background KV)	Nov 2004 to March 2005	13.00	Average
Matsyagaon (Valley Background)	Nov 2003 to March 2004	2.00	Average
Matsyagaon (Valley Background)	Nov 2004 to March 2005	3.00	Average
Valley Overall average	Nov 2003 to March 2004	17.00	Average
Valley Overall average	Nov 2004 to March 2005	18.00	Average
Pokhara	26 Nov 2000	11.34	8-hour ave time
Birgunj	30 Nov 2000	23.20	8-hour ave time
Biratnagar	4 Dec 2000	19.53	8-hour ave time
Janakpur	7 Nov 2000	20.3	8-hour ave time
Narayanghat	10 Dec 2000	17.61	8-hour ave time
Butwal	19 Dec 2000	23.96	8-hour ave time
Bhairahawa	22 Dec 2000	22.68	8-hour ave time
Nepalgunj	26 Dec 2000	16.41	8-hour ave time
Mahendra Nagar	29 Dec 2000	19.84	8-hour ave time

Sources: IUCN (2004) and MOEST (2006).

Reporting of AQ Information

The air quality data monitored by the six monitoring stations in the Kathmandu Valley are reported electronically in MOEST's website (http://www.most.gov.np/pollution/pollution.php). The data, however, is reported on a weekly basis with health-related descriptors. Table 3.6 shows the air pollution (PM_{10}) descriptors used to describe the effect on human health from the daily air pollution level in Kathmandu. Air quality monitoring data are also presented in reports published by MOEST.

TABLE 3.6

Nepal Air Quality Descriptors for PM_{10}

Descriptor	Color	PM_{10} (µg/m^3)
Good	Green	< 60
Moderate	Yellow	60-119
Unhealthy	Orange	120-349
Very unhealthy	Red	350-425
Hazardous	Purple	> 425

Source: MoEST (2005).

» Part Four

Impacts of Air Pollution

Health

A number of studies, especially in the Kathmandu Valley area, suggest adverse health outcome from exposure to air pollution. The summary of key findings of these studies is presented in Table 4.1.

Environment

Environmental impact of air pollution is also well-documented in Nepal. The atmospheric data obtained from the Kathmandu airport from 1970 onwards shows that there has been a substantial decrease in visibility in the valley since 1980. The number of days with good visibility (>8,000 m) around noon, decreased in the winter months from more than 25 days/month in 1970 to 5 days/month in 1992. The present visibility situation is such that during the period November–February the visibility is very poor before 9:00 am, with only 10% of the day with visibility >8,000 m. The trend toward reduced visibility in the valley is quite dramatic for the months November–March, and particularly for December–February. The number of days per month in December–February with good visibility at noon is approaching zero (Sapkota et al., 1997).

Although not extensively investigated, observations on the negative impact of air pollution on vegetation have also been conducted in Nepal. The air pollution from Himal Cement Plant was observed to cause low yield of crops in the surrounding area. High levels of pollution caused foliar injury and low yield of crops due to dust deposition on leaves, blocking the stomata and disrupting the photosynthetic process. Soil was also observed to have high calcium deposition that affected germination of seeds. Among the plants studied, *Pinus roxburghii* was the most affected (ENPHO, 1999).

Economic

Tourism is one of the main industries that contribute largely to the Nepal economy. A number of surveys have been conducted in different time periods to assess the impact of air pollution on this major industry. Findings of the Departing Visitors Survey conducted among 1,702 tourists between May and June 2001 by MARG Nepal indicate that the quality of air is the number one area where tourists feel improvement is needed (Business Age, 2001). A more recent survey of tourist perception on Kathmandu's air quality was conducted between April and June 2005. The survey had 2,800 respondents, 69% of whom rated the city's air quality as poor while 77% felt that the air quality outside Kathmandu is better. A substantial number of tourists also experienced difficulty in breathing (49%) and had visibility problems (58%) during their stay (KEVA, 2005). A World Bank study also estimated that Nepalese rupees (NRs)0.5 billion (about US dollar [US$]8.78 million)[1] in tourism revenue had been lost due to air pollution in Kathmandu Valley (World Bank, 1997).

Economic valuation of health impacts due to air pollution showed varying ranges of damage: NRs210 million ($36.9 million) per year from respiratory problems (Shah and Nagpal, 1997); respiratory problem costs from about NRs30 million to NRs55 million ($0.4 million–$0.72 million)[2] per year (NESS, 2001); hospitalization due to respiratory problem among children in the valley was estimated at NRs2 million ($0.02 million)[3] for 2002 and NRs5.4 million ($0.07 million)[4] for 2003 (Saraf, 2005). Cost of illness per episode of ARI-related hospital admission was also estimated at NRs5,279 ($71.35)[5] (Saraf, 2005).

[1] Currency exchange rates from Nepalese rupees (NRs) to United States dollars (US$) are based on average historical exchange rates from http;// oanda.com on the year cited in the publication source or base year of study. For 1997, $1 = NRs56.92689.

[2] Currency exchange rate is $1 = NRs75.99989 for 2001 from http://oanda.com

[3] Currency exchange rate is $1 = NRs80.41584 for 2002 from http:// oanda.com

[4] Currency exchange rate is $1 = NRs78.18204 for 2003 from http:// oanda.com

[5] Currency exchange rate is $1 = NRs73.98509 for 2005 from http:// oanda.com

TABLE 4.1

Summary of Health Impact Studies Conducted in Nepal

Author and Year	Methods and Key Findings
Pandey and Neupane (1984)	• Reviewed discharge cases in 10 hospitals • Acute respiratory infection (ARI) accounted for 32.1% of infant mortality and 11.2% of mortality for children aged between 1 and 4 years old. • In the Kanti children hospital alone, for period April 1982 to March 1993, 37.8% of 3,319 admissions were due to ARI.
Shah and Nagpal (1997)	• Study used dose-response function developed in the United States and 41 $\mu g/m^3$ as the benchmark threshold for PM_{10}. • In 1990, PM_{10} pollution caused 84 excess deaths, 475,298 restricted activity days, 1.5 million respiratory symptom days, and 99 respiratory hospital admissions. • Among the sources of air pollution, traffic (exhaust and resuspension) had the largest impact on health. • It was estimated that reduction of vehicle exhaust emissions was the most effective in terms of reduced health damage, Rs341 per kg emission reduction (i.e. savings of US$11.61 per kg reduction in emission). • The World Bank study had some major limitations; it was based on the epidemiological studies conducted in the United States. Similarly, it assumed threshold level of 41 $\mu g/m^3$ for PM_{10}; however, WHO has admitted that no such threshold exists.
Child Workers in Nepal (CWIN) (1997)	• Survey of 60 children working as conductors (helpers) in *tempos* (65% of whom were below 14 years of age) and examined the health (including chest X-ray and blood test) of 38 of these children • These children worked for about 14 hours each day, hanging behind the tempos just above the emission pipe; they breathe 4,116 µg of PM_{10}, 1,255 µg of NO_x and 17,687 µg of TSP each day. • 42% of the children said that they had been sick during work. • Health complaints included eye problem (84%); chest pain (82%); headaches and nausea (58%); fever (53%); cough and cold (55%); difficulty in breathing (45%); pneumonia, tuberculosis, bronchitis, and chest problems (29%); anemia (18%); and skin problems (21%).
LEADERS (1999)	• Analyzed hospital records for respiratory diseases especially on children. • Urban residents exceeded the number of respiratory-related cases in the hospital compared with that from the rural area in Kathmandu.
NESS (2001)	• Updated World Bank Study (Shah and Nagpal, 1997 ed.) using threshold concentration of 40 $\mu g/m^3$ for PM_{10} • PM_{10} pollution caused 92 premature deaths annually among children < 5 years and about 65,000 cases of respiratory problems.
Shakya (2001)	• Studied impact of air pollution on traffic police using questionnaire survey for 90 traffic police and unstructured interview of 20 traffic police, field observations and medical tests (oxy-hemoglobin and flow meter test) of 15 traffic police • Impact on nervous system ranged between 58% and 74%, including dizziness, depression, headaches, forgetfulness, irritation, lack of concentration, etc. • Impact on respiratory system ranged between 26% and 87%, including severe cold, asthma, cough, sneezing, nose irritation, and low resistance to influenza. • Impact on cardiovascular system ranged from 39% and 63%, including rapid heartbeat, chest pain, high blood pressure, and anemia. • Other impacts included reddening of eyes, watery and burning sensation in the eyes, and reduction in vision.
Shrestha (2002)	• Analyzed records of respiratory illness in main hospital of Kathmandu Valley (Bir hospital, Patan hospital, Kanti Children hospital, and Tribhuvan University Teaching Hospital) • Increasing number of patients were diagnosed with respiratory problems over a 5-year period • Concluded that increased prevalence of respiratory illness is due to the rising level of particulate concentration in Kathmandu's air.
Tuladhar and Raut (2002)	• Studied the impact of brick kilns on health of children living next to the kilns using surveys, as well as medical examinations of respondents • PM_{10} in the area with kilns was about three times higher than PM_{10} levels in an area without kilns • Concluded that people living near brick kilns are more likely to suffer from illness related to air pollution compared with people living in an area without kilns • Medical examination of children attending school in an area with brick kilns (High View School of Tikathali) compared with students from school in an area without kilns (Valley Public School) showed that the kilns adversely affected the health of young children (under the age of 6) exposed to the pollution. • Out of 290 individuals surveyed, 54% from area with brick kilns reported symptoms of respiratory disorders compared with 41% in the control area. • Elderly people were the most affected in terms of respiratory disorders in both areas. This was followed by children up to the age of 4 years.

CEN and ENPHO (2003)	• Analyzed records of Cardiovascular Obstructive Pulmonary Disease (COPD) patients and control patients admitted to Patan Hospital from April 1992 to April 1994, as well as from other hospitals in the country • The odds of having COPD are 1.96 times higher for Kathmandu Valley residents compared with outside valley residents. COPD is also the number one killer of adult patients. • Records from three major hospitals in Kathmandu indicated that the number of COPD patients admitted to hospital, as well as the percentage of COPD patients as a percentage of total medical patients has increased significantly in the last 10 years. • Number of COPD patients was highest in the dry winter months, when air pollution is at its peak and elder subpopulation is most vulnerable to respiratory illness. • Estimated that reduction of $PM_{2.5}$ level in Kathmandu by half of the existing (47.4 µg/m^3) will result in reduction in daily mortality by 7% and hospital admissions by 24%. • Reduction in the annual average PM_{10} level in Kathmandu to international standard (50 µg/m^3) will avoid over 2,000 hospital admissions, over 40,000 emergency room visits, about 135,000 cases of acute bronchitis in children, over 4,000 cases of chronic bronchitis, and half a million asthma attacks.
Rana (2004)	• Assessed air quality of Birgunj, Pokhara, and Kathmandu Valley (including Putalisadak and Matsyagaon stations) • Also assessed the environmental burden of disease due to outdoor air pollution using WHO guidelines. • TSP and PM_{10} were the pollutants of primary concern. • In Kathmandu Valley, the attributable burden due to current PM_{10} concentration against the baseline concentration of 10 µg/m^3 was found to be 1,926 cases of premature mortality per year (lower and upper bounds of 1,184 and 2,973, respectively). • The number of cases of premature mortality from short-term exposure to current PM_{10} concentration in Kathmandu Valley, which could be avoided if the Government could reduce the ambient PM_{10} concentration to national standard, was calculated to be 212 cases of premature mortality per year, with upper and lower bounds of 127 and 338, respectively.
Saraf (2005)	• The study estimated dose-response relation between PM_{10} and number of ARI-related hospitalization in children in Kathmandu Valley, controlling for major confounding variables, such as temperature, precipitation, and relative humidity. A multiple (log-linear) regression model was formulated and robust regression coefficients (corrected for auto-correlation) and elasticities were estimated for respective explanatory variables. • ARI is one of the major public health problems and is ranked as top three diseases affecting morbidity among children below 5 years of age in Nepal. • ARI incidence in 2003 was 136 per 1,000 children in 0–4 age group inside Kathmandu Valley. • The descriptive statistics showed negative correlation coefficient between PM_{10} and meteorological variables. • Similarly, a positive and statistically significant (at 10% level of significance) partial regression coefficient was obtained for PM_{10}. The study estimated that 1% point increase in PM_{10} results in about 0.544% point (95% confidence interval: 0.098, 1.247) increase in number of ARI patients.
Khanal and Shrestha (2005)	• Quantified health effects using exposure-response model based on time series data. • Estimated Environmental Burden of Disease (EDB) for each risk factor considered in the study. • Percent increase in all cause mortality, respiratory mortality, respiratory hospital admissions, COPD hospital admission, and lung cancer hospital admissions per 10 µg/m^3 increase in PM_{10} are 0.69%, 3.48%, 1.92%, 3.22%, and 3.06%, respectively. • Corresponding relative risk for average ambient PM_{10} exposure above the threshold limit (10 µg/m^3) are 1.0856, 1.5178, 1.2609, 1.4722, and 1.4437, respectively. • Burden of disease attributable to ambient air pollution exposure with respect to PM_{10} has been calculated for 20 µg/m^3 and 10 µg/m^3 baseline PM_{10} level. • Of the total 16,966 deaths, 1,337 cases of deaths can be attributed to ambient air pollution taking threshold limit 10 µg/m^3 for PM_{10} for 2004. • Similarly, out of 236 respiratory deaths; 3,188 respiratory hospital admissions; 15,948 COPD; and 122 lung cancer hospital admissions, 32, 660, 5,115, and 37 cases, respectively, can be attributed to the risk factor for 2003–2004.

» Part Five

Air Quality Management

Legislation and Mandate

There is no specific law in Nepal that seeks to address the country's urban air pollution problem. The Environment Protection Act (EPA) 1997 and the Environment Protection Rules (EPR) 1997 and 1999 update are the umbrella legislation for environmental protection. The Act covers environment conservation; pollution control and prevention; conservation of natural heritage sites; operation of environmental funds; additional incentives to minimize pollution; and compensation for environmental damage. EPA and EPR defined various sectors that will require environmental assessment either in the form of an Initial Environmental Examination (IEE) or an Environmental Impact Assessment (EIA).

To fulfill the country's commitment to the Millennium Development Goals (MDG) of having a national agenda and strategy on sustainable development in place by 2005, His Majesty's Government (HMG) has endorsed the Sustainable Development Agenda for Nepal (SDAN) in 2003. One of the broad goals of the SDAN clearly indicates that each citizen will have easy access to clean air. To achieve this goal, SDAN gives high priority to the development of and compliance to environmental standards and strengthening of institutional capability (MOEST, 2006).

To implement EPA, MOPE was established and empowered to prohibit the use of any matter, fuel, equipment, or plant that has or is likely to have adverse effects on the environment. MOPE has the mandate to manage and protect the atmospheric environment of Nepal.

Prior to this, however, no single organization had overall responsibility for air quality management even AQ monitoring; private sector companies, however, have been actively involved in generating air quality information. Although several agencies have responsibilities relating to the prevention and control of air pollution, there seems to be a lack of coordination and commitment between the departments to enforce existing rules.

Another ministry that had an environment mandate was the Ministry of Science and Technology (MOST) and, for some years, the environment units of both MOPE and MOST were implementing air quality-related activities. In April 2005, MOPE was dissolved, and its Environment Division was transferred to MOST, establishing MOEST as a new Ministry with main mandate to carry out environmental activities.

When MOPE was created in September 1995 to act as a focal point for interrelated areas to population and environment, its responsibilities included the (i) formulation of environment-related policies and plans; (ii) preparation of environment-related legal and regulatory provisions and guidelines; (iii) undertaking surveys and studies; (iv) dissemination of information; (v) monitoring and evaluating programs; and (vi) human resources development for the environment sector. All these responsibilities now have been taken over by the new MOEST (ADB, 2005a).

Although the Local Self-Governance Act (1999) entrusts municipalities or local governments the mandate for environmental protection, this provision has not been fully implemented.

Ambient AQ Standards

In June 2003, MOPE set the national standards for seven major air pollutants (see Table 5.1). Unlike other Asian countries with cities that implement standards more stringent than those at the national level, Nepal has only one set of ambient air quality standards. These standards are generally more lenient compared with the updated 2005 WHO Guidelines; however, the NO_2, CO, and Pb standards are comparable to the 2000 WHO guidelines (Table 5.1). There is a lack of annual standards for particulate matter (TSP and PM_{10}), which is Nepal's main pollutant of concern. Nepal's ambient air quality standards have never been updated since their release, and there is no clear indication of any plans of updating them in the near future.

TABLE 5.1

Nepal's Ambient Air Quality Standards vs WHO Guidelines and USEPA Standards (μg/m³)

Parameter	Averaging Time	Nepal's Ambient Air Quality Standards	WHO Guidelines (2005)[a]	USEPA[c]
TSP	Annual	—	—	—
	24-hours	230	—	—
PM_{10}	Annual	—	20	revoked
	24-hours	120	50	150
Sulfur dioxide	Annual	50	—	78 (0.03 ppm)
	24-hours	70	20	365 (0.14 ppm)
Nitrogen dioxide	Annual	40	40	100
	24-hours	80	—	—
Carbon monoxide	8 hours	10,000	10,000[b]	10,000
	15 minute	100,000	—	—
Lead	Annual	0.5	0.5[b]	—

μg/m³ = microgram per cubic meter, TSP = total suspended particulates, PM_{10} = particulate matter with diameter less than 10 micrograms, ppm = parts per million, WHO = World Health Organization, US = United States, USEPA = United States Environmental Protection Agency
Sources: [a] WHO (2005), [b] WHO (2000), and [c] USEPA (2006).

Management of Mobile Sources

The Ministry of Labor and Transport Management (MOLTM) has the specific mandate to establish technical vehicle standards, including pollution standards for vehicles and its implementation. Since mobile sources have been tagged as the major source of urban air pollution in Nepal, activities to manage emissions from this source would have a great impact on the quality of air in Nepal.

The Government has taken active measures to reduce emissions from vehicles, including introduction of vehicle emission standards, ban on leaded gasoline, ban on polluting vehicles, and promotion of electric vehicles.

As early as 1994, Nepal already introduced vehicle exhaust tests with limits of 65HSU for diesel vehicles and 3% CO for petrol vehicles. In January 1998, HMG relaxed the vehicle emission standards to 4.5% CO for petrol four-wheelers manufactured until 1980 and 75 HSU for diesel vehicles manufactured until 1994. Vehicles that pass the tests are given green stickers and those that do not are given red stickers. A Nepal Vehicle Mass Emission Standard, equivalent to Euro 1, was also promulgated in 2000 (see Table 7.4 for specific standards).

The implementation of the emission standards, however, is not fully efficient because of a number of reasons. Emission testing capacity is still limited such that the Government still relies on certificates from manufacturers that the vehicle meets Euro 1 standards. Emission testing is also not for licensing and registration purposes but for procurement of the green stickers (see Table 5.2 for detailed emission standards). In addition, vehicles with red stickers still ply the roads.

The emission test results of in-use vehicles indicate an average of 25% failure for the last few years. On-the-spot emissions testing in June 2003 indicate high failure rates in diesel vehicles (more than 70%) and petrol vehicles (33%), as well as imported microbuses (86%).

TABLE 5.2

Nepal Vehicle Emission Standards for Green Stickers

Type of Vehicle	CO% by Volume	HC (ppm)
Petrol-Operated Vehicles		
Four-wheelers 1980 or older	4.5	1,000
Four-wheelers 1981 onwards	3.0	1,000
Two-wheelers (2-stroke)	4.5	7,800
Two-wheelers (4-stroke)	4.5	7,800
Three-wheelers	4.5	7,800
Gas-Operated Vehicles		
Four-wheelers	3.0	1,000
Three-wheelers	3.0	7,800
Diesel-Operated Vehicles		
Older than 1994	75.0	
1995 onwards	65.0	

Source: MOPE (2003).

Unleaded gasoline was first introduced in Kathmandu in July 1997 and, since 2000, only unleaded gasoline was sold in the entire country.

The ban on polluting vehicles started as early as September 1999, when three-wheeled diesel *tempos* or *vikrams* were banned in Kathmandu Valley, Pokhara, and Lumbini. In November 1999, vehicles more than 20 years old and all three-wheelers, as well as 2-stroke engines, were also banned in the Kathmandu Valley. This resolution, however, was not properly implemented due to protests from vehicle owners. The Government, however, managed to ban registration of new 2-stroke engine vehicles in Kathmandu. Also, the Government banned 2-stroke, three-wheeled vehicles from plying in Kathmandu. The Department of Transport and Management also charge taxes according to the date of vehicle manufacture.

Another major measure taken by the Government and the private sector in Nepal is the promotion of electric vehicles for public transport. As of end of 2004, there were 600 *safa tempos* operating in Kathmandu, servicing 100,000 people daily in 17 routes. There are also 37 charging stations. These safa tempos are assembled in Kathmandu using body and chassis parts from India and electronic parts and batteries from the United States. These vehicles can carry an average load of 12 persons and one set of batteries.

To help the electric vehicle industry, the Government does not impose any tax on vehicle parts importation and there are no fees for annual registration of electric vehicles. These incentives however, are still insufficient to fully promote electric vehicles. Electric safa tempos have high operating costs. Safa tempos cost NRs11.62/km to operate versus NRs7.06 and NRs6.17 for petrol and LPG three-wheelers, respectively. This high cost is mainly due to high electricity tariff and high cost of replacement battery (batteries have16–18 months' life).

A levy on vehicle fuel (petrol and diesel) sales (NRs0.50 per liter) for Kathmandu Valley was introduced to supposedly finance the Kathmandu Development Fund for pollution control, environmental protection, and road improvement; however, this has not been implemented yet (Personal communication, MOEST as quoted in ADB, 2005a).

Management of Stationary Sources

The Ministry of Industry, Commerce and Supplies (MOICS) is the government office particularly involved with environment-related issues in industries, including air pollution. Nepal's major accomplishments to manage air pollution from stationary sources can be summed into three major activities: i) closure of the Himal Cement Plant; ii) ban on old brick kiln technology and introduction of cleaner technology; and iii) promotion of renewable energy and energy efficiency. A number of policies and laws were drafted to control air pollution from stationary sources, namely, the Industrial Enterprises Act of 1992 and the Renewable Energy Subsidy Policy of 2000.

One of the Industrial Enterprises Act's important provisions was to grant a 50% reduction in the taxable income of industries and companies that will invest on an industry process or equipment that will help control pollution. The discounted tax was either deducted on a lump sum or on installment basis for a period of 3 years. The Energy Subsidy Policy granted subsidies to investments and industries engaged mostly in solar and photovoltaic (PV) energy, hydro and microhydro energy and biogas.

Closure of the Himal Cement Plant. Emissions inventories and observations from the URBAIR project and other studies have identified the Himal Cement Company (HCC) as the largest source of air pollution in Kathmandu. Through a government decree, HCC was moved outside of Kathmandu Valley on 20 December 2001; the cement plant was finally closed down on 1 May 2002 (KFW, 2004).

Upgrading of the Brick Kiln Technology. Also on the same year (2002), the Government, through the Industrial Promotion Board, decided to stop registering brick kilns that use outdated Bulls Trench Kiln technology in the Kathmandu Valley. Two years after, in 2004, it eventually banned brick kilns with this old technology from operating within Kathmandu Valley. The Government has also been active in promoting cleaner brick kiln technologies. The main gains in the new technology are energy cost savings and quality production, which eventually pays for the initial investment by increasing production of grade "A" bricks to more than 90% (from about 40% using the older technology) (ADB, 2005a).

Promotion of Energy Efficiency and Renewable Energy. The MOICS' active promotion of energy efficiency in industries was initiated in 1994 through the Industrial Energy Management Project, a technical assistance from the World Bank. The Project conducted energy audits of industrial boilers, industrial equipment, and hotel lighting. The project has led to the establishment of an Office of Energy Efficiency Services in 1998. The program on energy efficiency was also continued, with the support of funds from ESPS as an additional subcomponent under the Cleaner Production component of ESPS. Of the 302 industries that were identified to have energy-saving potential, 202 industries made investments and implemented measures to achieve energy efficiency.

Nepal has a large potential in terms of various sources of alternative and renewable energy, such as biogas, small- and microhydropower, solar energy (photovoltaic and thermal), improved cook stoves, and wind energy, among others. To encourage the use of alternative and renewable energy sources, subsidies have been given as a provision of the Renewable Energy Subsidy Policy 2000 (and its latest amendment in 2006). Subsidies are provided for installation of new, as well as improvement or rehabilitation of renewable energy projects.

Private Sector Initiatives

Some private companies are also involved in controlling Kathmandu's air pollution. The best example may be the approximately 600 electric three-wheelers (safa tempos) running in the Kathmandu Valley as a public transportation. There is potential for more of such electric vehicles in Kathmandu with the trolley bus expansion for mass transportation. Electric vehicles are very good means for reducing air pollution as they virtually emit zero pollutants and use the clean hydropower abundant in Nepal. Stakeholders of the electric vehicle industry have recently formed the Electric Vehicle Association of Nepal (EVAN), an umbrella organization of all entrepreneurs. EVAN is involved in advocacy, research, and public education to promote electric vehicles. Some private companies are also involved in managing urban greenery and building bus stops to manage public transportation (Shrestha and Raut, 2002).

Public/Nongovernment Participation

Numerous local and international nongovernment organizations (NGOs), as well as academic institutions and public associations and societies, have contributed toward raising the level of understanding of the air pollution problem in Nepal. A large number of NGOs have been engaged in projects that measured air pollution, built capacity, and proposed policy measures relevant to improving the air quality management in Nepal, especially in the Kathmandu Valley.

The awareness level of the average Nepalese of the air pollution problems in Nepal is relatively high. As early as 1978, one resident has already complained about a factory's exhaust fumes, pointing out that the factory's operation has affected the well-being and health of the population living around it.

» Part Six

Conclusion

Nepal has gone through rapid yet poorly planned urbanization especially in the Kathmandu Valley area. This has led to rapid increases in the vehicle fleet size and in the demand for energy, resulting in increased emissions of some air pollutants. In addition, Kathmandu Valley is inherently vulnerable to air pollution because of its topography and climate. Bans on highly polluting brick kiln factories, formulation of emissions standards, bans on the import of 2-stroke engines, and promotion of electric vehicles are some of the major steps undertaken by the country to better manage its air quality. Additional actions to address the quality of fuels and emissions of particulate matter are urgently required.

Particulate matter (as TSP and PM_{10}) is the main pollutant of concern in urban areas of Nepal, in general, and in the Kathmandu Valley in particular. Ambient concentrations usually far exceed air quality standards. NO_2 and SO_2 levels are increasing although still fall generally below national ambient air quality standards and WHO guidelines. Emissions from mobile sources are of main concern. Respiratory infection, one of the top five diseases in the country, is partly attributed to prolonged exposure to air pollution. Numerous studies show that impacts of particulate matter on health of urban residents of Nepal are severe.

Air quality management in Nepal remains focused in the Kathmandu Valley. Kathmandu Metropolitan City's (KMC) government has played important roles in activities, such as raising public awareness campaigns and routinely monitoring the quality of the atmosphere. Private associations, advocacy groups, and NGOs, as well as external funding agencies have also contributed to the improvement of air quality management in Nepal.

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