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3.8 Kathmandu

Situational Analysis and Urban Air Quality Trends

Kathmandu is the capital city of the Kingdom of Nepal and had a population of 661,836 according to the last census in 1991. It is located in the Kathmandu valley as are four other municipal towns, Lalitpur, Bhaktpur, Kirtipur and Madhyapur-Thime which together constitute the main urban area of Nepal. This major urban area, otherwise known as the 'Kathmandu urban zone', had a population of approximately 1.1 million in 1991. Kathmandu valley is situated 1,350 m above sea level and has an average rainfall of about 1300 mm. The Valley is surrounded all sides by the hills ranging from 2,100 m to 3,132 m in altitude. Because of this, the occurrence of calm or low wind-speed conditions is common in the valley leading to low dilution and dispersion of air pollutants (Devendra Prasad Adhikari, personal communication). The Valley's topography also encourages the formation of temperature inversions, especially in winter months, which allow air pollutants to build up to high levels (Shrestha, 2001). For these reasons Kathmandu Valley is classified as a High Air Pollution Potential Zone. Most of Nepal's economic and business activities are centred in the Valley which is becoming environmentally stressed due to the high population pressure, unmanaged industrial establishments and the increasing number of vehicles.

Rapid urbanization, industrialization, poorly maintained vehicles and a lack of public awareness are contributing to a deterioration in ambient air quality in Kathmandu Valley. Brick kilns, cement and marble factories are the major air polluting industries in the Valley. In the early 1990s, there were over 300 brick kilns in the Valley (ENHPO, 1993a) ranging from very small, manually operated and seasonal kilns to very large semi-mechanized units with a year-round operation (ENPHO, 1993b). There is also a large cement factory in the Valley. For these industrial sources, particulate matter (PM) and sulphur dioxide (SO₂) are the major air pollutants. Emissions of air pollutants from the transport sector are also of concern in the Kathmandu urban zone. Of the total number of vehicles registered in Nepal in 1998, 56 per cent (approximately 122,400) were in the Kathmandu Valley.

About half of the vehicles in 1998 had two-stroke engines which emit much more PM than four-stroke vehicles. Passenger vehicles such as buses, minibuses and three-wheelers are relatively old compared to private vehicles, and therefore tend to be the most polluting. Another major source of air pollution in the Kathmandu urban zone is open-burning of refuse.

Air Quality Monitoring

Air quality monitoring has not been carried out systematically in Kathmandu Valley as no organization has responsibility for air quality management. However, a few institutions have been involved in recording air quality from time to time. A Kathmandu based non-government organization (LEADERS Nepal) has been monitoring roadside and ambient concentration of air pollutants in the Valley for about four years and a large amount of air quality-related information was generated during the Urban Air (URBAIR) project and Kathmandu Valley Vehicular Emission Control Project (KVVECP).

Monitoring results for PM₁₀ (particulate matter with diameters $\leq 10 \mu\text{m}$) showed air concentrations in the Valley ranging from 230 $\mu\text{g}/\text{m}^3$ to 3790 $\mu\text{g}/\text{m}^3$ (Otaki *et al.*, 1995). The Department of Hydrology and Meteorology (DHM) has been measuring the ambient concentration of total suspended particulate matter (TSP) in the Kathmandu Valley since December 1993. Table 3.8.1 shows the average TSP concentrations in the Kathmandu Valley over recent years. Means for all four years exceeded the WHO (1979) guideline (annual mean TSP (in conjunction with SO₂ 60-90 $\mu\text{g}/\text{m}^3$) by more than a factor of two.

Ambient concentrations of carbon monoxide (CO) around 5.5 ppm have been measured during busy office-hours and around 4.5 ppm during off-peak hours in heavy traffic areas (Devkota, 1993). ENPHO (1993a) also recorded CO concentrations in the Kathmandu Valley which were all below the WHO Air Quality Guideline (AQG) value (10 mg/m^3 8-hour mean).

Nitrogen dioxide (NO₂) and SO₂ concentrations

Table 3.8.1 Average ambient concentration of TSP ($\mu\text{g}/\text{m}^3$) in Kathmandu Valley

Year	Maximum	Minimum	Mean
1997	269	139	200
1996	381	31	186
1995	727	70	226
1994	467	54	202

are below WHO guidelines representing little risk at present (Shrestha, 2001). In one study, a 24-hour NO_2 concentration of $18 \mu\text{g}/\text{m}^3$ was determined for a regional background site in Kirtipur with the highest concentration ($38 \mu\text{g}/\text{m}^3$) being recorded for the Himal Cement Company site (Devkota, 1993). LEADERS Nepal measured 24-hour average NO_2 concentrations in different locations within the Valley in June 1998 and found they varied from 0.02 ppm to 0.04 ppm with an average of 0.027 ppm (LEADERS, 1999). Devkota (1993) found 24-hour SO_2 concentrations ranging from $17 \mu\text{g}/\text{m}^3$ to $77 \mu\text{g}/\text{m}^3$ in the Valley with a value of $38 \mu\text{g}/\text{m}^3$ recorded for the regional background site in Kirtipur. These values are all below the WHO 24-hour SO_2 concentration guideline of $125 \mu\text{g}/\text{m}^3$.

ENPHO (1993a) reported that the average 24-hours lead (Pb) concentration in the Valley was $0.32 \mu\text{g}/\text{m}^3$ and ranged from $0.18 \mu\text{g}/\text{m}^3$ to $0.53 \mu\text{g}/\text{m}^3$.

Impacts of Air Pollution

Information regarding the health impacts of air pollution in Nepal is very limited. LEADERS Nepal (1998) stated that the number of urban children reporting respiratory-related cases in the Children Hospital was higher than the equivalent number of rural children in the Kathmandu Valley. The same organisation also found that respiratory infections increased from 10.9 per cent of the total out-patient visits in 1996 to 11.6 per cent in 1998 (LEADERS, 1999).

Enforcement and Control Strategies

There is no strategic air quality monitoring policy in Nepal and there are no ambient air quality standards. Several different agencies have responsibilities related to the prevention and control of air pollution but coordination between them is lacking (Devendra Prasad Adhikari, personal communication). There is also a lack of commitment to the enforcement of existing

rules, regulations, guidelines and standards. In addition, no coherent legislative framework exists to control air pollution as it is spread over various statutes in about 16 different acts and by-laws (including the Industrial Enterprise Act (1992) and the Environment Protection Act (1996)). No single organization has overall responsibility for air quality monitoring although monitoring capabilities have been developed in the private sector and non-governmental organisations have also been actively involved in generating air quality information.

Regulations governing the testing of vehicular emissions are limited to three- and four- wheelers in the Kathmandu Valley. The Government has already passed regulations for monitoring two-wheelers but no such action has been taken to date (2002) because of inadequate infrastructure for testing facilities and lack of procedural arrangements (Devendra Prasad Adhikari, personal communication). Unleaded gasoline was introduced in the Kathmandu Valley in 1997 on trial basis and has been distributed all over the country since January 2000.

However, in 2001, the government took the bold step of completely banning diesel-operated three-wheelers from operating within the Valley. This has resulted in the removal of about 800 diesel three-wheelers from the streets and their replacement with electric- or liquefied petroleum gas- (LPG) powered three-wheelers. Credit with subsidized interest has been channelled through the banking sector to encourage people making the investment in electric vehicles. In December 1999, the government also introduced the Nepal Vehicle Mass Emission Standards for newly registered vehicles; equivalent to Euro I standards. The government has also banned the registration of two-stroke two-wheelers and has been providing tax exemptions for the importation of cleaner vehicles.

Conclusions

Air pollution problems are increasing in the Kathmandu Valley with high levels of suspended particulate matter (SPM) currently posing the greatest threat to human health. The sources of this air pollution are varied and include emissions from industrial facilities (a large cement factory and numerous brick kilns located in the Valley), vehicular exhaust and refuse burning. At the same time, air quality management capacity in Nepal is somewhat limited. This is due to the lack of coordination amongst the various agencies responsible and the lack of a coherent legislative or policy framework. However recent initiatives, notably the banning of diesel-operated three-wheelers, signal a more positive move in the management of air quality within the Kathmandu urban zone.

3.9 Mumbai

Situational Analysis and Urban Air Quality Trends

Mumbai is located on India's west coast and consists of a peninsula originally composed of seven islets. Drainage and reclamation have caused the islets to join and form the present – day Mumbai (Mumbai) Island, with the Arabian Sea to the west, and Mumbai harbour and the inlet of Thane creek to the east. Mumbai has a mean elevation of 11 metres above sea level and consists of several islands on the Konkan coast. It has a tropical savannah climate. The annual average temperature is 25.3 °C, with a maximum of 34.5 °C in June and minimum of 14.3 °C in January. Average annual precipitation is 2,078 mm with July having the maximum rainfall. High pollution concentrations usually occur in the winter when adverse meteorological situations with weak winds may prevail. Mumbai harbour is India's busiest, handling more than 40 per cent of India's maritime trade. Besides being India's financial and commercial centre, Mumbai is also one of the most industrialized Indian cities. There are approximately 40,000 small and big industries in the city, of which 32 have been classified as hazardous. Industries in the air-polluting category include textile mills, chemical, pharmaceutical, engineering and foundry units. Process emissions and those from fuel consumption, constitute the main sources of air pollution. Major air pollution sources include a giant fertilizer/chemical complex; two oil refineries and a thermal power plant, all based in CHEMBUR, a suburb on the eastern coast of Mumbai (World Bank, 1997). Mumbai's population was 16.4 million in 2001 (www.censusindia.net/results/million_plus.html)

Heavy industry on the island tends to create most of the pollution, which is often blown by westerly winds over mainland Mumbai. The natural wind movements cause a ventilation effect and help maintain the quality of ambient air over the coastal city. Thus, the annual average concentrations of SO₂ and NO₂ in Mumbai are lower than that of the inland Delhi megacity. However, 24 hour averages of SO₂ and NO₂ do show occasional violations of national air quality standards. (CPCB, 2001)

Mumbai is the only Indian city to have good

environmental pollution data covering the last 25 years. There has been a declining trend of SO₂ over the years, and besides a few aberrations, the annual mean levels have been below the WHO guideline value of 50 µg/m³. This may be because of the low usage of furnace oil and the use of low-sulphur coal for heating purposes in the textiles mills. Moreover, a number of them were closed in the inner city area and relocated elsewhere. This is the main reason for the declining trends of SO₂ in the atmosphere. The chemical industry accounts for nearly all SO₂ emissions in Mumbai, estimated to be around 157,000 tonnes per annum. The levelling off in emissions is due to the introduction of natural gas as a major fuel source from the newly opened gas fields located off the west coast. Monitoring conducted in the Air Pollution Survey of Greater Mumbai indicates that SO₂ levels probably started to decrease as a result of planning measures such as the relocation of industry and increased stack height.

In 1978, the annual level of NO₂ was around 13 µg/m³, which was less than the WHO guideline value of 40 µg/m³ but from 1978 onwards up to 1982 there was a steep growth in the levels of NO₂ reaching 50 µg/m³ in 1991, well over the WHO guideline value. This increase in the levels of NO₂ is probably due to the tremendous growth in the number of petrol and diesel vehicles in the city.

Of greater concern are the levels of suspended particulate matter (SPM) as annual concentrations always exceeded the WHO guideline range (60-90 µg/m³) reaching a peak of 385 µg/m³ in 1987. After 1987, the annual average came down to 285 µg/m³ by 1991 and it more or less maintained the same level until 1999. However, SPM emissions have increased significantly in recent years and are projected to continue rising. Domestic emissions have remained relatively constant in the past and are forecast to remain stable despite the projected increase in population. This is in part through the switch from biofuels (such as wood charcoal and animal dung) and coal, to less dirty fuels such as liquid petroleum gas (LPG) and kerosene. SPM emissions attributable to transport have increased