

Kathmandu's Air Quality

1. Introduction

Air Pollution

Clean air is vital for human survival. A human body requires approximately 25 kg of air everyday to sustain its requirement of oxygen, meaning that a human being breaths nearly 22,000 times, or about 9 liter, per day. This figure reflects the importance of air to human beings and any contamination in the air will have a direct impact on our health.

Pure air consists of oxygen (21%), nitrogen (78%) and a number of other gases and water vapor. Any contamination, natural or anthropogenic, to pure air is known as "air pollution" and the causing agent is known as air pollutants. In general, the term "air pollution" refers to the accumulation of any substances in the air in sufficient concentration to effect man, animals, vegetation or other materials. Although not all impurities in the air will cause harm, they may harm adverse health impact according to the nature, concentration, and duration of exposure. Normally anthropogenic air pollutants causing harm to one's well-being are Particulate Matter less than 10 micron (PM₁₀), Sulphur Dioxide (SO₂), Nitrogen Oxides (NO_x), Carbon monoxide (CO), Lead (Pb), Ozone (O₃) and Hydrocarbons (HCs).

Air pollution is a growing problem in the world, especially in urban areas due to the increasing use of fossil fuels primarily for transportation. Unmanaged urban settlements have only compounded the problem as more people are exposed to the pollutants, which adversely impact their

health. It is estimated that air pollution in South Asian cities causes nearly 100,000 premature deaths per year and over a billion work days of lost or reduced productivity (ADB, 2001)

Kathmandu Valley

Kathmandu, the capital of Nepal, is the country's economic as well as cultural center. The valley has an area of about 351 km² and is situated at an altitude of 1300m to 1350m. The Kathmandu valley includes three districts namely Kathmandu, Bhaktapur and Lalitpur. The cross section of valley is about 20km north to south and 30km east to west. Population growth in Kathmandu has been critical because of centralization and migration of the rural people to the capital for different opportunities. Overall country's population growth is 2.27 percent where as in Kathmandu, population is growing at 4.83 percent per annum. According to the 2001 census, a total of 1,656,951 people reside in the three districts of Kathmandu valley; Kathmandu, Bhaktapur and Lalitpur.

The valley is especially vulnerable to air pollution due to rapid and haphazard urbanization, valley centric industrialization and significant increase of vehicular transport in narrow streets. Furthermore, the bowl like topography of the valley restricts wind movement and retains the pollutants in the atmosphere. This is especially bad during the winter season when thermal inversion, where cold air flowing down from the mountains is trapped under a layer of warmer air, creates a lid, which keeps the pollutants, sealed within the valley.

2. Status of Ambient Air

The main problem in Kathmandu's air is the high concentration of particulate matter. According to a recent study, 24-hour average PM₁₀ value ranges between 49 and 495 µg/m³ and average values were 225,

135 & 126 $\mu\text{g}/\text{m}^3$ in core, subcore and remote part of the valley respectively. Similarly, TSP (Total Suspended Particulate) values were found to be between 61 and 572 $\mu\text{g}/\text{m}^3$ with average values of 379, 214 and 137 $\mu\text{g}/\text{m}^3$ in core, subcore and remote parts of the valley respectively. These values are significantly higher than WHO guidelines (TSP: 120 $\mu\text{g}/\text{m}^3$ PM_{10} : 70 $\mu\text{g}/\text{m}^3$). Other air pollutants such as SO_2 , NO_x , and CO were well below the international guideline value. Similarly, 24-hour average lead (Pb) values have been found to be within the range of 0.005 to 4.25 $\mu\text{g}/\text{m}^3$ (NESS 1999).

There is significant seasonal variation in the concentration of air pollutants. Dry winter periods are most vulnerable to air pollution while during the rainy season pollutants are washed down from the air. The concentration also varies according to the time of the day and the location. As vehicle emission is the main source of pollution in Kathmandu, air pollution levels are highest during peak traffic hours and at places where traffic density is highest. The major hotspots for air pollution in Kathmandu are Sundhara, Singha Durbar, Kalimati, Ranipokhari, Lainchaur, Indra Chowk, Royal Palace, Bir Hospital, Thamel, Asan, Kasthamandap, Ratna Park (Bus Park) and Putali Sadak (NESS 1999). Similarly, areas around polluting industries mainly brick kilns situated at the southern part of the valley are also prone to problems of air pollution.

Trends

Due to the absence of a proper air pollution monitoring system in Nepal, there is a lack of reliable air quality data. Previous studies have shown that there is a large variation during the process of data generation. Data have been collected at various intervals using different equipment and the samples have often been taken at different locations, at different heights, seasons, and distance from the source. However, a comparison of research data gathered in 1993 and 1999

show an increasing trend of the air pollution in Kathmandu valley. On average, PM_{10} in core area has increased from 114 $\mu\text{g}/\text{m}^3$ to 225 $\mu\text{g}/\text{m}^3$ between 1993 and 1999. TSP in core area has increased from 291 $\mu\text{g}/\text{m}^3$ to 379 $\mu\text{g}/\text{m}^3$. Similarly, PM_{10} and TSP in subcore and urban area has increased by about 2-3 folds since 1993.

A study has indicated that with the present rate of vehicle increase, PM_{10} concentration in Kathmandu valley will increase by 82 percent within 15 years (from 1996-2011 AD) if no control measures are taken (Pokhrel 2002, cf Clean Energy Nepal, 2002). Similarly, PM_{10} concentration at Putalisadak (a core city and high traffic) will cross the US EPA (United States Environment Protection Agency) standard almost 42 percent of the days in a year and it can cause serious health damage to the urban residents. But control measures such as ban of 20 year old and two stroke vehicles, enforcement of tail pipe emission regulation, technology enhancement and programs to control re-suspension of roadside dust can check this increase level of PM_{10} .

3. Sources of Air Pollution

Air Pollution Inventory

Shrestha and Malla (1995) using data from 1993 have estimated air pollution load by different sectors, based on energy use. The transport sector was found to have the largest contribution in the total emissions of the selected pollutants followed by the household, industrial, and commercial sectors. Total emissions from the use of fossil fuels are much higher (almost 3 times) than that from biomass fuels. Gasoline is found to be the largest contributor (55%) to the total combined emission of all pollutants, while fuel wood and coal were the other two major contributors with shares of 16 and 14 percent respectively. Table 1 gives the

estimated emission from energy use pattern in Kathmandu.

Table 1 Estimated emissions from different energy use in Kathmandu in 1993 (tons)

Source	TSPs	CO	HCS	NOx	SO ₂	Total
Transport	475	23693	11024	1353	133	36678
Household	2382	9867	1281	213	503	14246
Industrial	3574	5220	1492	628	1349	12263
Commercial	24	234	11	5	3	277
Total	6455	39014	13808	2199	1988	63464

Source: Shrestha and Malla, 1996

Vehicular Emission

Vehicle emission is a major source of air pollution in Kathmandu. This is mainly because of the large number of vehicles on congested streets, poor quality vehicles, poor quality fuels and lubricants and weaknesses in the emission inspection & maintenance system.

Kathmandu valley alone accounts for about 57 percent of the total vehicles registered in Nepal. At the end of the year 2001, Kathmandu valley had 183,402 registered vehicles (DoTM, 2002). Over the last two years, this number has been growing at an alarming rate of 21 percent per year. At this

rate the number of vehicles will double in less than five years. This is causing serious problems of traffic congestion and air pollution.

On top of this, poor road infrastructure also adds to the problem. A study conducted by Department of Transport Management

(DoTM), indicated that the number of vehicles in Kathmandu exceeded the valley's carrying capacity by about 30,000 in 1999/2000 fiscal year. Since then more than 30,000 vehicles have been added to the streets of Kathmandu, while the road infrastructure has remained more or

less constant. The total road network within the valley is 1339 km.

Table 2 shows the total number of vehicles registered in Bagmati zone (mainly plying within Kathmandu valley) over the last six years. This table indicates that there is a very small increase in the number of buses and 3-wheelers which are the main public transport vehicles, but phenomenal increases in the number of car/jeep/van and two-wheelers, almost all of which are private vehicles. In the past two years, the number of motorcycles has been increasing at 25 percent per year. Clearly, the dramatic rise in the number of private vehicles is a cause of concern as public vehicles tend to emit less pollution per passenger.

Table 2 Total number of vehicles registered in Bagmati Zone over last six years

Vehicle Type	1996/97	1997/98	1998/99	1999/00	2000/01	2001*
Bus	1163	1298	1403	1632	1744	1786
Mini bus	1468	1500	1527	1610	1804	2063
Truck/Tanker	4483	4759	4811	5295	5484	5609
Car/Jeep/Van	27153	28915	30919	35993	40674	41433
3-Wheeler	3844	3925	4262	4778	4949	5065
2-wheeler	58029	64142	71612	94217	112000	122099
Tractors	1672	1672	1672	1672	1673	1673
Other	3020	3278	3311	3338	3350	3674
Total	100831	109489	117836	148535	171678	183402

Source: Department of Transport Management

* Till the end of 2001 AD (Poush 2058 BS)

New vehicles must now meet EURO I standards. However in the absence of a

system to test vehicles for their Type Approvals (TA) and Conformity of Production (COP), there is no guarantee, except the word of manufacturers, that the new vehicles are of EURO I standards. Furthermore, while other countries have moved towards EURO-IV emission norms, Nepal is still at EURO-I and so far there are no plans to move up the standards ladder.

Similarly, to control the vehicle emission in Kathmandu valley, there is a provision for emission testing. However, this has not been very effective, as many drivers tamper with the air to fuel ratio to lower the emissions just before checking and even vehicles that do not comply with the emission standard are still free to ply all over Kathmandu valley, except a few streets.

Besides the number of vehicles, the type of vehicles on the streets of Kathmandu is also a problem. Many vehicles in Kathmandu are old and poorly maintained which emit more pollutants. Old vehicles normally do not have emission control devices so they are more polluting than new vehicles manufactured after emission standards have been introduced. Similarly, two stroke engines produce emission with higher concentrations of PM_{10} , which makes the air of Kathmandu dirtier. Although the import of new two-stroke vehicles have been banned, there are still significant number of two-stroke two and three wheelers in town, which cause significant amount of pollution.

Quality of lubricants being used in vehicles is another cause for poor vehicle exhaust. Use of poor quality lubricants and wrong amount of lubricants also causes an increase in emission. A recent study by CEN indicated that about 98 percent of the two-stroke three-wheelers in Kathmandu are using various quantities of loose oil instead of the recommended quantity of 2T oil.

Industrial Emission

Industries situated within the valley, using poorly maintained and old technology, are also responsible for air pollution. Most polluting industries are situated at the south and southwest parts of the valley. Unfortunately, southwest wind in the valley helps to blow air pollutants from remotely situated industries to the urban areas.

The industrial census of 1996 showed that Kathmandu valley had 37.7 percent of the total manufacturing establishments in Nepal. Emission load from the industrial sector in the Kathmandu valley in 1993 was estimated to be 3574 tons of TSP, 5220 tons of CO, 1492 tons of Hydrocarbon, 628 tons of Nitrogen Oxides (NO_x) and 1349 tons of Sulphur Dioxide (SO_2) per year (Shrestha and Malla 1996).

Now that the Himal Cement factory is closed, the brick kilns is the main polluting industry in the Valley. There are about 125 brick kilns operating in Kathmandu valley out of which 113 are bull's trench type, 9 are clap kiln type and 3 Hoffmann kilns (ENPHO 2001). As the brick manufacturing process in Bull's Trench (*Chimney Bhatta*) and Clamp Kiln (*Thado Bhatta*) is very poor and inefficient, the amount of smoke spewing from these kilns is very high. Due to its polluting nature, this technology has even been banned in India.

Recent studies carried out by Clean Energy Nepal in Tikathali VDC in Lalitpur and Jhaukhel VDC in Bhaktapur indicate the air pollution in brick kiln affected areas are three times higher than normal. In Tikathali the concentration of PM_{10} during the brick-making season was found to be $602.16 \mu\text{g}/\text{m}^3$ while in the off-season it was only $217.95 \mu\text{g}/\text{m}^3$. Similarly, in Jhaukhel, PM_{10} concentration in an area with brick kilns was found to be $568.78 \mu\text{g}/\text{m}^3$ while it was only $158.33 \mu\text{g}/\text{m}^3$ at Sipadol area, a valley background (CEN 2002).

4. Impact of Air Pollution

Impact on Human Health

The health impact of air pollution in the Kathmandu valley can be assessed by the increase in number of patients suffering from diseases related to air pollution. Medical records from hospitals in the Kathmandu valley revealed that urban residents have more respiratory diseases than rural residents (LEADERS 1998).

Similarly, looking at the database of human health, total OPD visits, and the percentage shared by the respiratory disease (ARI) for two years, it quite clearly reflects the increasing trend of respiratory disease. From 1996 till 1998, number of ARI patient is increasing at the rate of 22.89 percent per year. Similarly, share of ARI patient out of total OPD visit has been increased from 9.99 to 10.11 percent within the same span of time. Table 3 shows the total OPD visit

Table 3 Respiratory Diseases in Kathmandu compares to Nepal

District	1996		1998	
	Total OPD Visit	Total ARI Patient	Total OPD Visit	Total ARI Patient
Kathmandu	53457	5341	77021	7786
National	5167378	410206	7115981	608753

Source: Annual Report, 1995/96, 1997/98, 1998/99; Department of Health Services

and percentage of ARI shared in Kathmandu valley for the year 1996 and 1998 years.

Similarly, the total annual mortality cases in the Kathmandu valley due to air pollution is estimated to be 84 and the number of respiratory symptom days at about 1.5

million using the data of 1990. The cost of morbidity resulting from PM₁₀ was found to be NRs. 180 million and total health damage to be NRs. 210 million. Table 4 describes the detail impact on mortality and health in Kathmandu valley due to air pollution (PM₁₀).

Table 4 Health Impacts due to Kathmandu's air pollution

Types of Health Impact	Number of Cases
Excess Mortality	84
Chronic Bronchitis	506
Restricted Activity Days	475298
Emergency Room Visit	1945
Bronchitis in Children	4847
Asthma	18863
Respiratory Symptom Days	1512689
Respiratory Hospital Admissions	99

Source: World Bank, 1997

It is estimated that among the sources of air pollution, traffic sources (exhaust and resuspension) might have the largest impact on health. Furthermore, it is estimated that the reduction in vehicle exhaust emissions is most effective in terms of reduced health damage (NRs 341 per kg emission reduction) (World Bank, 1997).

Impact on Tourism

It is estimated that NRs. 0.5 billion per year in tourism revenue is lost due to air pollution in Kathmandu valley (World Bank, 1997).

Findings of a 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. This shows that Kathmandu's poor transportation system and pollution is not only affecting human health and environmental quality,

but also the tourism industry (Business Age, 2001).

Impact on Visibility

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 (>8000m) around noon, decreased in the winter months from more than 25 days/month in 1970 to 5 days/month in 1992 (World Bank, 1997).

5. Response to Air Pollution

His Majesty's Government of Nepal

His Majesty's Government of Nepal (HMG) first responded to the growing problem of air pollution in Kathmandu in November 1991, by stopping the import of three-wheelers into the valley. In 1995, HMG introduced tail pipe emission standards of 65 HSU for diesel vehicles and 3 percent CO for petrol operated vehicles in Kathmandu. HMG, then realizing the need for an independent body to look after the environmental issues including air pollution, established the Ministry of Population and Environment (MoPE) in 1995. But in January 1998, HMG relaxed the vehicle emission standards to 4.5 percent CO for petrol four wheelers manufactured till 1980 and 75 HSU for diesel vehicles manufactured till 1994. On 26 December 1999, HMG made a public announcement regarding the distribution of unleaded petrol.

In 2000, HMG/MoPE introduced the Nepal Vehicular Mass Emission-2056 for new vehicles, which is similar to the EURO - I

Norm. Realizing the effect of older vehicles in air pollution level in Kathmandu, MoPE in the later part of 2000 announced a ban in all public vehicles older than 20 years and all two stroke three wheelers in Kathmandu valley effective from 16 November 2001. This decision however has not been implemented.

Table 5 Emission Standard of CO and HSU in Nepal

For Gasoline Vehicles	Permissible Smoke Unit (CO in %)
Up to 1980 manufactured four wheeler Vehicle	4.5
1981 and later manufactured vehicle	3.0
Up to 1991 manufactured three wheeler Vehicle	4.5
For two wheeler Vehicle	4.5
For Diesel Vehicles	Hatridge Smoke Unit (HSU)
Up to 1994 manufactured all types of Vehicles	75
1995 and after manufactured vehicles	65

Source: MoPE, 1998

MoPE has initiated a program of testing vehicle emissions. Almost all vehicles, except two-wheelers plying in the valley have undergone the testing process. Vehicular movement is prohibited in selected areas to those vehicles, which do not comply with the standards. Since 1996, when the program began, a total of 175,792 stickers had been issued up until the 1999/2000 fiscal year. Table 6 indicates the compliance result together with total vehicles (which may include repetition) to have undergone testing.

The table below (Table 6) reveals that only 75.96% of the total tests indicate the compliance with the emission standard of CO and HSU. The standard compliance with other toxic chemicals such as HC, NOx etc. are yet to be determined.

Regarding industrial pollution recently, HMG has announced to ban polluting Bull's Trench Kilns from Kathmandu valley after one and half year and it has already announced to stop the registration of these kilns. Government has also decided to shift

the Himal Cement Factory outside the valley.

Among these Kathmandu Metropolitan City (KMC) has taken a few steps to manage air pollution. KMC has an Environment Department and it is involved in public education through community groups, schools and weekly radio programmes. KMC is also involved in building infrastructure such as roads and overhead bridge, and a bicycle lane is to be constructed soon.

Table 6 Vehicle Emission Test Results

Year	Total Vehicle Tested	Pass	Fail
1995/96	486	162	324
1996/97	41466	25220	16246
1997/98	31173	22984	8189
1998/99	28018	24240	3778
1999/2000	42826	34255	8571
2000/2001*	31823	26669	5154
Total:	175792	133530	42262

* During first 11 months

Source: Valley Traffic Police

Although the steps taken by HMG are to be appreciated, the rising levels of pollutants in Kathmandu's air clearly indicates that a lot more needs to be done. The government needs to have a clear action plan to tackle the growing air pollution of Kathmandu. Furthermore the government needs implement some of its own policies. For example, although the government has a policy for promoting electric vehicles, new electric vehicles are not being registered in Kathmandu and even the trolley bus system which operated for over 25 years has now been closed down due to political interference and mismanagement.

Private Sector Initiation

The best example of private sector participation in controlling Kathmandu's air pollution is the investment in approximately 600 electric three wheelers, locally called 'SAFA Tempos', running in Kathmandu valley as a public transportation. The private sector has also shown interest in operating the trolley bus system.

Municipalities

The Kathmandu valley consists of five municipalities: Kathmandu, Lalitpur, Bhaktapur, Madhyapur and Kirtipur.

Non Government Organizations

There are several non-governmental organizations involved in research, advocacy, public awareness, and pilot project demonstration work related to air pollution control. Environment and Public Health Organization (ENPHO) and Society for Legal and Environmental Analysis and Development Research (LEADERS) Nepal have been involved in air quality monitoring and research. Similarly, Forum for Protection of Public Interest (Pro-Public), Clean Energy Nepal (CEN), and Martin Chautari are involved in public awareness and advocacy related to air pollution and its mitigation measures. Organizations like Himalayan Light Foundation (HLF) are involved in demonstration and pilot projects. HLF has recently developed a four wheeler electric vehicle. Recently, 12 organizations working in the field of environment have formed a group, Coalition for Clean Environment (CCE), to work in a coordinated manner.

International Organizations

International organizations like DANIDA with its Environment Sector Program Support (ESPS) project, IUCN, International Center for Integrated Mountain Development

(ICIMOD) are now working in air pollution monitoring, research and information dissemination work. ESPS, is assisting HMG in monitoring air pollution, promoting electric vehicles, strengthening institutions and demonstrating new brick kiln technologies. Similarly, Renewable Energy Programme Support Office (REPSO Nepal) of Winrock International is assisting in promotion and development of alternative fueled vehicles.

6. Conclusion and Recommendations

The fact that the concentration of respirable particles in Kathmandu's air is already several times higher than WHO guidelines and it is getting worse day by day calls for urgent action to control the Valley's air pollution. Now that the Himal Cement Factory has been closed and the government has decided to ban the polluting Bulls Trench brick kilns, the focus should be on controlling the emission from Kathmandu's vehicle fleet, which is growing at an alarming rate of 21 percent per year. The following 10 steps need to be taken immediately for this purpose:

1. Increase effectiveness of public transportation system.
2. Improve road network and other transportation infrastructure
3. Revive the trolley bus system and expand the system
4. Promote environment-friendly transportation such as electric vehicles, bicycles and walking
5. Ban the use of age old and two stroke engine vehicles
6. Ensure the use of clean fuel
7. Effective planning to reduce demand for transportation
8. Introduce economic tools (tax and subsidies) to promote clean technologies
9. Improve the vehicle emission inspection and maintenance system

10. Raise awareness on the need for proper vehicle maintenance

Overall the government needs to make a serious commitment to improve Kathmandu's air by drawing up a comprehensive action plan with the involvement of all stakeholders and then take bold steps to implement the action plan.

7. CEN's Campaign for Clean Air

Recognizing the people's right to clean air and the urgent need to control Kathmandu's air pollution, CEN is campaigning for improved vehicle emission control, effective public transportation, promotion of zero emission vehicles, urban greenery and cleaner production in industries. CEN believes in research-based advocacy and education to stimulate action from concerned authorities as well as the public.

Fact Sheets are produced by CEN for informing the public, as well as decision-makers on the current state of affairs and the required actions. This Fact Sheet was prepared by Anil K. Raut and Bhushan Tuladhar in June 2002. For more information please contact us at:

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