Annex – 1:
Ambient Air Quality Status of Kathmandu Valley

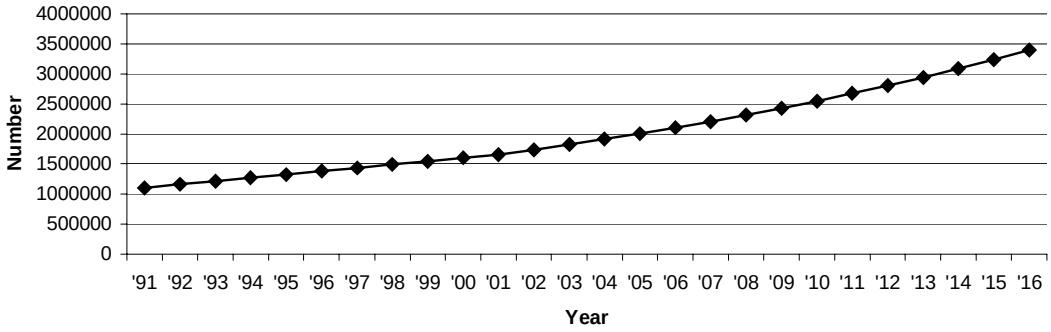
1. Kathmandu Valley - Topography, Climate and Population

Kathmandu Valley located between 27°37'30" N and 27°45'0" N latitude, and 85°15'0" E and 85o22'30" E longitude is about 1300 meter above m.s.l with the area of about 340 sq.km. The valley has the bowl-like structure surrounded by high hills and the altitude from the valley floor vary between 500 meter and 1400 meter. It lies between the Himalayas in the north and the Mahabharat range in the south. The prominent boundary features of the valley are Phulchowki Hill (3132m) in South West, Shivapuri (2713m) in North, Chapa Devi (2400m) in South West and Nagarjun (2100m) in West.

A temperate climate prevails in Kathmandu valley. The mean annual temperature in the Kathmandu Valley is 18 0C. The coldest month is January with a mean temperature of 10 ^{0}C. The warmest months are July and August, with an average temperature of 24 ^{0}C. The valley has an annual rainfall of 1400 mm. The wettest month is July with an average rainfall of about 370 mm. November and December are the driest months, the average rainfall is less than 6mm (URBAIR-Kathmandu Valley Report, 1997).

Kathmandu Valley being the economic and administrative center of Nepal is experiencing a very high population growth rate over the decades. According to the population census carried out in 1981 the population was 766345, which increased to 1105379 in 1991 census, with the annual growth rate of 4.2 %. The population census data for 2001 reveals that there are 1656951 people in the Kathmandu Valley by the end of 2001, with the annual growth rate of 4.9% per annum. In the present trend of population growth rate in Kathmandu Valley, it is estimated to reach 2104685 by the end of 2006 and 3395799 by the end of 2016. The population density of Kathmandu valley was 852 people per sq. km in 1981 and 1230 people per sq. km in 1991, which has reached 1843 people / sq. km in 2001. The population of Kathmandu Valley for 1991, 2001 and projection for coming 15 years presented in the figure below (ESPS, 2003).

Projection of Population in Kahtmandu Valley (1991-2016)



2. Kathmandu Valley: Air Quality Status

The concern over the air quality of Kathmandu Valley started only in early 90s and the information on the routinely monitored results are very limited. However, there have been many campaign air quality monitoring works carried out by many NGOs, private laboratory and the government institutions over the last decade which clearly indicate that the air of Kathmandu Valley is heavily polluted particularly with the particulate pollutants. Among the various studies carried out over the decade include: IUCN 1992, ENPHO 1993, KVVECP (NESS Pvt Ltd.) 1993, ENPHO 1993, ADB/MOPE 1999, NESS 1999. In addition to these, Department of Hydrology and Meteorology (DHM) started measuring TSP on a more continuous basis since 1993 and continued till 1996. The various air pollutants measured during these period primarily focuses on TSP, PM_{10}, NO_2, SO_2,

and CO. Although not directly comparative with WHO guidelines on an annual averages basis, these results show that Kathmandu is experiencing increasing trend over these pollutants, particularly with alarming rate in terms of particulate pollutants which is found significantly higher compare to WHO guideline values. Gaseous pollutants are found within the WHO prescribed values.

All these studies have been very instrumental in launching a special project on "Air Quality Management of Kathmandu Valley" in the Ministry of Population and Environment with DANIDA financial and technical assistance in 2001. One of the main working areas of this project is to establish a Permanent Air Quality Monitoring Network System in Kathmandu Valley with the objective of collecting routinely database on various air pollutants. In order to facilitate the design of the monitoring network system, the project has started monitoring of TSP and PM_{10} in seven different locations of the Valley in January 2001 on a three-hour basis. ENPHO was involved in the monitoring works by the project while Soil Test and NESS also participated in doing parallel monitoring. The annual averages of TSP and PM10 concentration of 3-hour monitoring results for the year 2001 are presented in Figure 2 and Figure 3 (ESPS, 2003).

Roadside monitoring in Putalisadak even recorded a highest concentration of 7285 ug/m^3 of TSP and the average concentration of TSP in the same station over the year is also significantly high, 1993 ug/$m^{3.}$ The annual averages for 2001 of 1363 ug/m^3, 1364 ug/m^3, and 830ug/m^3 at Chabhil, Patan, and Paknajol respectively are also significantly are high compared to the proposed national standard of 230 ug/m^3 (24 hr-average). Even the Machhegaun identified as a valley background station also recorded the highest concentration of 357 ug/m^3 and the average concentration of 154 ug/m^3 for the same year clearly indicate that the whole Kathmandu Valley is heavily polluted in terms of Total Suspended Particulate (ESPS, 2003).

Similarly, the maximum concentration of PM10 of 1336 ug/m^3 was observed at Chabhil while the maximum annual average concentration of 415 ug/m^3 was measured at Putalisadak. Annual average concentration of PM10 measured in other monitoring stations are 209 ug/m^3 at Paknajol, 286 at Patan, 289 at Chabhil, 120 ug/m^3 at Bhaktapur, 87 ug/m^3 at Kirtipur and 72 ug/m^3 at Matsyagau (ESPS, 2003).

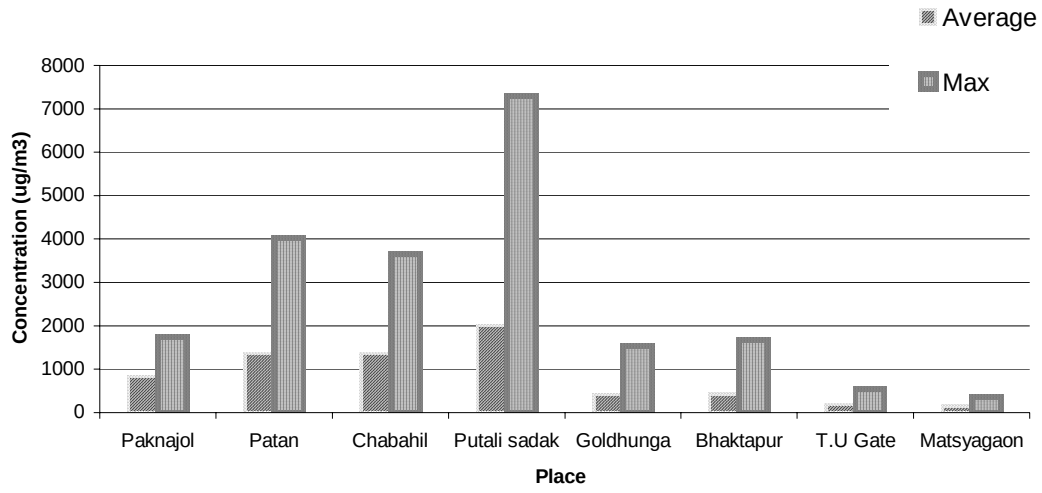
All the above mentioned annual average values of 3-hr basis which represent the peak traffic hours can not be directly compared to WHO annual prescribed values or the proposed national standard of 120 ug/m^3 (24-hr average).

MOPE/ESPS established the permanent monitoring network in late 2002 in six different locations of Kathmandu Valley. Of these six stations, stations at Putalisadak and Patan are the traffic stations, stations at Thamel is a traffic/residential, Bhaktapur and Kirtipur are the urban background stations, and the station at Matsyagau is the valley background station. MOPE/ESPS recently presented the results of this monitoring network in a training cum workshop organized for the assessment of the results. At the moment, the focus is on PM10 and the results since Novemebr 2002 are published. More recently, the secretary of MOPE organized the press conference and disseminated the results to general public. The results disseminated by MOPE also include the campaign monitoring carried out in Bhaktapur on PM2.5. This is the first time that results on PM2.5 are measured in Kathmandu Valley. The monthly average values of PM10 at all the six stations measured on the 24-hr average basis and the comparative study on PM10 and PM2.5 at Bhaktapur are presented in Figure 4 and Figure 5 respectively (ESPS, 2003).

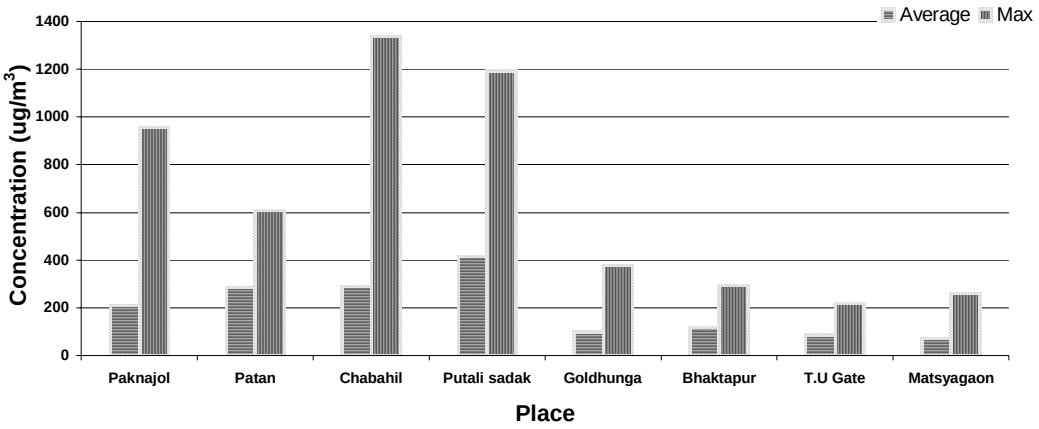
MOPE/ESPS has also published the results of benzene concentration in the ambient air monitored in the above mentioned monitoring sites. The results of Jan/Feb, 2002 and Feb/March, 2003 are presented in Figure 6. During a period of 1 year, the concentration of benzene in the heavy traffic areas has reduced significantly, from 66 ug/m^3 to17ug/m^3 in Putalisadak, and from 44 ug/m^3 to 14 ug/m^3 in Patan. The comparative study of 2002 and 2003 in Thamel and Bhaktapur is 30 ug/m^3 and 11 ug/m^3, 14 ug/m^3 and 9 ug/m^3 respectively. While in Kirpur and Matsyagau the average concentration for these periods have remained almost the same around 4 ug/m^3 and 3 ug/m^3 respectively. These days there are no safe limits prescribed by WHO for benzen, however it was 5-20 ug/m^3 maximum earlier.

The results of ambient air quality monitoring of Kathmandu Valley clearly shows that the valley is highly polluted in terms of particulate pollutants. The very high concentration of PM10 and PM2.5 is of great concern from the human health point of view. The high percentage of PM2.5 of almost 60-70% of PM10 indicate that the fossil fuel combustion in vehicles and industries are the major contributors. Similarly the trend seen in the benzene concentration at heavy traffic areas also indicate that it is directly related with the benzene content in gasoline supplied by NOC. It is learnt from NOC that the gasoline which used to be around 5% benzene content one year earlier is now less than 3 % benzene content.

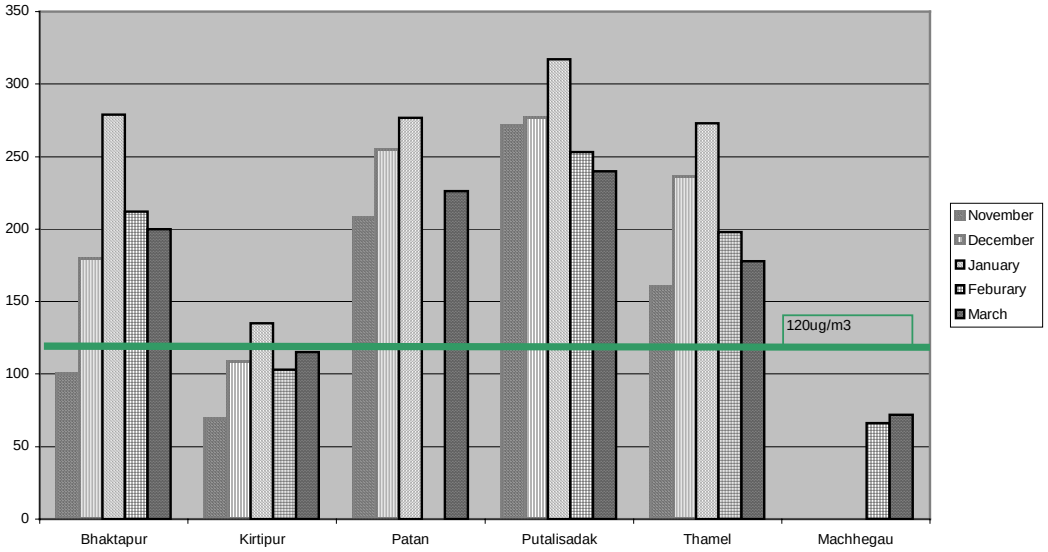
Average and Maximum TSP Concentration at Major Spots Kathamandu Valley, 2001



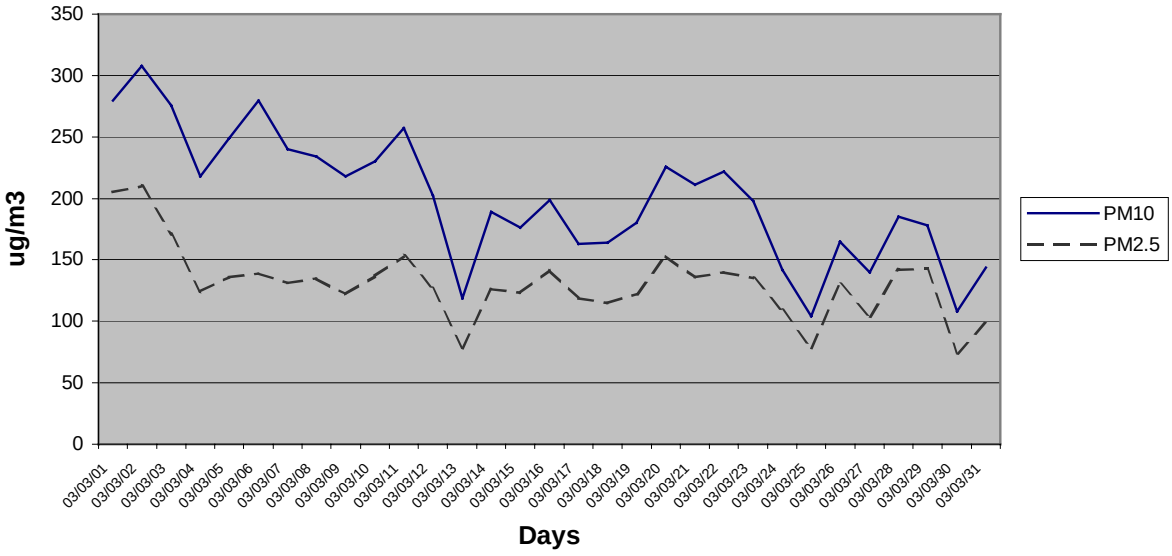
Average and Maximum PM10 Concentration at Major Spots in Kathmandu Valley, 2001



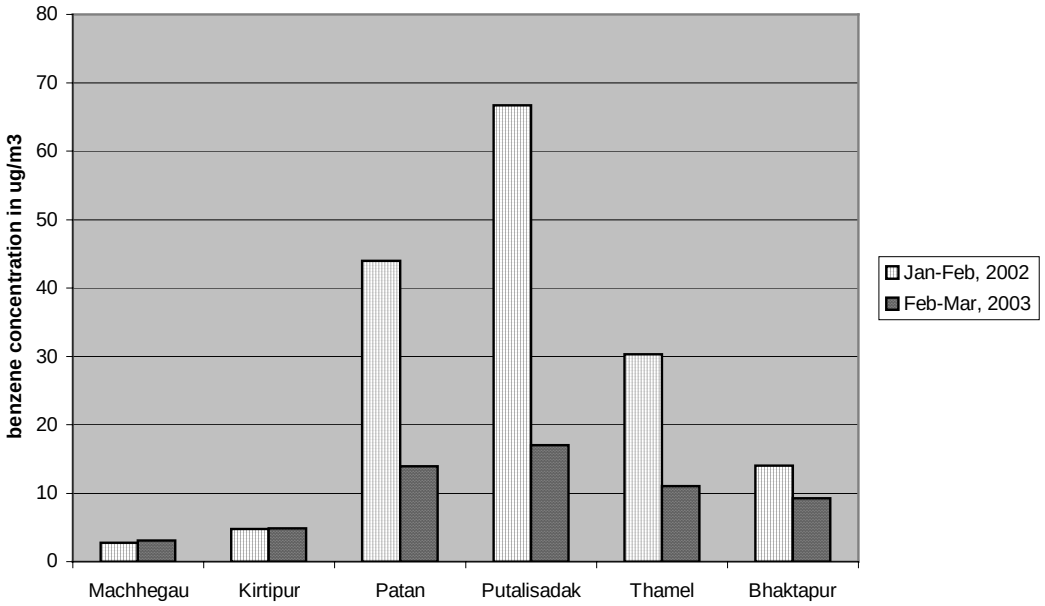
Monthly Average Concentrations of PM10 in Kathmandu Valley (Oct,2002-March, 2003)



Daily Comparision of PM10 and PM2.5 at Bhaktapur (March, 2003)



Benzene Monitoring Results of Jan/Feb 2002 and Feb/March 2003



3. Emission Inventory

There have been very limited studies on the inventory of air pollutants sources. The URBAIR Report has estimated the total emissions of some of the pollutants particularly focusing on TSP and PM_{10}. Also estimates of SO_2, NO_2, CO and CO_2 been made focusing on particular sources. The URBAIR study takes the base year for 1993. In 2002, MOPE/ESPS has developed the update of the URBAIR study for the base year 2001. The findings of URBAIR and MOPE/ESPS are presented in Table 1 and Table 2 respectively.

As the two tables show that the identified sources of air pollutants in the Kathmandu Valley are vehicular exhausts, the road resuspension, the brick manufacturing industries, the Himal Cement Factory, domestic fuel combustion, and the refuse burning. The latest study also mentions the industrial boilers. Looking into the changing scenario of sources, there is a decline in the production of bricks and the number of brick industries in operation. The total number of brick kilns in 1993 are 135 while in 2001 the number has decreased to 116. Similarly the production of bricks has gone down from 361 million pieces to 344 million pieces from 1993 to 2001. Another major source of air pollutants identified is the Himal Cement Factory and the annual production of this factory also has gone down significantly over the years. While it was 63392 tons per year in 1992/93 and went down to 36129 tons/year in 2000/2001. In between these years, the annual production was in decreasing trend, and now the factory is closed since late 2001.

As against the industrial sources, all other sources are in increasing trend with increase in the population in the valley. There have been significant increase in the vehicle numbers over the year. As this study primarily relates with the transport sector, focus is given to this sector also. The annual increase in the vehicle number over the years and the projection for coming years based on the recent growth rate is presented in the following figure.

Trend over vehicular growth in Bagmati Zone

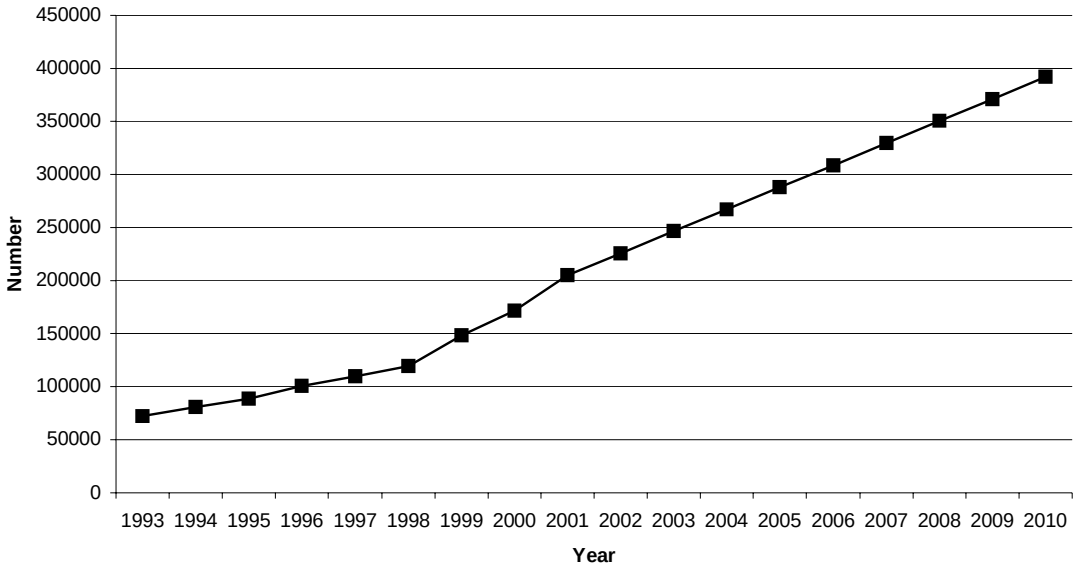


Table 1: Estimated Emissions from Air Pollution Sources in Kathmandu Valley, 1992/93 (URBAIR, 1996)

Sources of Emissions		TSP	PM10	S02
Vehicles				
Gasoline	Car/Taxi	38.4	-	-
	TC	67.5	-	4.2 - 105[1]
	MS	107.5	-	-
Diesel	Jeep	68.4	-	-
	Minibuses	22.5	-	-
	Buses	45.0	-	78-390[1]
	Trucks	114	-	
	Tractors	21.6	-	
	TC	85.8	-	
Sum vehicle exhaust		570	570	82-495[1]
Sum Resuspension from roads		1530	-400	
Energy/Industry Sector Fuel Combustion				
Industrial / commercial (excluding bricks and cement)	Fuelwood	61.9	31	
	Coal	48.0	24	172
	Charcoal	20.0	10	
	HSD	1.8	2	
	LDO/FO			
	Kerosene/LPG	0.1		
	Agri Residue	450.0	225	
Sum Industrial/Commercial		582.0	292	
Domestic	Fuelwood	1832.0	916	
	Agri- residue	454.0	227	
	Animal waste	30.0	15	
	Kerosene/LPG	2.3	2.3	
	Charcoal	10.0	5	
Sum Domestic		2328.0	1165	
Industrial Process	Brick Industry			
	Bulls Trench	5000	1250	4.8-4465[2]
	Chinese	180	45	
	Sum Brick	5180	1295	
	Himal Cement sum stack	-2000	-400	615
	Himal Cement diffuse dust	-4000	-400	
Other				
Sum Refuse burning		385	190	
Sum Construction		-	-	
Total		16565	4712	

1 High value: Based on max. allowable S content
Low value: Based on actual S content, according to IOC limited certificates

2 NESS (1995); Estimates based on different methodologies.

Table 2: Total Annual Emissions in Kathmandu valley,(tons/yr), 2001

		TSP	PM10	SO2	Nox	CO	CO2
1. Transport Sector							
Diesel							
	Bus	270	270		897		
	Minibus	100.4	100.4		869.7		
	Trucks/Tankers	644.1	644.1		2791.1		
	Tractor	31.68	31.68		49.28		
Gasoline							
	Car/Jeep/Van	244.04	244.04		3294.5		
	3 wheelers	80	80		1.12		
	2 wheelers	868.8	868.8		12.16		
Total vehicular exhaust		2175.97	2175.97	0	8034.38		
Total road resuspension		7008.01	1822.08				
2. Industrial Sector							
Himal Cement							
Total Himal Cement		2348.43	1828.16				
Brick Kilns							
	Bull's Trench	6493.21	1623.3	4177.16	813.37	820.27	
	Chinese	83.28	64.78	55.52	23.59	37.01	13880.1
Total Brick Kilns		6576.49	1688.0	4232.68	836.96	857.28	13880.1
3. Refuse Burning		687.68	339.56				
4. Boilers		28.25	15.34				
Total		18824.88	7869.23	4232.68	8871.34	857.28	13880.1

Source: MOPE/ESPS

Note: this estimate is based on the number of vehicles registered in Bagmati Zone and not on the actual number of vehicles running in Kathmandu Valley.

The emissions have increased significantly as shown by the comparison in the *Table 1 and Table 2.*. *Figure 7 and 8* highlights the percentage contribution of TSP and PM10 from various sources for the year 2001. In terms of TSP contribution, road resuspension is the biggest contributor with 37.2 % of the total followed by Brick Kilns and Himal Cement Factory with 34.9% and 12.5% respectively. In terms of PM10 contribution, vehicular exhaust is the major contributor with 28% followed by road resuspension (23%), Himal Cement (23%) and brick kilns (22%).

Figure 7: TSP Contribution form Various Sources in Kathmandu Valley, 2001

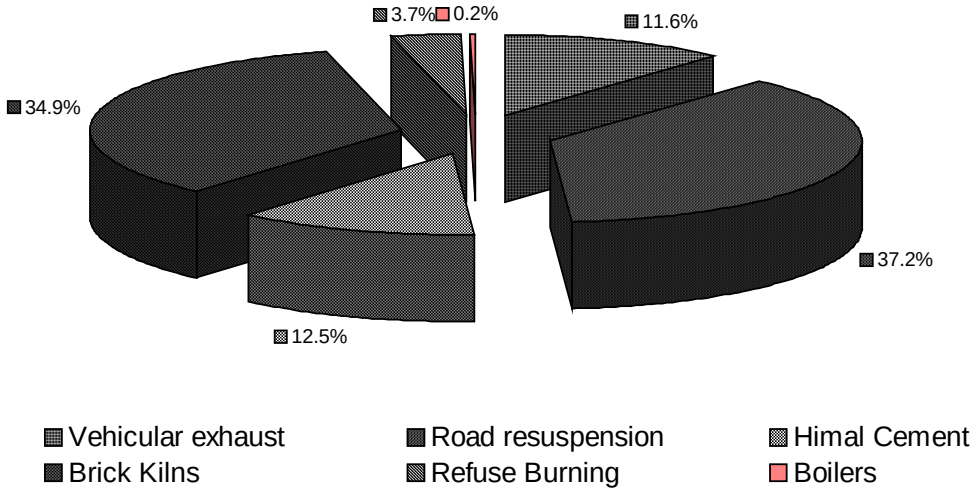
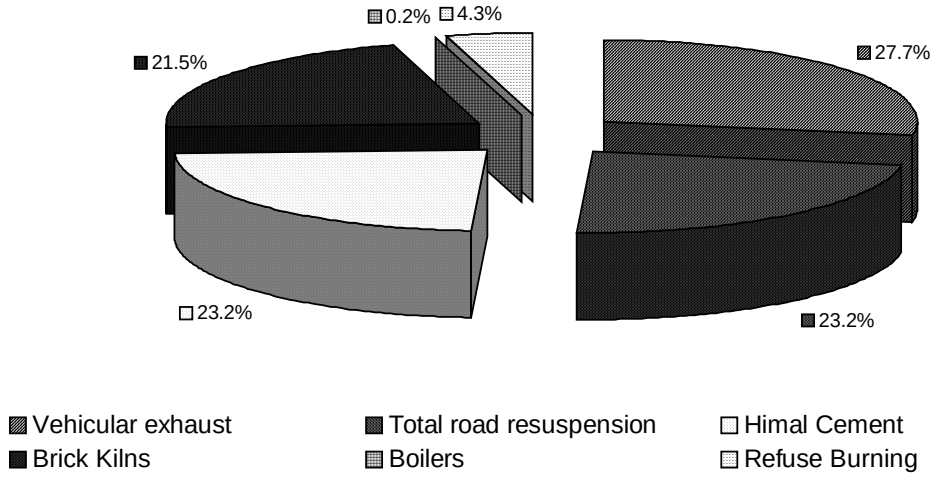


Figure 8: PM10 Contribution form various Sources in Kathmandu Valley, 2001



If we look into the number of vehicles registered in the Bagmati Zone, it has reached 171678 by 2000/2001 from 72037 in 1993, with the average growth rate of 15.3 %per year. Amongst the various categories of vehicles the maximum growth rate.21.8 % is for motorcycles followed by buses with 13.3 %. With the present rate of vehicular growth, the vehicular number is expected to reach around 400,000 by the end of 2010.

The increase in the vehicle numbers has direct impact on the demand of the petroleum products. The consumption of POL products increased from 181571 KL in 1996/97 to 209702.4 KL in 2001/2002.

The increased usage of petroleum products results with increased vehicular pollution. As compared to PM10 contribution of vehicles of 570 tons/year in 1993, the contribution of vehicular exhaust has almost increased by four fold in 2001. Considering the prevailing road conditions in the valley and the reduced vehicle km/hour speed, it is a major concern for policy makers. Further, the very high concentration of PM2.5 in the ambient air of Kathmandu Valley further demands more serious measures to be taken to curb the vehicular pollution in the valley. With increase in urban population and economic status of people in urban centers, the demand of more vehicles is there to increase. This results in more population exposed to increased pollution level resulting in more damage in terms of human health and economic cost. All these demand a long-term strategy in the transport sector development that focuses both on meeting demand and in the mean time reducing the pollution or at-least not allowing the increase of vehicular exhausts.