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(Collaborative Program of HMG/N and WHO on Health and Environment)

A Report

On

Air Pollution Situational Analysis and Management Plan

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Executive Summary

Introduction

Air pollution is a growing problem, especially in the urban areas, affecting millions of people in different parts of the world. It imposes a significant amount of social and economic costs to the national economy. Transport and industrial sectors are considered vital sectors, which are responsible for deteriorating air quality in urban areas. The broad objective of this study is to suggest legal framework leading to the development of Clean Air Act (CAA) and to develop guidelines for Air Quality Management Plan (AQMP) in order to prevent air pollution problems in the country.

Air Pollution Situational Analysis

Air pollution problems are dependent on two principal factors, natural and human. Natural factor is further dependent on physical setups, climate and meteorological conditions in the different locations of the country. Population growth and economic development are two primary human reasons that contribute further urbanization, and industrialization. A large number of motorized vehicles, consequently, start operating to cater transport demand that results from the needs for increased mobility in urban areas. A large number of industrial enterprises establish to support economic development. Urban centers and industrial areas are, thus, becoming victim of air pollution problems resulting from a higher concentration of unwanted pollutants released into the atmosphere from the utilization of different energy forms. Poorly built houses and burning of biomass fuel inefficiently deteriorate indoor air quality considerably. Prolong exposure on air pollution impacts human health adversely further imposing a significant amount of social and economic costs in terms of increased morbidity, mortality and reduced work-days loss. Air pollution problems have not caught much attention in Nepal in general, however, a few urban centers are severely facing the air pollution problems. As its result, public concern has increased tremendously especially in the Kathmandu Valley.

Nepalese economy has been predominantly agriculture based. The last thirty years trend indicated that the Nepalese economy had been shifting from its agricultural to commercial and manufacturing base, but at a very slow pace. Firewood still dominates on the total energy consumption. Traditional energy sources such as firewood, animal waste and agricultural residue together contribute a major share – more than 90 per cent -- on the total energy consumption in Nepal. A major amount of energy is consumed in residential or domestic sector. Industry is the second largest sector to consume a major share of energy. Commerce, transport and agriculture sectors together consume not more than five per cent of the total energy supplied. Petroleum products constituted a major share on energy supply for industry and transport sector. About 70 per cent of the total petroleum products consumed in Nepal were utilized in the Kathmandu Valley.

Biratnagar Jute Mills, which was established in 1936, was the first modern industry in Nepal. A total of 267 manufacturing industries were established up to 1964/65. By the year 1994/95, the number was estimated to have reached 4487. The recent census, however, revealed that the number of manufacturing industrial establishments was 3557 in Nepal. About 70 per cent of the manufacturing establishments were concentrated in 10 districts. The Kathmandu Valley accommodated 36.7 per cent of the total manufacturing establishments. A majority of pollution prone industrial plants were located in nine districts of three zones: (i) Bagmati (ii) Koshi, and (iii) Narayani. Cement, leather and tanning, paper and pulp, soap and chemicals, sugar and khandsari, and textile industries fell into the high priority categories in the pollution point of view. Industrial establishments are concentrated in certain areas in Nepal and hence industry related air pollution issues are confined in certain areas or localities.

The Kathmandu Valley houses a large number of industries. The major industries in the Valley include a large number of brick kilns and Himal cement factory. Brick kilns used various type of fuels. In addition to fuelwood, rice husks, agricultural residues, sawdust, coal of varying types and grades, scrap tyre and oil cake were used to fire bricks. Brick kilns, which used about 70 per cent of the Valley's total coal supply, contributed remarkably in air pollution problems in the Valley.

The first census was conducted in 1911 in Nepal and the population was 5.6 million. Population growth was the highest during 1971-1981, when it was 2.66 per cent per year. Population growth rate decreased slightly in the period of 1981-1991 and was 2.11 per cent per year. Urban population increased at the rate of 3.18 per cent per year during 1961-1971, 7.28 per cent during 1971-81 and 8.71 per cent per year during 1981-1991. The urban population was 2.28 million in 1991, which represented the 12.32 per cent of the total national population. Population of the Kathmandu Valley increased from 0.25 million in 1971 to 0.662 million in 1991. The growth rate of Valley population was about 6.0 per cent, which is higher as compared to national average growth rate. Besides the Kathmandu Valley; Pokhara, Birgunj and Biratnagar were among the fast growing urban centers in Nepal.

Growth in vehicles was uneven in the past. A large number of vehicles are concentrated in a number of urban cities. There were total 218,632 vehicles registered up to October 1998 in Nepal. Kathmandu Valley occupied about 56 per cent of the total vehicles registered in Nepal. The actual number of operating vehicles is not precisely known in Nepal. There exist no rules and regulations governing the vehicle phase-out plan. A large number of second hand vehicles were also registered mainly in passenger services. Car and two-wheelers have been dominating the total vehicle fleet in Nepal and comprised about 22 and 51 per cent on the total vehicle fleets respectively. Compared to the number of vehicles and their growth rates, road networks have not been extended considerably in Nepal. His Majesty's Government of Nepal has set emission standards for diesel and gasoline vehicles in the Kathmandu Valley in July 1994. The emission test result showed that about 40 per cent of the vehicles did not meet the required emission standards.

Estimation of emission load of air pollutants is not readily available for the urban centers except in the Kathmandu Valley. The latest estimation for the emission loads indicated that the transport sector contributed about 31 thousand tons of pollutants in 1996 in the Kathmandu Valley. Carbon monoxide (CO) was the major pollutants and constituted about 60 per cent of the total vehicular emissions. Other major pollutants were HCs and NO_x. Their contributions on the total emissions were 30 per cent and six per cent respectively.

Impacts on health due to environmental consequences are not precisely known in Nepal. However, there are some facts that hint the extent of air pollution. According to the morbidity health status, respiratory came among the top five diseases accounting for eight per cent of population reporting the case of acute respiratory infection (ARI). Respiratory disease has been largely dependent on the prolong exposure of smoke and dust. Acute respiratory infection continued to be the leading cause of death among young children, accounting for more than 30 per cent of deaths in children under five years of age.

Virtually no air quality-monitoring network exists in the country. However, A few institutions were involved in recording air quality from time to time. Information on air quality, so far, obtained from different sources provides generic information on air quality situations. There already exist enough information in the Kathmandu Valley. Lead particles were found as high as 6.08 μg/m³ in some locations and foreseen that roadside dusts contained even a higher concentration of lead particles, far exceeding the acceptable limit. Likewise, concentrations of suspended particulate matters have surpassed WHO guidelines value for a prolong duration in most of the sites. Concentrations of other pollutants, such as HC, CO, NO_x, and SO_2 have not noticed exceeding the limit considered unsafe for public health viewpoints in most of the areas. However, concentrations of these pollutants are approaching the threshold limits in many urban airsheds, especially in heavy traffic sites in rush hours.

Strategy for Air Quality Management

Assessment of the quality of air has not been carried out systematically in Nepal due to a lacking of an appropriate air quality management system. Observations made on most of the studies are not inter-comparable. Analysis of historical data on ambient air pollution levels, however, warrants an urgent need for ambient air quality monitoring program to define the actual status of the problems.

There are three air quality management capability indicators. These are (i) Stated air quality monitoring objectives, (ii) Adequacy of base information to use in policy decision and (iii) Administrative and legal frameworks. Defining objectives is one of the most important and primary steps for any air quality management program. There exist no formal institutional, administrative and legal frameworks to carry out monitoring assignment in the country. An air quality management plan should consist of the following components.

i) An air quality monitoring network
ii) Emission inventories
iii) Numerical prediction models
iv) Air quality standards
v) Emission control policies and measures

Almost all of these components are lacking in the country. In the absence of a well-defined monitoring network with specified monitoring objective, information so far obtained can not be further used to establish air quality standards and to develop model for predicting concentrations of air pollutants in different meteorological conditions. A well-defined emission inventory is indispensable for designing a range of cost-effective emission control policies and measures. Air pollution models can be developed after analyzing scattered or time series data on air quality along with other variables such as meteorological information and pollution characteristics.

Assessment of ambient concentration of pollution is an indispensable component of any air quality management capability. Measurement and evaluation of ambient concentrations of pollutants should be initiated first in the Kathmandu Valley and should gradually be expanded in other urban centers in Nepal. The objective of air quality monitoring should be to generate enough information for formulating air quality management strategies and to monitor the progress of the plans once implemented. Monitoring capabilities are essential in providing information to assist decision-makers in formulating appropriate responses to reduce emissions of pollution. Monitoring capabilities are required to produce data enabling the identification of air quality problems, range of pollutants, pollution sources and methods of imposing emissions controls. The following steps are fundamental elements on any air quality monitoring plan: (i) Decide the institutional framework, (ii) Air quality monitoring network design, and (iii) Adoption of cost effective instrumentation.

Air Quality Management Plan

Transport Sector

Transport sector has emerged as the largest sector for contributing a large amount of pollutants into the atmosphere especially in urban areas. Policies and technologies that target to reduce emissions from the vehicular sector are keys to address air pollution problem in urban areas. Fuel quality and engine condition significantly influence the level of vehicle emissions. To arrest this escalating problem, a concerted effort with public involvement is essential. Awareness of the issues, proactive policies, economically affordable standards and technologies and effective enforcement program are fundamental elements in any air quality management plan. Leaded, substandard and adulterated fuels, poor traffic management, a large number of old vehicles, and poor state of vehicle maintenance are consequential reasons for a high level of vehicular emission. The goal of vehicular emission control program is to reduce emissions from motor vehicles in-use to the degree necessary to achieve ambient air quality of a city or the country to the practical limits of technological, economic and social feasibility. In order to accomplish this goal, emission standards for the motor vehicles require to be established, monitoring program should be designed and executed to enforce acquiescence with these standards, and to check vehicle usage wherever is practicable. Consequently, to bring the vehicular emissions at the desired national level, a multi pronged strategies needs to be developed and implemented with active participation of government, non-governmental and private sector as well. Emission control program focussed on "end-of-pipe" technologies along with the introduction of cleaner vehicles needs to be focussed in order to obtain the desired results. An especialized and responsible organization with a clear mandate and sufficient resources is lacking in the country. An independent institution should be established with sufficient authorities to coordinate activities and organizations, develop strategies and implement various programs for improving air quality and to prevent, control or abate air pollution from the different sources in the country.

Using policy and technological options can control vehicular emission. The solution to the vehicular air pollution problem has to follow a multi-pronged approach, as it is a multi-dimensional problem. Table-1 exhibits the comparative assessment of the different vehicular emission control measures.

Table-1: Comparative Assessment of Emission Control Options and Strategies

Measure	Target Vehicles	Present Status	Effectiveness of Emission Reduction	Strategy	Responsible Organization
1. ULG and CC	Passenger cars and taxis	ULG already introduced in Kathmandu Valley	Reduce about 80 % CO, HC, and NOx emission	1. Regulation urging vehicles to use CC for vehicles above 1400 CC	1. Pollution Control Board (PCB) -Proposed
2. I/M Program	All	Emission limit has been fixed for 2-,3-, and 4-wheeler vehicles	Dependent on enforcement and monitoring program, effective if properly implemented	1. Set emission limits and qualify testing centers 2. Random spot checking	1. PCB 2. PCB in collaboration with Traffic Police
3. Fuel Quality Improvement	All	Kerosene has recently been coloured	Prerequisite for effective emission control program	1. Testing fuel sample for petrol station	2. PCB
4. Cleaner Vehicles	Three wheelers and minibuses	Electric and LPG 3-wheelers have already been introduced in the Valley. Trolley bus operating for 26 years	Effective	1. Rate Liberalization 2. Declare clean vehicle zone	1. PCB 2. PCB in collaboration with Municipalities
5. Four Stroke Vehicles	Two and three wheelers	4 – and 2 – stroke have no different price for similar types	Effective to reduce CO and HC	1. Banning further registering of two-stroke 2. Imposing progressive tax system	1. PCB in collaboration with Transport Management Office 2. PCB
6. Workshop Strengthening	-	No attention has given yet	Prerequisite for effective I/M program	1. Capability assessment 2. Grading the workshops 3. Provide training and supports	1. PCB 2. PCB 3. PCB
7. Vehicle phase out program	passenger bus, minibus, three wheeler and taxi, government, and corporation vehicles	No attention has given yet	Effective as new vehicles are environment friendly these days in general	1. Automatic phase out 2. Progressive tax	1. PCB 2. PCB
8. Control Devices	All	Few devices are available in market	Yet to be verified in Nepalese condition	1. Promotion and awareness	1. PCB in collaboration with dealer and supplier
9. Cleaner Fuel	Gasoline Vehicles	Research is going on	Substantial emission reduction	1. Further research and popularization	1. PCB in collaboration with institute /NGOs
10. Urban Planning	--	Yet to be initiated effectively	Facilitate smooth vehicular operation	1. Dust control 2. Traffic management 3. Land use planning	1. Municipality 2. Traffic police 3. Municipalities and concerned government agencies

Industrial Sector

A new vision is required to manage industrial air emission as well as total industrial environmental quality management. It is imperative to develop a comprehensive policy cum strategy with definite responsibility of the line agency. On national scale, rules making may not be a problem but regulating them is an essential concern. It is suggested to establish an independent environmental regulating agency with a clear mandate comprising the following entities.

Table-2: Emission Control Strategies for Industry Sector

Policy	Strategy	Relevant sectors/actions
Command and control plus market tools should be introduced concurrently	• Standards and charges, subsidies, taxes, refund etc. should be supplementary to each other	• Air pollution minimizing technologies or equipment • Energy efficient boilers • Stack loss should not exceed the designated level
Marketing of pollution	• Emission trades in an airshed bubble	• Industrial zones • A definite airshed
Polluter-pays to Green bank	• Polluter pays to revolving fund to be managed by industrialist	• Pollution prone industries. Encourage them to be resource efficient
Win-win philosophy	• Promote cleaner energy sources or relatively clean energy than dirty sources of energy • Encourage preventative measures • Ambient air quality standard in particular airshed	• Tax relief to clean sources energy like rice husk and taxation to dirty energy like coal • Provide incentives to resource efficient industries • Convince the industries between difference of ambient and individual stack emission standards
Encourage private-private partnership	• Entrust the private sector for environmental services • Government agencies should limit to regulate them • Streamline the distorting market	• Environmental expertise requiring for industries such as boiler tuning, waste minimization etc. should be available from the market. Government shouldn't be tempted to establish a consulting agency of its ownership to compete with the private sector
Streamline on environmental regulating agency with clear mandate	• Established an environment protection board/authority	• An independent technical arm with total responsibility for monitoring pollution and regulating the polluting sources

Domestic Sector

Indoor air pollution problems can be brought down through the two measures: (i) Cooking fuel substitution, and (ii) Improving fuel efficiency.

Application of the first measure is largely dependent on the economic status of the people. As the economic level rises, people start using kerosene and LPG and abandon using wood and other biomass fuels. Developing sustainable frameworks and strategies for making ICS program technically, socially and economically acceptable are challenging job. Alternative Energy Promotion Center (AEPC) has been instituted under the Ministry of Science and Technology (MOST) and formulating ICS promotion program. The proposed organization so in this regard can work together with AEPC to promote ICS dissemination program in rural Nepal.

Legal Framework

After the Earth Summit on Environment and Development at Rio De Janeiro in Brazil, Nepal has formulated and has been implementing several policies for the protection of environment at the national and local level. Accordingly, Environment Protection Council (EPC) is formed under the chairmanship of Rt. Honorable Prime Minister. The Council has initiated the formulation of various policies on environment protection and planning including pollution control programme. However, the situation has not been changed, in fact the air quality is being worsened. It is hard to find specific policy formulated for prevention and control of air pollution in Nepal. Policies formulated for the purpose of protection of environment provide some provision for prevention and control of air pollution. On revision of the existing legislation it is realized that many agencies or institutions have been authorised or are made responsible to prevent and control the air pollution, but there is a lack of coordination among these institutions. This, however, has created confusion among the authorities and provided an easy way for them to shift their responsibilities to others. The pathetic condition of the Valley and urban areas due to air pollution is because of lack of commitment to enforce the existing rules, regulations, guidelines and the standards formulated. There is no coherent legislative framework to control air pollution. Rather, air pollution control is spread over various statutes.

In enacting Clean Air Act or Regulation, parliament or government should choose a technology forcing strategy which embodies a policy that polluters must invent (if necessary) the necessary control technology to meet applicable emission standards or close down. It must be recognised that technological or economic unfeasibility is not a legitimate basis for setting aside an implementation plan which is otherwise sufficient to attain national air quality standards. However, the prerequisite should be to fix and enforce air quality standards. It has already been mentioned that existing Nepalese legislation do empower the government to fix and enforce air quality standards.

An independent, powerful and efficient institution should be setup in the centre to monitor air quality; fix air quality standards; and to establish coordination among the sectoral ministries, agencies, and other groups or organizations. The institution should develop strategies and implement them to maintain air quality with the view to ensure public health. It should be consist of experts, government authorities representing their sectoral ministries, departments, councils, RONAST, NGOs, and other individual experts. It should be clear that an institution under an existing ministry can not serve the purpose. Air pollution covers various spheres of life. So one sectoral ministry could not work effectively without the cooperation of others. An integrated approach should be adopted. So that, an institution not under any ministry but with representation from different relevant ministries, independent experts, NGOs and other stakeholders should be established. The Environment Protection Council (EPC) will probably serve this purpose provided it is made independent by amending the Environment Protection Act and by giving it more power, authority, independent secretariat and other infrastructure. The Central Board should make policy decisions, formulate policies, programmes for prevention of air pollution and monitor and evaluate the functioning of regional, zonal or district level boards, as the case may be. The government should be willing to provide required human and financial resources including equipment and other infrastructure. It must be kept in mind that part time or voluntary board members appointed by political decisions will not to contribute effective functioning of the Board(s).

A Clean Air Fund should be established at the centre to act as a reserve fund. Donation received from various sources should be deposited in the fund. Government should also be required to provide certain amount from budget annually. The amount collected in the fund should be spent in such programmes aimed at preventing and controlling air pollution and securing public health. In the long run, the fund also used to provide incentives to environment friendly industries.

Conclusions and Recommendation

The major conclusion of this study is that air pollution problems are increasing in urban centers gradually in Nepal. However, in the absence of systematic air pollution monitoring, prevention and controlling system, no action so far has been effective in combating air pollution problems. Using policy and technological options can prevent air pollution problems. One of the most important constraining elements is the policy and legal frameworks, which are almost completely lacking in the country. The long-term goal of reducing air pollution can be achieved by the following strategic considerations. These are:

i. To decide the institutional framework for air quality monitoring
ii. To establish air quality standard arbitrary at the beginning and revised periodically as the data becomes sufficient to establish more precise standard
iii. To formulate separate and comprehensive policy and legal framework, and
iv. To establish an specialized and responsible organization with clear mandates, legal authority to take overall responsibility of air pollution prevention and control in the country.

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List of Abbreviations

APFZ : Air Pollution Free Zone
APZ : Air Pollution Zone
AQP : Air Quality Plan
ARI : Acute Respiratory Infection
B. S. : Bikram Sambat
BACT : Best Available Control Technology
BHEL : Bharat Heavy Electric Limited
BID : Balaju Industrial District
CAF : Clean Air Fund
CAPPCB : Central Air Pollution Prevention and Control Board
CARB : California Air Research Board
CBS : Central Bureau of Statistics
CC : Catalytic Converter
CD : Corps Diplomat
CDR : Central Development Region
CEDA : Central for Economic and Development Agency
CEMS : Continuous Emissions Monitoring System
CNG : Compressed Natural Gas
CO : Carbon Monoxide
CO2 : Carbon Dioxide
CSP : Citizen Suit Provision
DHM : Department of Hydrology and Meteorology
DoHS : Department of Health Service
DOMT : Department of Management of Transport
EDR : Eastern Development Region
EIA : Environmental Impact Assessment
EPA : Environment Protection Act
ENPHO : Environment and Public Health Organization
EPC : Environment Protection Council
FWDR : Far Western Development Region
GDP : Gross Domestic Product
GEMS : Global Environmental Monitoring System
GJ : Giga Joule
GTZ : German Development Agency
HC : Hydro Carbon
HMGN : His Majesty's Government of Nepal
hrs : Hours
HSD : High Speed Diesel
HSU : Hatrigde Smoke Unit
I & A : Incentives and Awards
I/M : Inspection and Maintenance
ICS : Improved Cooking Stove

IF	:	Integrated Forum
IOC	:	Indian Oil Corporation
ISC	:	Industrial Service Center
IUCN	:	International Union for Nature Conservation
JICA	:	Japan International Cooperation Agency
KEVVEP	:	Kathmandu Valley Vehicular Emission Control Project
kl	:	Kilo Liter
km	:	Kilo Meter
kW	:	Kilo Watt
kWh	:	Kilo Watt Hour
LAER	:	Lowest Achievable Emission Rate
LDO	:	Light Diesel Oil
LEADERS	:	Legal and Environmental Analysis and Development Research
LNG	:	Liquefied Natural Gas
LPG	:	Liquefied Petroleum Gas
LSGB	:	Local Self-Governance Bill
mg/m3	:	Milligram per cubic meter
MOF	:	Ministry of Finance
MoHS	:	Ministry of Health Service
MOI	:	Ministry of Industry
MOPE	:	Ministry of Population and Environment
MS	:	Motor Spirit
MWDR	:	Mid Western Development Region
NCS	:	National Conservation Strategy
NBSM	:	Nepal Bureau of Standard and Meteorology
NEA	:	Nepal Electricity Authority
NECG	:	Nepal Environmental Conservation Group
NEPAP	:	Nepal Environment Policy and Action Plan
NESS	:	Nepal Environmental and Scientific Services
NESS	:	Nepal Environment and Scientific Services
NGO	:	Non Governmental Organization
NLSS	:	Nepal Living Standard Survey
NOC	:	Nepal Oil Corporation
NO_x	:	Oxides of Nitrogen
NPC	:	National Planing Commission
NSIC	:	National Standard of Industrial Classification
NTA	:	Nepal Treaty Act
O	:	Oxygen
Pb	:	Lead
PM10	:	Particulate Matter less than 10 micron
ppm	:	Parts per million
PSD	:	Prevention of Significant Deterioration
R&D	:	Research and Development
RONAST	:	Royal Nepal Academy of Science and Technology
Sec.	:	Section

SKO	:	Special Kerosene Oil
SO_2	:	Sulfur Dioxide
TSP	:	Total Suspended Particle
ULG	:	Unleaded Gasoline
UN	:	United Nations
UNDP	:	United Nations Development Program
URBAIR	:	Urban Air (A World Bank Project)
US	:	United States
VDC	:	Village Development Committee
VTNA	:	Vehicles and Transport Management Act
VTP	:	Valley Traffic Police
WDR	:	Western Development Region
WECS	:	Water and Energy Commission Secretariat
WHO	:	World Health Organization
□g/m3	:	Micro gram per cubic meter

List of Conversion Factors

Pollutants	Unit	0°C, 1 atm	25°C, 1 atm
SO_2	1 ppm	2856 □g/m^3	2600 □g/m^3
CO	1 ppm	1.250 mg/m^3	1.145 mg/m^3
NO	1 ppm	1340 □g/m^3	1230 □g/m^3
NO_2	1 ppm	2050 □g/m^3	1880 □g/m^3
O_3	1 ppm	2140 □g/m^3	2000 □g/m^3

Source: UNEP/UNDP, 1993

Chapter - I

Introduction

1.1 Background

Air pollution is a growing problem, especially in urban areas, affecting millions of people in different parts of the world. It imposes a significant amount of social and economic costs to the national economy. Effects of air pollution on human health, plant and animal life, productivity and cultural heritage are not precisely known in Nepal. However, there are a few past studies and widely accepted observations, which imply the extent of air pollution and its impacts on human well beings. Transport and industrial sectors are considered vital sectors, which are responsible for deteriorating air quality in urban areas. Indoor air quality is, in many instances, affected adversely by burning of biomass fuel inefficiently in rural areas.

Protection of air quality is essential to the integrity of ecosystems and human health and the management of air quality interacts between technological options, policy formulation, regulatory enforcement, political commitment, and public awareness. However, we are at the initial stage as far as these management aspects are concerned. Subsequently, air pollution has become a prominent issue not among the public but also among the policy- and decision-makers. A strong need was felt to develop management strategies targeted in improving air quality considering technical, socio-economic and legal feasibility of control options and measures in broader perspective.

1.2 Study Objectives

The broad objective of the study is to suggest legal framework leading to the development of Clean Air Act (CAA) and to develop guidelines for Air Quality Management Plan (AQMP) in preventing air pollution problems in the country. The specific objectives of the study are to:

- make a situational analysis of present air quality and air pollution
- develop and suggest guidelines for air quality management plan and strategies
- analyze and suggest legal framework

1.3 Expectation from the Study

Air quality improvement seems to be indispensable for improving social welfare of society. Improved air quality enhances human productivity and consequently helps to improve national economy. Protection of air quality is essential to the integrity of ecosystems with human health. There exist many technological as well as policy measures to mitigate concentrations of air pollutants from the atmosphere. Application of such technologies and policy options is largely determined on how laws are in-acted and enforced in the country. There is a growing consensus among the policy makers and the general people that act and regulations are the immediate requirements for executing policies and plans to protect environment effectively. There are a few regulations and acts already developed in many environmental areas; however, such acts and regulations are not adequate for implementing an effective air quality management program. Air quality management plan, if developed considering local conditions, can serve an effective tool for improving air quality.

This study assesses air pollution situation in the country and sheds light on fundamental considerations such as economic development, energy consumption, urbanization, industrialization, etc., which have direct implications on air quality. This study provides comprehensive analysis on air quality and provides emissions inventories of different sources. This study also presents overall health situation of the people residing in rural as well as urban areas of the country.

Strategies developed for air quality management help policy makers to develop national strategies that are required in controlling and preventing air pollution from transport and industrial sectors. Legal framework provides policy makers enough information in designing and implementing an effective regulatory framework.

1.4 Study Methodology

A comprehensive review and analysis of previous works, studies and information was carried out. Information available on air quality from urban areas other than Kathmandu Valley was also collected and reviewed. A Steering Committee Meeting was organized to get the experts' opinions and inputs on designing study methodology and approach. Final output of the study was presented and discussed on the national workshop held on October 4, 1999 in Kathmandu. About 25 experts from the related institutions and private sector participated on the workshop. A questionnaire was also prepared and circulated among the workshop participants, before the workshop, for getting a wider opinion and views on some of the pertinent and important aspects. Comments and suggestions received from the experts have also been incorporated on finalizing the report.

1.5 Scope and Limitations

The study looked into air pollution problems arising from domestic, industrial and transportation sectors on national perspective. However, especial attention was paid for air pollution problems arising from transport and industrial sector in urban areas. In-depth analysis is presented on air pollution control options and measures for transport sector, however, analysis of industry-specific pollution control options and measures was beyond the scope of the present study. Air pollution due to noise and odour was not included in this study.

Chapter – II

Air Pollution Situational Analysis

Air pollution problems are dependent on two principal factors, natural and human. Natural factor is further dependent on physical setups, climate and meteorological conditions in different airsheds of the country. Population growth and economic development are two primary human reasons that contribute further urbanization, and industrialization. A large number of motorized vehicles, consequently, start operating to cater transport demand that results from the needs for increased mobility in urban areas. A large number of industrial enterprises establish to support economic development. Urban centers and industrial areas are, thus, becoming victim of air pollution problems resulting from a higher concentration of unwanted pollutants released into the atmosphere from the utilization of different energy forms. Poorly built houses and burning of biomass fuel inefficiently deteriorate indoor air quality considerably. Prolong exposure on air pollution impacts human health adversely further imposing a significant amount of social and economic costs in terms of increased morbidity, mortality and reduced work-days loss.

Along with the situational analysis, in this chapter, a through analysis on the air pollution problems is carried out in order to explicate the nature, extent, severity and situation of outdoor as well as indoor air pollution problems in the country. It helps further formulating an appropriate policy framework, designing suitable strategies, and implementing workable mechanism for combating the air pollution problems pragmatically.

2.1 Physical Setup and Major Environmental Issues

Nepal occupies 147,181 km^2 land area extending about 885 km from East to West and about 193 km from South to North. Physiographically, the country can be divided into five distinct regions; High Himalayan, High Mountain, Middle Mountain, Siwalik and Terai. All these regions posses different climatic, geological, and ecological characteristics. The High Himalayan Region is mostly covered with snow and has over 200 peaks exceeding 6,000 m. Eight out of the ten highest peaks exceeding 8,000 m in the world, including the Mount Everest, is located in this region. It occupies 23 per cent of the total land area of Nepal. The High Mountain Region occupies about 20 per cent of the total land area. Except a few traditional handicraft enterprises, no industrial and economic bases exist in this region. A large portions of economically active population -- mostly male -- of this region travel periodically to bordering Indian and Tibetan centers through out the year to carry out business activities. Small clusters of human settlements are found in the High Mountain regions. Productivity in the limited agriculture land is comparatively low. Energy resource base is insufficient to meet daily heating and cooking requirements of the residence of the region. Animal waste and biomass are the main energy sources used in the region. Due to its cold climatic condition, major portions of energy resources are used for space heating and cooking food. A large number of settlements are found in the Middle Mountain Region, where the Kathmandu Valley, the Capital City of Nepal lies. The Valley constitutes one of the major traditional and cultural heartland of the country. Most of economic, cultural, historical, educational and business activities are centered in this region. This region is environmentally stressed due to a high population pressure, unmanaged industrial establishments and increased vehicular movement. There are a few Terai-like valleys lying in Siwalik Region. This region is sandwiched in between the Siwalik and Terai region and extents in a small stripe almost from East to West. Terai constitutes the most productive agricultural region and has shown a good potential for industrial development. This region is highly populated and provides home for nearly 48 % of the national population. It occupies about 14 per cent of total land area. Most of the industrial centers such as Biratnagar, Birgunj are located in Terai region. This region borders India on its South direction. All three regions: Middle Mountain, Siwalik and Terai are equally important from the agriculture and industrial point of view. However, only a few centers have been developed as urban and industrial centers in these regions of the country. Table 2.1 illustrates the different physiographic features of these regions.

Table 2.1: Physiographic Characteristics of Nepal.

Region	Elevation (m)	Coverage (%)	Width N- S (km)	Major Cities/Urban Centers
High Himalayan	Above 4000	23	20-100	-
High Mountain	2200 – 4000	20	20-120	-
Middle Mountain	800 – 2400	30	40-60	Kathmandu, Pokhara
Siwalik	200 – 1500	13	8 – 10	Chitwan, Dang
Terai	60 – 330	14	50	Biratnagar, Janakpur, Birgunj, Nepalgunj

Source: Interpolated from different maps

Deforestation, landslides and soil erosion are some of the major environmental issues that Nepal is facing these days. In urban areas, disposal of sewerage and solid waste has always become major environmental concerns. Contamination of river water resulting from the toxic effluent disposed from the industrial plant is another major environmental concern that draws much more attention than the issues related to air pollution problems. Air pollution problems have not caught much attention in Nepal in general, however, a few urban centers such as Kathmandu Valley are severely facing the air pollution problems. As its result, public concern has increased tremendous in the Kathmandu Valley.

2.2 Economic Development

Nepalese economy has been predominantly agriculture based. The last thirty years trend indicated that the Nepalese economy had been shifting from its agricultural based to commercial and manufacturing base, but at a very slow pace. However, agriculture sector still dominates considerably on the total national gross domestic product (GDP). It contributed more than 40 per cent on GDP in the fiscal year 1996 as compared to 65.2 per cent in 1964. Contribution of manufacturing sector on national GDP has not increased significantly for the period of last thirty years. Manufacturing sector contributed nine per cent on total national GDP in year 1996 whereas it was eight per cent in 1964. This indicates that manufacturing sector has not grown-up significantly to contribute considerably in the total national development in Nepal. Table 2.2 exhibits the share of agriculture and manufacturing sector on national economy during the last thirty years in Nepal.

Table 2.2: Share of Agriculture and Manufacturing Sector on National GDP in Nepal

Year	Agriculture Sector	Manufacturing Sector	Other Sector	Total
1996/97	41.6	9.4	49.0	100
1989/90	50.6	6.0	43.4	100
1984/85	51.2	5.6	43.2	100
1979/80	61.8	4.4	33.8	100
1974/75	71.6	4.2	24.2	100
1969/70	67.5	8.9	23.6	100
1964/65	65.2	8.0	26.8	100

Source: National Account of Nepal, 1997 in Malla, 1998

The pace of economic development was slow during the third, fourth and fifth five-year plan periods in Nepal. The annual average GDP growth rates were around two per cent during those periods. A slight increase in growth rates was observed during the sixth, seventh and eighth five-year plan periods, when the average GDP growth was nearly five per cent per year. The annual average GDP growth rate relating to manufacturing sector was 4.9 per cent during the seventh five-year plan period and growth rate was increased slightly during the eighth five-year plan period. Table 2.3 shows the average annual GDP growth rate in different five-year plan periods in Nepal.

Table 2.3: Average Annual GDP Growth Rate in Nepal

Plan Period	Year	Overall GDP	Manufacturing Sector
Third	1965/66 – 1969/70	2.6	-
Fourth	1970/71 – 1974/75	1.8	-
Fifth	1975/76 – 1979/80	2.3	-
Sixth	1980/81 – 1984/85	4.9	-
Seventh	1985/86 – 1989/90	4.8	4.9
Eighth	1992/93 – 1996/97	4.6	7.1

Source: Malla, 1998

Slightly different figures were quoted in the World Bank report (1998) relating to economic development scenarios of Nepal. In real term, total GDP growth rate declined from 5.5 per cent during 1991-94 to 1.9 in 1998. The last three years period observed a declining economic trend in the development history of Nepal. Agriculture sector GDP increased at a slower rate of around two per cent per year. The GDP growth rate relating to industrial sector observed declining from eight per cent per year during the year 1991-94 to 0.2 per cent in 1998. Table 2.4 shows the real GDP growth rates in the period from 1991 to 1998 in Nepal.

Table 2.4: Real GDP Growth (in percent per annum)

Sector	FY 1991-94	FY 95-96	FY 1997	FY 1998[1]	FY 1998[2]
Agriculture	2.0	2.0	4.1	2.0	1.0
Industry	8.0	4.9	3.2	4.6	0.2
Trade/Transport	7.4	8.2	6.0	4.3	3.3
Other Services	8.4	5.8	4.1	5.8	5.8
Total GDP	5.5	4.3	4.2	3.5	1.9

Source: World Bank, 1998

Economic distribution is uneven in Nepal. The National Living Standard Survey (NLSS) - 1995 - indicated that there was a marked difference in income level of the people residing in rural, urban and Kathmandu Valley areas. The average per capita income of Nepalese people was 7,690 rupees in 1996. People residing in urban area earned about 16,000 rupees per year whereas the rural people earned about half of that. Annual income level of the resident of the Kathmandu Valley was the highest in Nepal, about 24,000 rupees. The average annual income level of urban-rural residents in Nepal is shown in Table 2.5.

[1] Early estimate of CBS.
[2] World Bank staff estimate.

Table 2.5: Average Household and Per-Capita Income (Annual Income in 1995/96 Rupees)

Area	Average Household Income	Household Size	Average Per-Capita Income
Nepal	43,732	5.7	7,690
Urban	86,797	5.4	16,118
Rural	40,400	5.7	7,075
Kathmandu	118,939	4.9	24,084

Source: CBS, 1996b.

2.3 Energy Consumption in Nepal

Nature and the extent of air pollution are largely dependent on type, quality and quantity of energy used. There are three principal types of energy utilized in Nepal. These are (i) Traditional (ii) Commercial, and (iii) Renewable or Alternative forms of energy. Traditional energy includes the firewood, agricultural residue and animal waste, whereas coal, petroleum products and electricity are the commercial form of energy used in Nepal. Share of renewable energies such as micro hydropower, biogas and solar is negligible on national context. A large number of renewable energy technologies are, however, implemented and utilized in rural Nepal. The number of micro hydropower (installed capacity in the range of 1 to 100 kW) plants and biogas plants were 1600 and 48407 respectively (Adhikari, 1998). In addition to the solar Photovoltaic used in rural telecommunication and aviation sector, 1067 solar Photovoltaic home systems were installed in the initiation taken by the rural communities for electrifying the rural households. The Nepal Electricity Authority (NEA) system has solar installed capacity equivalent to 130 kW for electrifying the rural and areas isolated from the national grid.

Firewood still dominates on total energy consumption. Traditional energy sources such as firewood, animal waste and agricultural residue together contribute a major share – more than 90 per cent -- on the total energy consumption in Nepal. Fuelwood supplied about 68 per cent of 285,600 thousand gigajoules of energy consumed in year 1994. Likewise, agricultural residue contributed 15.03 per cent, animal waste 8.10 per cent, coal 0.99 per cent, petroleum products 6.19 per cent and electricity contributed 0.99 per cent on the total energy consumption in Nepal. Table 2.6 exhibits the energy consumption patterns of the last 15 years by fuel type in Nepal.

Table 2.6: Energy Consumption by Fuel Type (%)

Year	Fuel-wood	Agri. Residue	Animal Waste	Coal	Petroleum Products	Electricity	Total	
							%	GJ (000)
1994/95	68.71	15.03	8.10	0.99	6.19	0.99	100	285.600
1993/94	69.11	14.87	8.21	0.94	5.96	0.91	100	277.768
1992/93	67.88	14.87	8.12	1.02	7.21	0.9	100	270.915
1991/92	69.07	14.56	8.33	0.88	6.25	0.9	100	261.416
1990/91	70.89	14.49	8.68	0.82	4.26	0.85	100	248.190
1989/90	71.69	14.49	8.90	0.13	4.30	0.79	100	239.633
1988/89	72.18	13.63	8.97	0.81	3.69	0.73	100	235.358
1987/88	72.61	13.20	9.10	0.92	3.46	0.70	100	229.602
1986/87	72.77	12.74	9.19	1.02	3.67	0.61	100	224.866
1985/86	74.36	12.32	9.39	0.19	3.21	0.53	100	217.806
1984/85	73.22	12.21	9.3	1.68	3.1	0.48	100	216.525
1983/84	73.25	12.28	9.36	1.67	3.02	0.42	100	212.084
1982/82	74.00	12.47	9.5	0.86	2.76	0.41	100	205.715
1981/82	74.27	12.61	9.61	0.78	2.4	0.33	100	200.343
1980/81	73.68	12.72	9.69	1.06	2.55	0.3	100	195.636

Source: WECS, 1996

A major amount of energy is consumed in residential or domestic sector. Industry is the second largest sector to consume a major share of energy. Commerce, transport and agriculture sectors together consume not more than five per cent of the total energy supplied. Energy consumption profiles of the last 15 years showed that the share of domestic sector on total energy consumption was declining, while the share of industry, commerce, transport and agriculture sectors was increasing, but at a slow pace in Nepal. Table 2.7 exhibits the energy consumption profile of the fifteen years period by different sectors in Nepal.

Table 2.7: Energy Consumption By Sector

Year	Residential	Industry	Commerce	Transport	Agriculture	Total	
						%	GJ (000)
1994/95	90.8	4.4	1.3	2.7	0.7	100	285.600
1993/94	91.13	4.31	1.32	2.47	0.66	100	277,768
1992/93	91.27	3.41	1.42	3.2	0.66	100	270,915
1991/92	92.14	3.16	1.23	2.79	0.6	100	261,416
1990/91	93.2	2.4	1.0	1.9	0.4	100	248,190
1989/90	95.68	0.98	0.89	2.20	0.19	100	239,633
1988/89	95.15	2.29	0.57	1.61	0.30	100	235,358
1987/88	93.93	2.43	0.56	1.70	0.32	100	229,602
1986/87	93.88	2.55	0.57	1.64	0.30	100	224,866
1985/86	95.6	2.1	0.60	1.4	0.2	100	217,806
1984/85	93.55	2.80	0.69	1.80	0.14	100	216,525
1980/81	96.24	1.68	0.41	1.51	0.12	100	195,636

Source: WECS, 1996

Residential sector consumed 270.4 million gigajoules energy, on which firewood contributed 72.3 per cent. Agricultural residue and animal waste contributed 16.1 and 8.7 per cent on the total energy consumption in residential sector. Petroleum products and electricity supplied only 2.6 and 0.4 per cent on the total energy consumption. Petroleum products constituted a major share on energy supply for industrial sector. Industrial sector consumed 12.5 million gigajoules of energy, on which the share of petroleum products was 36.8 per cent, fuelwood 24.8 per cent, coal 20.8 per cent, electricity 10.4 per cent and agricultural waste 7.2 per cent on the total energy supply. Fuelwood and petroleum products were the major energy sources used in commercial sector. Petroleum products were the major energy types used in transport and agriculture sectors. Table 2.8 exhibits the energy consumption profiles by sector and by fuel type in 1995/96.

Table 2.8 : Energy Consumption by Sector and Fuel Type (1995/96)

Sector	Fuel-wood	Agri. Residue	Animal Waste	Coal	Petroleum	Electricity	Non-Energy	Total	
								%	10^6 GJ
Residential	72.3	16.1	8.7	-	2.6	0.4	-	100	270.4
Industrial	24.8	7.2	-	20.8	36.8	10.4	-	100	12.5
Commerce	37.8	2.7	-	8.1	37.8	13.5	-	100	3.7
Transport	-	-	-	1.2	98.8	-	-	100	8.5
Agriculture	-	-	-	-	100.0	-	-	100	0.6
Others	-	-	-	-	-	100	-	100	0.1
Non-Energy	-	-	-	-	-	-	0.3	100	0.3
Total									296.1

Source: WECS, 1997.

In domestic sector, a major portion of energy is used for cooking purpose. About 68 per cent population relied on firewood for meeting their energy demand for meeting cooking energy requirements whereas about 25 per cent of the total population relied on animal waste and agriculture residue. Kerosene was the principal fuel used for cooking in urban areas. More than 70 per cent population in urban Nepal was relying on kerosene for meeting their cooking energy requirements. About 70 per cent of the Kathmandu Valley residence used kerosene for cooking purpose. Use of LPG has been increasing in the Kathmandu Valley for meeting the cooking energy requirements of the urban resident. Table 2.9 shows the percentage of population using different types of fuels for meeting their cooking energy requirements.

Table 2.9: Main Fuel Used for Cooking (Percentage of Population)

Area	Wood	Animal Waste and Agriculture Residue	Gas (LPG)	Kerosene	Others[3]	Total
Nepal	67.74	25.82	0.99	4.62	0.83	100
Urban	31.34	13.71	10.84	70.21	2.12	100
Rural	70.60	26.77	0.21	3.55	0.73	100
Kathmandu	2.37	5.26	20.83	70.21	1.33	100

Source: CBS, 1996a.

There are three major sources for collecting firewood in Nepal. These are: (i) Government Forest, (ii) Community Forest, and (iii) Forest in Individual Land. About 66 per cent population collected firewood from the government forest. Both urban and rural populations were relying heavily on government forest. Community forest did not exist in the Kathmandu Valley. Firewood from individual land supplied about 50 per cent of the total firewood consumed in the Valley. Availability of firewood, almost free of cost in government forest, has triggered the use of forest as a major fuel source in Nepal. Table 2.10 shows the sources for firewood collection in urban and rural areas of the country.

Table 2.10: Places of Firewood Collection (Percentage)

Area	Own Land	Community Forest	Government Forest	Other	Total
Nepal	18.95	11.90	66.06	3.09	100
Urban	22.66	7.54	63.85	5.95	100
Rural	18.90	11.95	66.09	3.06	100
Kathmandu	49.92	0.00	27.56	22.52	100

Source: CBS, 1996a.

Industry sector became the second largest sector behind the domestic sector on consuming a major share of the total energy supplied. Coal and electricity were the principal energy sources used mainly in the industrial sector. Coal supplied about 40 per cent on the total energy consumption in large industries, whereas electricity supplied about 60 per cent in the total energy consumed in small industries. Kerosene has been the principal energy used in traditional industries, where it supplied about 71 per cent of the total energy requirements. Contribution of different energy sources in the large, small and the traditional industries is shown in Table 2.11.

Table 2.11: Energy Consumption in Industrial Sector (GJ)

Fuel Type	Large Industries	Small Industries	Traditional Industries	Total
Coal	2867866	459988	7521	3335105
Electricity	1966404	921748	30159	2918311
Rice Husk	954800	38773	400	993973
Crude Oil	602218	9427	0	611645
Fuelwood	391109	85369	69869	546347
Kerosene	0	0	321889	321889

[3] Others fuels includes electricity, coal/charcoal, biogas and other categories.

Diesel	207793	16337	18076	242206
Bagasse	43240	22786	180	66206
Charcoal	0	0	5067	5067
	7033430	1554428	453161	9040749

Source: DIP Consultancy, 1998.

Lighting and heating were the major energy end uses in traditional industries. In modern -- both small and large -- industries, a major portion of energy was utilized in process heating, operating motive power and boiler, and for lighting purposes. Coal, diesel and bagasse were the principal energy sources used in boiler operation whereas electricity was primarily used in operating motive power. Industrial sector consumed almost all form of energy sources for meeting its lighting and heating energy requirements. Table 2.12 exhibits energy end uses by fuel types in traditional and modern industries in Nepal.

Table 2.12: Energy End Uses By Fuel Types (GJ)

Fuel Type	Traditional	Modern Industries (Large and Small)					Total
	Lighting & Heating	Process Heating	Motive Power	Lighting	Boiler	Total	
Fuelwood	69869	209097			0	209097	278966
Coal	7251	476478			1598729	2075207	2082458
Kerosene	321889	0			0	0	321889
Diesel	18076	208639			20619	229258	247334
Crude Oil	0	611645			0	611645	611645
Bagasse	5676	4728			1578111	1578111	1588485
Rice Husk	400	991662			0	991662	992062
Charcoal	5067	44313			0	44313	49380
Electricity	30159	569600	2677441	153752	0	2888153	2918312
	458387	3116162	2677441	153752	3197459	8627446	9090531

Source: DIP Consultancy, 1998.

Amount of different forms of energy used in industry sector was the highest in Central Development Region in Nepal. As most of the industries were established in Central and Eastern Development Regions, Eastern Development Region became the second largest region on consuming different forms of energy in industry sector. Energy consumption in industry sector on remaining three regions was comparatively lower than those two regions. Table 2.13 shows the amount of energy used in the industry sector region wise.

Table 2.13: Amount of Energy Used In Industrial Sector

Region	Firewood "000"ton	Coal "000"ton	Diesel (kl)	Petrol (kl)	Kerosene (kl)	Electricity (10^6 kWh)	
						Purchased	Generated
Eastern	26.3	45.1	5573.2	152.5	2102.9	67.7	2.9
Central	29.8	61.7	12001.1	838.2	5049.8	153.8	4.3
Western	8.8	10.0	2570.1	543.3	1467.8	34.7	4.3
Mid-Western	2.2	3.4	83.8	12.4	777.3	4.4	0.002
Far-Western	3.2	1.2	215.4	1.4	53.8	1.8	0
Total	70.4	121.57	20443.5	1547.8	9451.8	262.5	11.64

Source: CBS. 1998 regional

Domestic and industry sector consumed about two-third of the total electricity supplied in the country. Domestic sector was the largest sector in consuming a major share of electricity supplied up to the year 1990. The latest available information indicated that industry sector has been emerging as a major sector to consume a large share of electricity these days. Electricity consumption on other sectors constituted only one third of the total electricity supplied. Percentage of households with electricity was 80.35 per cent in urban areas and 8.91 per cent in rural areas, whereas in an average 14.13 per cent the households in Nepal had access of electricity (CBS, 1996a). Table 2.14 exhibits the use of electricity in different sectors in Nepal.

Table 2.14: Use of Electricity in Different Sectors in GWh (percentage in parenthesis)

Year	Household	Industry	Commerce	Export	Other	Total
1995/96	333.2 (35.8)	354.6 (38.1)	61.6 (6.6)	66.3 (7.1)	113.9 (12.4)	929.6 (100)
1990/91	261.4 (39)	206.9 (31)	36.6 (5.5)	80.6 (12)	83.8 (12.5)	669.3 (100)
1985/86	140.6 (41.2)	110.4 (32.3)	19.3 (5.6)	21.5 (6.3)	49.6 (14.7)	341.4 (100)

Source: MOF, 1998.

A major share of petroleum products was utilized in transport and industry sector. About 70 per cent of the total petroleum products consumed in Nepal were utilized in Kathmandu Valley. Kerosene was primarily used in industry and household sector in urban areas. Among the petroleum products, consumption of high-speed diesel (HSD) and kerosene had a major share, whereas gasoline and aviation fuels had little share on petroleum products' consumption. The consumption of LPG has increased remarkably since the last three years in Nepal. Most of the urban centers consumed LPG mainly for cooking. There are about 100 LPG run Tuk-tuks operating in the Kathmandu Valley. A small share of LPG is, hence, consumed in the transport sector in the Kathmandu Valley these days. In rural areas, use of petroleum products is limited. Table 2.15 illustrates the consumption of petroleum products in the last 20 years period in the country.

Table 2.15: Petroleum Fuel Consumption in Nepal (10^3 kl)

Year	MS	HSD	SKO	LDO	Aviation Fuel	Fuel Oil	LPG	Total
1997/98	44.71	257.91	243.81	1.98	47.86	17.29	21.82	635.38
1996/97	41.12	250.50	208.50	4.45	40.62	18.29	18.60	582.08
1995/96	34.98	226.62	180.9	3.79	37.52	32.00	13.05	528.86
1994/95	31.06	195.69	162.16	1.53	30.65	27.32	9.3	457.71
1993/94	28.96	177.27	143.59	1.65	28.74	20.22	7.8	408.23
1992/93	28.3	156.9	131.1	0.3	28.1	20.3	0	365.00
1991/92	26.22	145.70	117.56	2.54	24.29	11.06	10.57	337.96
1990/91	24.6	135.6	97.7	3.0	19.0	6.3	7.6	293.68
1989/90	17.9	98.9	86.28		9.16			212.30
1988/89	20.4	90.13	82.04	7.27	22.36	7.34	4.72	234.29
1987/88	22.5	85.75	68.33	6.91	25.07	7.97	4.30	220.88
1986/87	20.3	87.23	71.25	7.53	24.91	14.27	3.52	228.76
1985/86	20.4	80.4	62.2	8.3	23.2	15.8	2.6	212.80
1984/85	18.4	75.92	53.48	7.98	24.24	9.26	2.03	191.34
1983/84	17.27	65.32	45.66	7.29	23.23	6.72	1.63	167.13
1982/83	15.44	62.02	35.62	6.59	19.76	6.08	1.31	146.83
1981/82	13.46	52.07	33.58	7.78	19.37	3.44	1.03	130.74
1980/81	11.5	57.3	37.8	10.3	16.8	3.0	0.7	137.4
1979/80	12.6	47.14	37.15	8.33	16.39	3.13	0.65	125.39
1978/79	11.11	48.59	34.53	9.10	15.09	1.98	1.19	121.59
1977/78	11.09	36.59	32.31	9.73	13.33	0.99	1.13	105.17
1976/77	11.45	35.91	32.90	9.07	12.11	1.07	0.78	103.29
1975/76	10.5	30.8	32.2	9.4	11.2	1.8	0.6	96.5
1974/75	10.23	27.11	33.24	9.43	9.23	0.508	0.398	90.146
1973/74	11.26	20.14	29.15	10.15	6.16	0.75	0.26	77.87

Source: NOC in Leaders, 1998

2.4 Energy Consumption in Kathmandu Valley

Kathmandu Valley has the largest human settlements in the country. It, alone, consumed a large share of commercial energies. Kerosene was the main fuel used for cooking in the Valley. In national context, use of LPG on household sector was the highest in the Valley. Firewood was extensively used in rural households and its consumption was 40.0 thousand tons in 1984/85 (Devkota, 1992), whereas the amount decreased to 20.0 thousand tons in 1989/90 (Sharma, 1997). These days, use of kerosene and LPG has lowered the firewood consumption from the Valley. Kathmandu had a largest number of vehicles and hence use of petroleum products was also high. In an average, about 70 per cent of the total petroleum products were consumed in Kathmandu Valley. Table 2.16 shows the amount of petroleum products consumed in the Valley.

Table 2.16: Consumption of Petroleum Products in Valley ("000" kl)

Year	1991/92	1992/1993	Nepal total 1994
Petrol	10.555	11.098	31.056
Diesel	18.818	21.825	196.047
Kerosene	34.745	34.600	162.077
Aviation Fuel	20.645	23.975	30.250
Furnace Oil	5.410	1.320	27.319

Source: Sharma, 1997.

Vehicular emission is dependent on specific fuel consumption, and distance covered by the vehicle. Traffic congestion, a poor state of vehicle maintenance and uneven driving conditions are some of the reasons behind low vehicular specific fuel consumption. Most of the vehicles, operating on passenger services; such as bus, minibus, three-wheeler and taxi have fuel consumption lower than that of the vehicles owned and operating on individual modes. In an average, bus consumed 3.5 liter and minibus 4.3 liter to cover a distance of one kilometer. Two-wheelers had the highest specific fuel consumption in an average -- 45.4 kilometer per liter -- compared to other vehicles. Table 2.17 exhibits the specific fuel consumption of different vehicle types in the Kathmandu Valley.

Table 2.17: Specific Fuel Consumption of Vehicles in Kathmandu Valley

Vehicle Type	Specific Fuel Consumption (km/liter)		
	Minimum	Maximum	Weighted Average
Bus	3	5	3.5
Jeep	6	20	13.4
Truck	3	10	5
Minibus	3	5	4.3
Three-wheeler (P)	10	20	15
Taxi	8	20	13.6
Car	11	20	15.5
Motorcycle	30	65	45.4
Tractor	3	8	5.7
Three-wheeler (D)	6	16	11.2

Source: Adhikari, 1997.

Kathmandu Valley housed a large number of industries. The major industries in the Valley include a large number of brick kilns and Himal cement factory. Brick kilns used various type of fuels. In addition to fuelwood, rice husks, agricultural residues, sawdust, coal of varying types and grades and oil cake were used to fire bricks. Scrap tyre was also extensively used in brick kilns in the Valley. Brick kilns produced about 83.2 % of the total brick and used about 12.61

2.4 Energy Consumption in Kathmandu Valley

Kathmandu Valley has the largest human settlements in the country. It, alone, consumed a large share of commercial energies. Kerosene was the main fuel used for cooking in the Valley. In national context, use of LPG on household sector was the highest in the Valley. Firewood was extensively used in rural households and its consumption was 40.0 thousand tons in 1984/85 (Devkota, 1992), whereas the amount decreased to 20.0 thousand tons in 1989/90 (Sharma, 1997). These days, use of kerosene and LPG has lowered the firewood consumption from the Valley. Kathmandu had a largest number of vehicles and hence use of petroleum products was also high. In an average, about 70 per cent of the total petroleum products were consumed in Kathmandu Valley. Table 2.16 shows the amount of petroleum products consumed in the Valley.

Table 2.16: Consumption of Petroleum Products in Valley ("000" kl)

Year	1991/92	1992/1993	Nepal total 1994
Petrol	10.555	11.098	31.056
Diesel	18.818	21.825	196.047
Kerosene	34.745	34.600	162.077
Aviation Fuel	20.645	23.975	30.250
Furnace Oil	5.410	1.320	27.319

Source: Sharma, 1997.

Vehicular emission is dependent on specific fuel consumption, and distance covered by the vehicle. Traffic congestion, a poor state of vehicle maintenance and uneven driving conditions are some of the reasons behind low vehicular specific fuel consumption. Most of the vehicles, operating on passenger services; such as bus, minibus, three-wheeler and taxi have fuel consumption lower than that of the vehicles owned and operating on individual modes. In an average, bus consumed 3.5 liter and minibus 4.3 liter to cover a distance of one kilometer. Two-wheelers had the highest specific fuel consumption in an average -- 45.4 kilometer per liter -- compared to other vehicles. Table 2.17 exhibits the specific fuel consumption of different vehicle types in the Kathmandu Valley.

Table 2.17: Specific Fuel Consumption of Vehicles in Kathmandu Valley

Vehicle Type	Specific Fuel Consumption (km/liter)		
	Minimum	Maximum	Weighted Average
Bus	3	5	3.5
Jeep	6	20	13.4
Truck	3	10	5
Minibus	3	5	4.3
Three-wheeler (P)	10	20	15
Taxi	8	20	13.6
Car	11	20	15.5
Motorcycle	30	65	45.4
Tractor	3	8	5.7
Three-wheeler (D)	6	16	11.2

Source: Adhikari, 1997.

Kathmandu Valley housed a large number of industries. The major industries in the Valley include a large number of brick kilns and Himal cement factory. Brick kilns used various type of fuels. In addition to fuelwood, rice husks, agricultural residues, sawdust, coal of varying types and grades and oil cake were used to fire bricks. Scrap tyre was also extensively used in brick kilns in the Valley. Brick kilns produced about 83.2 % of the total brick and used about 12.61

thousand tons of fuelwood and 46.02 thousand tons of coal in a year (ENPHO, 1993b). A few studies were conducted to estimate the fuel consumption in brick industries in the Valley. Air pollution problems resulting from the industrial operations in the Valley is largely determined from the brick manufacturing process and the types of energy used. Mostly low grade fuels and inefficient energy technologies were used in brick kilns in the Valley. Table 2.18 exhibits the findings of different studies on types and amount of different form of fuels used in brick manufacturing in the Valley.

Table 2.18: Fuel Consumption Pattern in Brick Industries in Valley

Source	Year	Fuel wood	Rice Husk	Saw Dust	Lignite	Coal	Fruit Seed and Other	Tyre
Industrial energy survey	1986	49 %	-	-	-	50 %+	-	-
B. Basnet	1991	32 %	10 %	-	-	58 %	-	-
Pricing Study	1992	9 %	19 %	-	-	72 %	-	-
HUDEC/GTZ	1992	-	3 %	11 %	11 %	54.8 %	19.9 %	0.3
NESS	1994	-	21 %	4 %	1 %	65 %	8.95 %	0.05

Source: NESS (1995) in Tuladhar, 1996

Brick kilns, which used about 70 per cent of the Valley's total coal supply, contributed remarkably in air pollution problems in the Valley. Only remaining 30 per cent coal was used in other industrial operation. Coal consumption in the Valley was about 3.3 thousand tons in 1970, whereas it increased to 54.80 thousand tons in 1994 (Sharma, 1997). Coal consumption in brick and cement industries was reported in the studies of Sharma (1997), Devkota (1992) and NESS (1995). Table 2.19 exhibits the findings of the information on coal consumption in brick and cement industries in the Valley.

Table 2.19: Coal Used in Brick and Cement Industries (ton)

Year	Bull Trench kilns	Hoffman kiln	Himal Cement
1994	54,800		
1993	43,800		
1992/93	21,000	4,100	17,100
1990/91		2,440	7,980
1985/86		2,200	5,860
1980/81		1,690	6,400
1975/76		2,950	
1970/71		3,300	

Source: Sharma, 1997, Devkota, 1992, NESS, 1995.

2.5 Improved Cook Stove Program

The first Improved Cooking Stoves (ICS) were introduced in the 1950s in Nepal. Up to date, a total of about 88,000 ICS have been installed through out the country with the involvement of government, donors, and non-government organizations. Despite more than forty years of ICS program, it has been of limited success in Nepal. His Majesty's Government of Nepal, however, planned to extent its ICS training, exhibition, and development program to 45 districts of Nepal in the running ninth five-year plan period (NPC, 1998). The Royal Danish Government has already signed an agreement to support His Majesty's Government of Nepal on energy sector assistance program (ESAP), on which Improved Cooking Stoves is one of the major project components.

2.6 Industrialization in Nepal

Biratnagar Jute Mills, which was established in 1936, was the first modern industry in Nepal. A total number of 267 manufacturing industries were established up to 1964/65. By the year 1994/95, the number was estimated to have reached 4487 (Bastola, 1998). The recent census, however, revealed that the number of manufacturing industrial establishments was 3557 in Nepal. The pace of industrial development has been slow in Nepal. The overall annual growth rate of manufacturing establishments was 8.42 per cent from 1964 to 1996 in the country. The highest growth rate was observed during the year from 1986 to 1991, whereas the negative growth rate was observed during the period of 1991 to 1996. The number of manufacturing establishments decreased by 714 from the previous census of 1991/92 to the latest census conducted in 1995. Table 2.20 exhibits the number of manufacturing establishments and its growth rate in Nepal.

Table 2.20: Number of Manufacturing Establishments in Nepal

Census Year	Number of Establishments	Growth Rate (%)
1996/97	3557	-3.5
1991/92	4271	15.71
1986/87	2054	17.1
1981/82	971	5.78
1976/77	733	10.7
1972/73	488	7.8
1964/65	267	-
Annual average growth rate for 1964/65 to 1996/97		8.42

Source: CBS, 1998c and Previous Censuses

The number of employees that engaged on manufacturing sector was 187,316 that was 1.7 per cent of economically active population in national context (CBS, 1992). The Central Development Region was the most prominent in manufacturing activities with concentration of 56.76 per cent, whereas the Far-western Region shared only 3.74 per cent of the total manufacturing establishments. Kathmandu ranked first with 24.99 per cent of the total manufacturing establishment, and which contributed 26.44 per cent of the census value added and 33.42 per cent of the employment in manufacturing sector. There were altogether 174 manufacturing establishments engaging 200 or more people and all together 72 establishments having the fixed assets of more than 50 million rupees in the country. A total of 97.55 per cent manufacturing establishments were privately owned and 1.01 per cent owned by the government. Carpets and Rugs had significant share considering all indicators, such as employment, export, manufacturing sector value-added etc. These groups of industries provided 28.15 per cent employment and contributed 17 per cent of the total census value added. As compared to the previous census, number of carpet and rugs, garments, bricks, distilleries and printing establishments decreased considerably in Nepal.

About 70 per cent of manufacturing establishments were concentrated in 10 districts, whereas the remaining 30 per cent in 65 districts in Nepal. Kathmandu Valley accommodated 36.7 per cent of the total manufacturing establishments. Most of the industries were concentrated in the Central and the Eastern Development Regions of the country. Table 2.21 exhibits the number of manufacturing establishments in ten major districts. Nepal Standard Industrial Classification (NSIC) is shown in Annex-1.

Table 2.21: Number of Establishment in Major Districts of Nepal

NSIC	Banke	Rupandehi	Bara	Kathmandu	Lalitpur	Bhaktapur	Sunsari	Morang	Parsa	Kaski	Total
15	27	64	22	73	16	3	79	61	22	35	417
16	2	0	10	0	0	0	0	3	2	0	33
17	2	12	8	474	124	39	15	19	25	9	744
18	0	1	0	100	11	5	1	9	2	1	148
19	0	14	5	7	2	1	4	7	27	1	87
20	7	11	1	13	19	2	8	7	2	9	99
21	0	6	2	16	5	1	5	8	8	3	75
22	0	1	0	46	8	0	2	7	2	3	91
23	0	0	2	0	0	0	0	1	0	1	27
24	3	2	9	13	6	5	9	16	14	2	103
25	3	11	6	28	19	3	12	34	14	6	161
26	43	37	16	36	53	31	23	17	15	0	297
27	1	3	8	0	2	0	3	3	0	13	60
28	6	22	9	33	32	4	10	8	12	0	164
29	0	3	0	2	6	0	5	2	0	0	47
31	0	3	1	5	1	0	2	11	3	2	59
32	0	0	0	2	1	1	0	0	1	0	37
34	0	0	0	0	0	0	0	1	4	0	39
36	5	14	0	41	47	2	15	23	4	30	217
	99	204	99	889	352	97	193	237	157	115	2442

Source: CBS. 1997

DIP Consult (1998), in its latest study report conducted for Water and Energy Commission Secretariat (WECS), showed that the total number of industry was 19713 in 1995/96 in Nepal. which included the large, small and traditional industries. There were all together 8160 small industries and 6649 traditional industries reported in the study. Table 2.22 shows the total number of large, small and traditional industries in the country in 1995/96, as indicated in the study report.

Table 2.22: Number of Industries in Nepal 1995/96

Region	Large Industries	Small Industries	Traditional Industries	Total
Eastern	1227	2095	1929	5251
Central	2655	3290	2526	8471
Western	636	1716	1197	3549
Mid-Western	242	748	665	1655
Far-Western	144	311	332	787
Total	4904	8160	6649	19713

Source: DIP Consultancy, 1998

This table indicates that the Central and the Eastern Development Regions had the largest and the second largest share of both small and traditional industries. The Mid-Western and the Far Western Development Regions had relatively a fewer number of industrial establishments.

A majority of pollution prone industrial plants were located in nine districts of three zones (Bastola, 1998a): (i) Bagmati (ii) Koshi, and (iii) Narayani. Cement, leather and tanning, paper and pulp, soap and chemicals, sugar and khandsari, and textile industries fell into the high priority categories in the pollution point of view. Cement, brick, quarrying, and those industries which need boiler and kiln operation are prone to air pollution. It can be concluded that industrial establishments are concentrated in certain areas in Nepal and hence industry related air pollution issues are also confined into the certain areas or localities.

2.7 Major Industries in the Kathmandu Valley

The industrial census of 1996 showed that Kathmandu Valley accommodated 37.7 per cent and Kathmandu district alone accommodated about 25 per cent of the total manufacturing establishments in Nepal. Brick kilns, cement and marble factories were the major air polluting industries in the Valley. Brick kilns were diverse in nature ranging from very small, manually operated and seasonal (Clamp kiln) to very large semi-mechanized units (Hoffmann kiln) with a round year operation (ENPHO, 1993b). There were only 120 brick kilns before 1985 in the Valley. ENHPO (1993) revealed that the number of registered, and unregistered brick kilns were 202 and 103 in the Valley respectively. Brick kilns were formerly located in all three districts of the Valley -- Kathmandu, Lalitpur and Bhaktapur. Now a few kilns remain in Kathmandu district and a majority of these kilns are concentrated in Lalitpur and Bhaktapur districts. Out of a total of 179 operational brick kilns in 1994, 172 were Bull's Trench kiln type. Among the remaining, six were semi mechanized Hoffmann's kilns and one Vertical Shaft kilns. It showed that nearly 96 % of the brick manufacturing industries in the Valley were of Bull's Trench kiln type. Between 1981 and 1994 Bull's Trench kiln showed an overall growth of 30 per cent, whereas the number of other brick kilns remained stagnant in that period (Sharma et al., 1995). In the same period, Bull's Trench brick kilns showed a decline in number in Kathmandu district whereas Lalitpur and Bhaktapur districts experienced a positive growth rate. More significantly, Bull's Trench kilns grew five fold in Bhaktapur district compared to 0.6 times in Lalitpur district in the same period (Sharma et al., 1995). This showed that these kilns were shifting from Kathmandu and Lalitpur to Bhaktapur in recent years.

Kathmandu Valley has three industrial estates: (i) Balaju Industrial District in Kathmandu district (ii) Patan Industrial District in Lalitpur district, and (iii) Bhaktapur Industrial District in Bhaktapur district. Balaju Industrial District had all together 78 industries on which only 64 were operating. Likewise, Patan and Bhaktapur Industrial District had 99 and 27 industries, on which 95 and 22 were operating respectively (Tuladhar, 1996). Brick kilns and Himal Cement Factory are the main industries that pose threats on polluting air in the Kathmandu Valley. Other industries operating on these industrial districts are not so prone to air pollution.

2.8 Urbanization

2.8.1 Population Growth

The first census was conducted in year 1911 in Nepal and population was 5.6 million. After eighty years of the first census conducted, the population of the country reached to 18.5 million, which indicated an annual growth rate of 1.52 per cent per year in eighty years period. Population growth was the highest during 1971-1981, when it was 2.66 per cent per year. Population growth rate, however, decreased slightly in the period of 1981-1991 and was 2.11 per cent per year. Considering the same growth rate experienced in the last decade, the country will have the population of about 22 million in year 2000. Table 2.23 shows the population and population growth rates in different periods in Nepal.

Table 2.23: Population Size and Growth Rates of Nepal

Census Year	Population (million)	Annual Growth Rate %
1991	18.5	2.11
1981	15.0	2.66
1971	11.6	2.12
1961	9.4	1.7
1941	6.3	1.36
1930	5.5	- 0.18
1920	5.6	0
1911	5.6	-
1952/54	8.3	2.30

Source: Sharma and Kayastha, 1998.

Out of the total national population of 9.4 million, the urban population was 0.336 million in 1961, which was 3.6 per cent of the total population. Urban population increased at the rate of 3.18 per cent per year during 1961-1971, 7.28 per cent during 1971-81 and 8.71 per cent per year during 1981-1991. The urban population was 2.28 million in 1991, which represented the 12.32 per cent of the total national population. Population of the Kathmandu Valley increased from 0.25 million in 1971 to 0.662 million in 1991. The growth rate of Valley population was about 6.0 per cent, which is higher as compared to national average growth rate of 2.11 per cent per year. Behind Kathmandu Valley, some town and urban centers like Bharatpur and Hetauda attracted most of the rural population from the hills. A few new settlements have developed mostly in Siwalik and Terai regions of the country. Table 2.24 shows the urbanization characteristics of the country.

Table 2.24: Characteristics of Urbanization in Nepal

	1961	1971	1981	1991
Urban Population	0.336	0.462	0.956	2.28
Urban Population Growth Rate		3.18	7.28	8.71
Population of Kathmandu Valley		0.25	0.363	0.662
Population Growth Rate of Kathmandu Valley			3.8	5.01

Source: Sharma and Kayastha, 1998.

Besides Kathmandu Valley; Pokhara, Birgunj and Biratnagar were among the fast growing urban centers in Nepal. During 1971-1981, Birgunj experienced the highest growth rate of 12.88 per cent per year. Pokhara also experienced a higher growth rate of 8.51 per cent surpassing growth rate of the Kathmandu district. Average growth rate during the 1971-1981 was higher than the growth rate experienced during 1981-1991 in major urban centers in Nepal. Pokhara had a growth rate of 7.41 per cent year during 1981-1991, when Kathmandu Valley experienced a growth rate of 5.83 per cent. Though the Kathmandu Valley had the largest absolute population, population growth rate was not the highest among the other urban centers. Table 2.25 exhibits the population and population growth rate in some of the major urban centers in Nepal.

Table 2.25 : Population Growth Rate in Urban Areas 1981-1991

Town/City	1952/54	1961	1971	1981	1991	G.R.1971-81	G.R.1981/91
Pokhara	3.178	5.413	20.611	46.642	95.311	8.51	7.41
Kathmandu				325.160	414.264	4.57	5.83
Lalitpur				79.875	117.203	3.07	3.99
Bhaktapur				48.472	61.122	1.91	2.35
Kathmandu	106579	121019	150402	363.507	592.589	3.83	5.01
Nepalgunj				34.015	48.656	3.76	3.64
Birgunj				43.642	68.764	12.88	4.65

Biratnagar	8.060	35.355	45.100	93.544	130.129	7.57	3.36

Source: CEDA, 1989 and CBS. 1992

Considering the present growth rate of Kathmandu Valley districts, population of Kathmandu district will be around 1.11 million and 1.26 million in 2006 and 2011 respectively. There will be around 1.5 million, 1.7 million and 1.9 million population in year 2001, 2006 and 2011 in Kathmandu Valley respectively. Table 2.26 shows the projected population of Kathmandu Valley and Valley districts.

Table 2.26: Projected Population of Kathmandu Valley

Year	Kathmandu	Bhaktapur	Lalitpur	Valley Total
2001	963,242	220,071	336,661	1,519,974
2006	1,114,538	244,890	378,005	1,737,433
2011	1,266,211	270,823	420,250	1,957,284

Source: CBS, 1996d

2.8.2 Transport Growth

Transport sector is one of the largest sectors for contributing the air pollutants especially in urban areas. Except air and road transport, other modes of transport almost do not exist in Nepal. Growth in road transport vehicles was uneven in the past. A large number of vehicles are concentrated in a number of urban cities. Bus, minibus, taxi and three-wheeler are used in passenger services, whereas a large number of cars and two-wheelers are operating as an individual transport vehicle. Trucks are used in goods vehicles especially for inter-city goods transport, but smaller trucks, tractors, and power tillers are used extensively in goods transport inside city areas.

There were total 218,632 vehicles registered up to October 1998 in Nepal. Kathmandu Valley occupied about 56 per cent of the total vehicles registered in Nepal. It is not precisely known in Nepal that what percentage of registered vehicles is actually being operated. Vehicle scrapping rate is not known yet. There exist no rules and regulations governing the vehicle phase-out program. A large number of second hand vehicles were also registered mainly in passenger services. Most of the minibus registered during the seventies and eighties in Nepal for operating in passenger services were out dated and second hand vehicles imported from abroad. Car and two-wheelers have been dominating the total vehicle fleet in Nepal and comprised about 22 and 51 per cent on the total vehicle fleets respectively. Growth rate of two-wheeler and bus was relatively higher among the other vehicles. Two-wheeler had a growth rate of 16.95 per cent per year and bus had almost similar growth rate during the period 1990-97. Table 2.27 shows the growth rate of automobiles by types in the period of 1990 – 1997 in Nepal.

Table 2.27: Growth of Automobiles by Types (1990-1997)

S.No	Types	Share in Total (%)	Growth Rate (%/year)
1	Bus	3.71	16.10
2	Mini-bus	1.28	7.57
3	Truck/Tanker/Dozer/Crane	9.01	12.00
4	Car/Jeep/Van	22.44	9.85
5	Three wheeler	2.72	11.90
6	Two wheeler	51.40	16.95
7	Tractor	7.56	12.90
8	Other	1.88	9.72
Total		100.00	14.22

Source: Ghimire (1998)

About 71 per cent of the vehicles registered in Nepal were registered as private vehicles. Commercial vehicles had the second largest share on vehicle ownership. Vehicles registered in tourist, government, corporation and other groups comprised only about 10 per cent in the country. However, vehicle growth rate was the highest in tourist vehicle category during the year 1990-91. Vehicles registered in private categories were increased at a rate of 15.90 per cent per year during the same period in Nepal. In this decade, overall vehicle growth was 14.22 per cent per year in Nepal. Table 2.28 indicates the share of vehicle ownership by their types and growth rates.

Table 2.28 : Ownership of Vehicles and their growth rates (1990-1997)

S. N	Types	Share in Total (%)	Growth Rate (%/year)
1	Tourist	0.14	33.25
2	Government	6.65	4.47
3	Corporation	2.55	6.16
4	Private	70.63	15.90
5	Commercial	18.12	13.01
6	CD/UN	1.92	10.00
Total		100.00	14.22

Source: Ghimire (1998)

Vehicle per thousand populations was the lowest in the Far- western Development Region of the country, where a population of one thousand people owned just 1.3 car on an average. Vehicle ownership was the highest in the Central Development Region, where one thousand people owned about 20 vehicles. However, Nepal has one of the lowest vehicle ownership ratios among the developing countries. In an average, ratio of vehicles per thousand populations was 8.6 in the country. The Central Development Region had a highest share of vehicles, which accounted more than 76 per cent vehicles registered in the country. The Western and the Eastern Development Regions each had nearly 10 per cent of the total vehicles registered in Nepal. The Far-western Development Region had the lowest share of vehicles in the country. Only 1.43 per cent of the vehicles was registered in the Far-western Region of the country. Annual growth rates of vehicles in all development regions were, however, nearly close to the national vehicle growth rate of 7.58 per cent per year. Among the five development regions, Western Development Region experienced the highest vehicles' growth rate. Table 2.29 shows the share of vehicle ownership, vehicle growth rate and vehicle ownership ratio by development regions.

Table 2.29: Share of Vehicle Ownership by Development Regions as of mid July 1997

S. N	Development Region	Share in Total (%)	Growth Rate (%/year)	Vehicle/000 population
1	Eastern	8.89	9.87	3.2
2	Central	76.08	6.92	19.3
3	Western	10.98	10.43	4.6
4	Mid Western	2.62	8.84	1.7
5	Far Western	1.43	8.38	1.3
	Total	100	7.58	8.6

Source: Ghimire (1998)

Out of 14 Zones of the country, Bagmati Zone had the maximum share on the number of registered vehicles. Bagmati Zone, which comprises the Kathmandu Valley, had 57.42 per cent of vehicles registered in Nepal. Share of vehicles in Mechi, Sagarmatha, Janakpur, Gandaki, Rapti, Bheri, Seti and Mahakali was less than five per cent of the total registered vehicles, while two Zones -- Dhawalagiri and Karnali -- had no office to register vehicles because of insufficient road networks to run the vehicles. Narayani Zone had the second largest share of registered vehicles in Nepal. Zonal wise, Gandaki and Koshi had the highest vehicle growth rate. Table 2.30 illustrates the vehicle ownership, share on total vehicle and growth rate by Zone.

Table 2.30: Vehicle Ownership by Zones (1993-1997)

S. N	Zone	Share in Total (%)	Growth Rate (%/year)	Vehicle/000 population
1	Mechi	1.38	9.20	2.0
2	Koshi	6.40	11.15	5.9
3	Sagarmatha	1.11	4.77	1.1
4	Janakpur	2.21	7.09	1.7
5	Narayani	16.45	9.93	13.7
6	Bagmati	57.42	6.16	39.9
7	Gandaki	4.53	11.52	5.8
8	Lumbini	6.46	9.71	5.0
9	Rapti	0.49	5.99	0.8
10	Bheri	2.13	9.59	3.0
11	Seti	0.89	9.19	1.4
12	Mahakali	0.54	7.15	1.3
		100.00	7.58	8.6

Source: Ghimire (1998)

A detail of vehicle numbers by ownership and type is presented in Annex-2 for Nepal and in Annex-3 for the Bagmati zone.

2.8.3 Road Network

Compared to the number of vehicles and their growth rates, road networks have not been extended considerably in Nepal. Out of the total 10724 km road network, 33 per cent was black topped, 25 per cent graveled and remaining 42 per cent was earthen. These figures indicated that only one third of the road was in good condition in Nepal. The total length of the road network in the Kathmandu Valley is 943 kilometer irrespective of over one hundred thousand registered vehicles. Insufficient road networks and a poor state of road condition affect vehicle movements adversely resulting a higher vehicular emissions. Since Nepal has insufficient and sub-standard road network, transport or vehicle related air pollution problems are related not only with the types and condition of vehicles but also with the infrastructure to accommodate them properly. Table 2.31 illustrates the road status in Kathmandu Valley and major districts in Nepal.

Table 2.31: Road Status in Valley and Major Districts in Nepal –1995 (km)

District	Major Urban Center	Road Type			Total
		Black Topped	Graveled	Earthen	
Kathmandu	Kathmandu	299	144	85	528
Lalitpur	Patan	84	48	158	290
Bhaktapur	Bhaktapur	59	50	16	125
Sunsari	Biratnagar	117	100	74	291
Dhanusha	Janakpur	84	68	90	242
Kaski	Pokhara	183	11	70	264
Banke	Nepalgunj	151	43	101	295
	Nepal	3533	2662	4529	10724

Source: Ghimire, 1998

About 36 per cent of the total road of Nepal lied in the Central Development Region whereas the Far-western Development Region had the shortest road network. The Central Development Region had the maximum traffic density in Nepal, which was even not that high in comparison to other developing countries. The average traffic density of the country was 13.83 vehicles per kilometer of road. These facts clearly indicated that the vehicular pollution was largely due to the concentration of vehicles at a few urban centers and insufficient road network on particular urban centers. A large numbers of old vehicle and a poor state of vehicular maintenance were a few but the most pertinent reasons for high vehicular related air pollution in urban areas. Table 2.32 depicts the traffic density by development region and zone in year 1995 in Nepal.

Table 2.32: Traffic Density by Development Regions and Zones -1995

Region	Zone	Total Road Length (km)	Registered Vehicles (No.)	Traffic Density /km of Road
Eastern		2523	12299	4.87
	Mechi	1000	1997	2.00
	Koshi	922	8582	9.31
	Sagarmatha	601	1720	2.86
Central		3831	115336	30.11
	Janakpur	872	3273	3.75
	Bagmati	1737	88661	51.04
	Narayani	1222	23402	19.15
Western		1899	14993	7.90
	Gandaki	706	6403	9.07
	Lumbini	1193	8590	7.20
Mid-Western		1456	3656	2.51
	Rapti	639	770	1.21
	Bheri	817	2886	3.53
Far-Western		987	2067	2.09
	Seti	533	1264	2.37
	Mahakali	454	803	1.77
Total		10724	148351	13.83

Source: Ghimire (1998)

2.9 Transport Characteristics in the Kathmandu Valley

The Kathmandu Valley is one of the largest urban centers in Nepal. Air quality of certain core airsheds has deteriorated considerably in heavy traffic areas in the Valley. A large number of vehicles and their movements have caused considerable adverse impacts on air quality in the Valley. Air quality has also been significantly affected by industrial dusts especially coming out from the cement and brick factories. Kathmandu Valley has relatively a large number of vehicles, and insufficient road networks especially in the city core areas where traffic density is high. Vehicular emissions are dependent on vehicle age, running duration, load factor, vehicle speed and types of fuel used.

The Kathmandu Valley has not only a large number of vehicles but also old vehicles in her fleet. Average age of the buses running in the Valley was nine years. Vehicles operating on passenger services such as bus, minibus, and three-wheeler were older compared to vehicles operating on individual modes. Cars and motorcycles were relatively new compared to passenger vehicles. Poorly maintained old vehicles emit a large amount of pollutants into the atmosphere. Average age of three-wheelers, which are considered among the high polluting vehicles' category, was eight years and a large number of three-wheelers were ever older than ten years in the Valley. Since heavy trucks were not allowed to enter inside the Ringroad, a large number of tractors and power tillers were used in goods transport in the Valley. The average age of the tractor was 14 years. Table 2.33 shows the average age of the vehicles operating in the Valley.

Table 2.33: Vehicle Age in Kathmandu Valley

Vehicle Type	Age (Year)		
	Minimum	Maximum	Weighted Average
Bus	1	20	9
Car	1	10	4
Jeep	1	5	2
Minibus	2	22	11
Motorcycle	0.5	10	3
Taxi	1	26	6
Three-wheeler (D)	5	10	8
Three-wheeler (P)	2	14	8
Tractor	12	15	14
Truck	2	15	5

Source: Adhikari, 1997.

There were significant deviations in designed load factor and actual load being carried by the vehicles in the Valley. The average designed load factor for the buses was 45 passengers per trip, but an average 49 passenger were carried by the buses. Similarly, the average designed capacity of the minibus was 30 passengers per trip, but in actual practice, the minibus was transporting 37 passengers per trip. Vehicles operating on the passenger services seem to be over-loaded visibly in traffic hours. No vehicles moved unless these were completely occupied. Standing capacity has been increased in almost all minibuses to accommodate a larger number of passengers. Table 2.34 shows the designed and actual load factor of the vehicles operating in the Kathmandu Valley.

Table 2.34: Load Factor of Passenger Vehicle

Vehicle Type	Design Passenger Capacity	Actual Passenger per Trip
Bus	45	49
Minibus	30	37
Taxi	4	2.5
Three-wheeler (D)	9	11
Three-wheeler (P)	3	2.2

Source: Adhikari, 1997.

The operating duration varied significantly among the different vehicles in a day and a month. Bus operated in an average ten hours in a day whereas minibus and diesel three-wheelers operated for about seven hours and ten hours per day respectively. Operation hour for the private car was about 1.2 hours on an average in a day. Motorcycle ran about less than one hour per day. Similarly, on an average, vehicles ran between 22 to 27 days in a month. The running duration of the vehicles in the Valley is shown in Table 2.35.

Table 2.35: Running Duration of Vehicles in Kathmandu Valley

Vehicle Type	Running Hours in a Day			Running Days in a Month		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Bus	7	12	10	25	28	27
Car	0.5	2.5	1.2	15	27	23.3
Jeep	1	5	1.5	20	30	26
Minibus	4	10	7	25	30	27.5
Motorcycle	0.5	2	0.92	20	30	27

Taxi	3	12	7	25	30	27.3
Three-wheeler (D)	7	12	10	25	28	26.5
Three-wheeler (P)	5	10	7.5	25	28	26.5
Tractor	4	6	5	25	26	25.5
Truck	1	8	4	10	30	22

Source: Adhikari, 1997.

Vehicle speed is dependent on the road congestion and operating condition of the vehicles. The average speed of buses was 39 kilometers per hour whereas average speeds of jeeps, trucks and minibuses were 53.2, 37.3 and 39 kilometers per hour respectively. The average speed of most of the vehicles lied within the range of 35 to 50 kilometers per hour in the Valley. Table 2.36 exhibits the speed of different vehicles in the Kathmandu Valley. There were some other studies (JICA, 1992 and IF, 1997), which also studied the speed patterns of the vehicles in the Valley. It was mentioned in JICA report that the vehicle speed was in the range of 20 – 50 kilometers per hour in the Kathmandu road condition. IF study report depicted that the speed range of the vehicles was about 20 – 60 kilometer per hour in the Kathmandu. Table 2.36 shows the vehicle speed in Kathmandu Valley.

Table 2.36: Vehicle Speed in Kathmandu Valley (km/hour)

Vehicle Type	Speed (km/hour)		
	Minimum	Maximum	Weighted Average
Bus	30	50	39
Jeep	20	60	53.2
Truck	25	50	37.3
Minibus	30	45	39
Three-wheeler (P)	30	40	36.6
Taxi	25	60	47
Car	25	75	45
Motorcycle	25	60	40.8
Tractor	8	12	10.5
Three-wheeler (D)	30	50	38.2

Source: Adhikari, 1997.

A majority of vehicles were being run either by gasoline or diesel fuel. About 73 per cent vehicles were found to be running on gasoline fuel. Only 26 per cent vehicles were found to be operated on diesel oil in the Valley. Upadhaya (1996) also mentioned that 75 per cent vehicles were operating on gasoline in the Valley. The concentration of the pollutants in engine exhaust varies with the type of fuels used. There are few vehicles, which have more or less no choice on fuel. Heavy vehicles like bus, truck and minibus are mostly powered by diesel, whereas two-wheelers are designed to be powered by gasoline. The cars are of two types depending on the fuels they use. Table 2.37 shows the vehicles by fuel type in the Valley.

Table 2.37: Vehicles By Fuel Type in Kathmandu Valley (%)

Vehicle Type	Fuel Type		
	Gasoline	Unleaded Gasoline	Diesel
Bus	0	0	100
Jeep	68	0	32
Truck	0	0	100
Minibus	0	0	100
Three-wheeler (P)	100	0	0
Taxi	90	0	10
Car	80	0	20

Motorcycle	100	0	0
Tractor	0	0	100
Three-wheeler (D)	0	0	100
Total Vehicle	73.7	0	26.3

Source: Adhikari, 1997

His Majesty's Government of Nepal set emission standards of 65 HSU for diesel vehicles and three per cent carbon monoxide for gasoline vehicles in the Kathmandu Valley in July 1994. In a period of first one year (1994 – 1995), Valley Traffic Police tested 13,918 vehicles, of which 7,367 (52.9 %) met the standard. Similarly in 1995-1996, 6,742 vehicles had undergone emission test, of which only 3,719 (55.2 %) passed the test (Adhikari, 1997). Emission standards were, however, relaxed to 75 HSU for diesel vehicles and 4.5 per cent of carbon monoxide for gasoline vehicles in 1998. In the period of eighteen months from June 1996 to January 1998, Valley Traffic Police tested a total of 59667 vehicles in the Kathmandu Valley, on which 36.5 per cent vehicles were failed the emission test. Vehicles operating on commercial service were found most polluting as indicated by a higher failure rate. Table 2.38 exhibits the number of vehicles undergone emission test and their pass and fail percentage.

Table 2.38: Emission Test Results of Vehicles by Their Ownership (June 1996 - January 1998)

Vehicle Type	Total Tested	Passed Percentage	Failed Percentage
Government	3041	66.0	34.0
Corporation	1242	62.0	38.0
Private	27250	68.0	32.0
Diplomatic	2574	76.5	23.5
Commercial (Taxi)	24198	56.0	44.0
Tourist	1362	67.0	33.0
Total	59667	63.5	36.5

Source: Valley Traffic Police in Bastola, 1998b.

The emission test result showed that diesel three-wheelers and minibuses were among the high polluting vehicles in the Valley. Only one out of seven diesel three-wheelers and one out of five minibus was able to pass the emission test conducted by the Valley Traffic Police. About three-fourth of cars had the emission below the prescribed level. Table 2.39 shows the emission test results of vehicles by their type in the Valley.

Table 2.39: Emission Test Results of Vehicles by Their Types (June 1996 - January 1998)

Vehicle Type	Total Tested	Passed Percentage	Failed Percentage
Car	27138	74	26
Jeep	9219	65	35
Van	6849	61	39
3-wheeler (petrol)	8017	56	44
3-wheeler (diesel)	1628	15	85
Minibus	2307	19.6	80.4
Mini-truck	2168	35	65
Bus	1349	51	49
Truck	985	28	72
Crane	11	73	27
Total	59667	63.5	36.5

Source: Valley Traffic Police in Bastola, 1998b.

Three-wheelers operating on diesel, electricity and LPG are running on the fixed routes for proving the similar type of services in the Kathmandu Valley. Looking into the life cycle cost of the vehicle operation, it is obvious why Vikram tempo (operating on diesel) has become so popular in a short span of time. It cost NRs. 2.91 per kilometer of the distance covered while the Safa tempo (electric three-wheeler) cost NRs. 5.75 for providing the similar services. LPG Tuk-tuk has emerged as a close competitor to the diesel and electric three-wheelers as it cost NRs. 2.97 per kilometer to provide similar services. Likewise, diesel and gasoline car could be a close substitute for each other. Life cycle cost was the highest for the trolley bus. It cost almost double of that of diesel bus. This has become one of the reasons for being stagnant of the expansion of trolley bus services in the Valley. The life cycle cost of the two-wheeler was the lowest in the Valley. Table 2.40 exhibits the life cycle costs of the different operating vehicles in the Valley.

Table 2.40: Life Cycle Cost of the Vehicles in the Valley

Fuel Type	Vehicle Type	Life Cycle Cost (NRs./km)	
		Financial Cost	Economic Cost
Diesel	Bus	9.67	7.62
	Minibus	8.30	6.67
	Car	7.21	3.80
	3-wheeler	2.91	2.15
Gasoline	Car	7.85	3.43
	3-wheeler	4.75	2.43
	2-wheeler	2.30	1.11
Electricity	Trolley	16.20	13.54
	3-wheeler	5.75	5.32
LPG	3-wheeler	2.97	2.89

Source: Adhikari, 1997

2.10 Meteorological Characteristics

Pollutants are emitted from sources and are removed from the atmosphere by sinks. All air pollutants emitted by point and distributed sources are transported, dispersed or concentrated by meteorological and topographical conditions. Concentration of air pollutants is dependent on the amount emitted from the different sources in certain airsheds and further more atmospheric weather and meteorological conditions. The direction and wind speed, temperature distribution, humidity and precipitation are some of the key factors that influence the level of concentration of air pollution.

The Kathmandu Valley lies in the high Air Pollution Potential Zone due to low ventilation coefficient. The percentage occurrence of calm conditions is very high and mixing heights are very low. In addition, the topography of Kathmandu urban zone being of valley characteristics, the dilution capacity is low (Aggrawal, 1993). Pokhara experiences the highest rainfall among the urban centers in the country. Wind speed is clam in comparison to Biratnagar. Pokhara and Kathmandu have similar type of average wind speed. Except in rainy season, natural purification of pollutants seems to be insignificant in Pokhara. Biratnagar has more average wind speed and hence it is likely to have slightly better natural purification of the pollutants. The Meteorological parameters for Kathmandu, Pokhara and Biratnagar are shown in Annex 4.

2.11 Inventory of Air Pollution

Estimation of emission load of air pollutants is not readily available for the urban centers except in the Kathmandu Valley in Nepal. A few past studies estimated the amount of air pollutants released into the atmosphere from the transport and industrial sector. Transport sector has been considered as one of the most prominent sectors for emitting a large amount of air pollutants. Air pollution issues that emerge from the industrial sector were confined to certain industrial areas and, so far, have not caught much attention in Nepal. Environmental issues related to water pollution and effluent discharges were considered more serious than air pollution issues in industrial sector.

2.11.1 Transport Sector

Emission loads from the transport sector were presented in the study report of Dhamala (1983), Sharma and Upadhyaya (1995), Shah and Nagpal (1996), Shrestha and Malla (1996) and Adhikari (1998). Dhamala was first to provide the estimation of emission load from the transport sector in the Kathmandu Valley. It has been mentioned in his report that transport sector emitted annually 22,000 tons of carbon monoxide, 200 tons of oxides of nitrogen, 400 tons of hydrocarbons and 333 tons of sulfur dioxide and particulate matters in the Kathmandu Valley. According to the estimation of Sharma and Upadhyaya (1995), 15 tons of lead was emitted considering daily gasoline consumption of about 70 thousand liters for the study year. It suggested that even if 30 per cent lead particulate matters were retained in the vehicle tailpipe, nearly 10 tons of Pb dusts got its way into the atmosphere of the Valley. According to Shah and Nagpal (1997), transport sector contributed a total of 570 tons of total suspended particulate matter of less than ten micron in size and sulfur dioxide in the range of 82 – 495 tons in 1993 in Kathmandu Valley. Among the vehicles, two-wheeler and truck were found as the main contributors of the particulate matters. Table 2.41 shows the amount of particulate matters and SO_2 emissions from the transport sector in the Kathmandu Valley.

Table 2.41: Total Annual Emissions in Kathmandu Valley- 1993 (tons)

Fuel Type	Vehicle Type	TSP	PM_{10}	SO_2
Gasoline	Cars/Taxis	38.4		
	Three-wheeler	67.5		4.2 – 105
	Two-wheeler	107.5		
Diesel	Jeeps	68.4		
	Minibus	22.5		
	Buses	45.0		78 – 390
	Trucks	114.0		
	Tractors	21.6		
	Three-wheeler	85.8		
Total		570	570	82 - 495

Source: Shah and Nagpal, 1996.

Shrestha and Malla (1996) estimated the annual emission load of the pollutants from the transport sector. It indicated a total of about 36 thousand tons pollutants released into the atmosphere in 1993. Carbon monoxide and hydrocarbons were the major pollutants emitted in a large quantity into the atmosphere of the Kathmandu Valley. Emission of carbon monoxide comprised about 65 per cent of the total vehicular emission load. According to the findings of the study, two-wheelers were the major contributor of the pollutants and contributed about 56 per cent of the total emissions. Likewise, cars and jeeps contributed about 36 per cent of the total pollutants in to the atmosphere. According to Shrestha and Malla, transport sector contributed 23.693 tons of CO, 11024 tons of HC, 1353 tons of NO_x, 475 tons of TSPs and 133 tons of SO_2 in year 1993. Stedman and Ellis (1993), in their summary of findings of "Five Nations Asia Motor Vehicle Sampling Tour", mentioned that Bangkok and Kathmandu were much more like Mexico City in their emissions profile than Seoul and Hongkong. It had been mentioned that the average CO level per vehicle tested in the Kathmandu Valley was the second highest mean CO levels (trailing only behind Mexico City).

The latest estimation for the emission loads was available in Adhikari (1998). This study inferred a slightly different result than that of Shrestha and Malla. Transport sector contributed about 31 thousand tons of pollutants in 1996 from the number of then operating vehicles in Kathmandu Valley. Carbon monoxide (CO) was the major pollutants and constituted about 60 per cent on the total vehicular emissions. There was about 19 thousand tons of CO emitted from the transport sector in the Valley. Other major pollutants were HCs and NO_x. Their contributions on the total emissions were 30 per cent and six per cent respectively. Among the total vehicle registered, there were about 20 per cent diesel vehicles operating in the Valley. Diesel vehicles contributed about 10 per cent of the total vehicular emissions in the Valley. Gasoline vehicles contributed the remaining 90 per cent pollutants. Carbon monoxide and hydrocarbons were the major pollutants released from the gasoline vehicles, where CO was about 68 per cent and HCs about 30 per cent on the total emissions from the gasoline vehicles. There were small traces of other pollutants, such as NO_x, TSPs, SO_2 and Pb emitted by the gasoline vehicles.

Carbon monoxide and HCs constituted 61 per cent and 30 per cent of the total pollutants emission from the transport sector respectively. Total suspended particulate matters constituted about two per cent of the total pollutants emission from the transport sector. Among the vehicles type, motorcycles were the major contributors of HCs, which , alone, contributed more than 80 per cent of HCs. Two-wheelers, cars and taxis were the main source of CO emission. Two-wheelers contributed 39 per cent on the total TSPs emissions. Table 2.42 shows the details of pollutants' emission from the transport sector.

Table 2.42: Vehicle Emissions in the Kathmandu Valley in 1996 (ton)

Fuel	Vehicle	TSPs	CO	HCs	NO_x	SO_2	Pb	Total
Diesel	Truck	34	137	42	148	20		381
	Bus	83	332	102	360	48		926
	Minibus	61	91	51	526	16		745
	Jeep/car	34	118	50	54	15		271
	Tractor	11	27	15	17	5		75
	3-wheeler	59	88	49	509	15		721
	Total	282	794	310	1,614	119		3,118
Gasoline	Taxi	10	3,107	416	135	7	1	3,675
	Car	15	4,601	616	200	10	1	5,444
	3-wheeler	8	890	556	8	2	1	1,465
	2-wheeler	203	9,732	7,704	28	8	1	17,677
	Total	236	18,330	9,292	372	26	4	28,260
Total		518	19,124	9,602	1,986	145	4	31,378

Source: Adhikari, 1998b.

Based on the number of future operating vehicles, Adhikari (1998b) estimated the amount of future emissions from the transport sector in the Valley. It was expected that the transport sector would release 53 thousand tons of pollutants in 2020. Exhaust emission of TSPs was expected to increase by 1.36 per cent. Similarly, CO was expected to increase by 2.5 per cent per year. HCs 1.8 per cent per year, NO_x 0.88 per cent, $S0_2$ 1.65 per cent and Pb 2.9 per cent per year. There would be an overall increase of the level of pollutants at the rate of 2.2 per cent per year in the Valley. Table 2.43 illustrates the emission level of different pollutants in various years in the Kathmandu Valley.

Table 2.43: Future Vehicular Emission from the Transport Sector (ton)

Year	TSPs	CO	HCs	NO_x	SO_2	Pb	Total
2000	539	20,898	10,284	1,998	151	5	33,875
2010	609	26,561	12,314	2,125	174	6	41,789
2020	717	34,496	14,852	2,456	215	8	52,744

Source: Adhikari, 1998b.

2.11.2 Industry Sector

The main sources of air pollution from the industrial sector are combustion of fuels, stack emission and dusts from industrial process. A few past studies indicated the nature, types and extent of emission of air pollutants from the industrial sector in Nepal. Miyoshi (1981) was the first to estimate the industrial emission of air pollutants. He estimated $S0_2$ emission from the combustion of fuels in boilers of two factories – one located in the Kathmandu Valley and another located in Hetauda district. This study, however, did not provide clear information on emission load of $S0_2$ from these industrial operations but it indicated that the emission factor for the boiler operation. The emission factors were found to be 70 ppm for Vegetable Gee plant located in Hetauda district, which used furnace oil as its fuel. The daily fuel consumption for the boiler was 4000 liter per day in the plant. Another plant located in the Kathmandu Valley used 800 kg of coal per day. The emission rate of the boiler for the plant was in the range of 55 – 100 ppm (Miyoshi, 1981).

Industrial Service Center (1987) recorded the composition of emissions in two cement industries, Himal Cement Factory and Hetauda Cement Factory. The major air pollutants of the cement industry were particulates and gaseous waste such as $S0_2$, $N0_x$, $C0_2$ and C0, emitted from stacks. Dusts particles from the limestone mines, coal storage and clinkers were emitted into the air. ISC (1987) reported that the flue gas emitted from the Himal Cement Factory contained various gaseous compounds, including NO, NO_2 and $S0_2$. Carbon dioxide constituted 16.4 per cent of the flue gas and, 2.6 per cent CO. The flue gas emitted by the Hetauda Cement Factory was composed of 18.42 per cent $C0_2$, and only 0.1 per cent CO. The amount of $N0_x$ was 150 ppm and $S0_2$ was 50 ppm. Table 2.44 illustrates the composition of emission of gases of cement industries.

Table 2.44: Composition of Emission of Gases of Cement Industries

Industry	SO_2 ppm	NO_2 ppm	NO ppm	CO_2 %	CO %	O %	N_2 %	Moist %	Dust gm/m^3
Himal Cement	5	30	200	16.4	2.6	10.9	70.1	19.5	4.5
Hetauda Cement	50		150	18.42	0.1	10.4	59.7	14.42	0.1

Source: ISC, 1987

Out of the total 125 industries surveyed as point source of pollution, 105 industries had air pollution problem (NECG, 1990). Cement, marble, magnesite, brick, tyle, jute, lime, textile, paper, pesticides, chemicals, soap, stone, quarry and bone industries were identified as pollution hot spot. These industries had been using wood, coal, diesel, furnace oil, kerosene, saw dusts, husk etc. as the principal fuel for furnace, boiler, kiln, and incinerator operation. Combustion of these fuels emitted a lot of smoke, gaseous materials and particulate matters. Himal Cement emitted dusts as large as 400 tons/year (NECG, 1990). Out of the 125 industries surveyed, 49.6 per cent of the industries were found to possess unsatisfactory pollution control facilities, whereas only 50.4 per cent industries fell into the category of satisfactory and good pollution control facilities. Industries having unsatisfactory pollution control facilities include: cement, textiles, soap and chemicals, leather and tanning, jute, sugar and khandasari, brick, tiles and ceramics, marble, magnesite and quarry, paper and pulp, canning, foam and feed factory (IUCN, 1991). Geographical pollution hot spots were identified in nine districts within the three zones. The Kathmandu Valley districts – Kathmandu, Lalitpur and Bhaktapur – had been identified as pollution hot spots in Bagmati zone. Likewise, Morang and Sunsari districts in Koshi zone and Narayani, Parsa, Bara, Makwanpur and Chitwan district in Narayani zone were identified as pollution hot spots (IUCN, 1991). Table 2.45 illustrates the industrial plants with high air pollution characteristics.

Table 2.45: High Air Polluting Industrial Plants

Name of Industry	Zone/District	Industry Category
Himal Cement	Bagmati/Lalitpur	Cement
Sher Bone Mill	Bagmati/Lalitpur	Feed
Godavari Marble	Bagmati/Lalitpur	Marble, Magnesite & Quarry
Purna Roda Dhunga Udyog	Bagmati/Lalitpur	Marble, Magnesite & Quarry
Shree Paper Pulp Board Ind.	Bagmati/Kathmandu	Paper and Pulp
Agricultural Lime	Bagmati/Kathmandu	Soap and Chemical
Balaju Kapada Udyog	Bagmati/Kathmandu	Textile
Pashupati Textile Mill	Bagmati/Lalitpur	Textile
Raghupati Jute Mills	Koshi/Morang	Jute
Pashupati Soap Ind.	Koshi/Morang	Soap and Chemical
Ashok Textile	Koshi/Morang	Textile
Shah Udyog	Koshi/Morang	Textile
Hetauda Cement	Narayani/Makwanpur	Cement
Triveni Cement	Narayani/Makwanpur	Cement
Annapurna Cements	Gandaki	Cement
Nepal Oriend Magnisite	Janakpur	Marble, Magnesite & Quarry
G. B. Textile Mills	Lumbini	Textile
Nepal Pesticides & Chemicals	Lumbini	Soap and Chemicals
Bhrikuti Paper Mill	Lumbini	Paper and Pulp

Source: IUCN, 1991.

Devkota and Neupane (1994) estimated the total polluting industries in Nepal. According to their estimation, 3156 industries were found to be in the category of polluting air, in which Kathmandu Valley, alone, accommodated 47.5 per cent of them. Cement and brick were in the major industrial category identified in all regions of the country for contributing a major share of TSP and SO_2 emissions. A total of 76,383 tons of TSP was estimated to be emitted by the industrial sector in Nepal (Devkota and Neupane, 1994). The Kathmandu Valley contributed about 50 per cent of the total TSP load of the country. The Central Development Region excluding the Kathmandu Valley, contributed about 26 per cent of TSP and other remaining four regions contributed about 24 per cent of TSP load. Brick factories were the major contributor of TSPs and contributed 70 per cent of the total TSP load. Cement factories contributed 30 per cent of the total TSP Load in Nepal. In their estimation, 12300 tons of SO_2 emitted in Nepal on which, industry sector had a share of 39%, domestic 8%, agriculture 11 %, trasnport 37% and commercial 4%. Table 2.46 illustrates the number of air polluting industries regionwise in Nepal.

Table 2.46: Regionwise Number of Air Polluting Industries in Nepal

NSIC	EDR	CDR	WDR	MWDR	FWDR	Total
31	186	78	65	36	37	433
32	66	1264	70	14	2	1448
33	34	47	16	15	14	159
34	54	102	14	6	7	217
35	90	127	21	10	3	286

36	100	372	111	46	74	739	
37	7	5	3	0	0	52	
38	16	24	13	8	0	99	
	Total	313	135	137	137	3433	3433

Source: Devkota and Neupane, 1994

Emissions from the industrial boilers are one of the major sources of air pollution. Emissions from the boilers are largely dependent on the types and amount of fuel used. Carbon monoxide, oxides of nitrogen and sulfur dioxide are the major air pollutants released into the atmosphere due to the consequences of energy use. Furnace oil, diesel, kerosene and rice husk were the major fuel used in boiler operation in industry sector. Devkota (1997) found that boilers fired by diesel fuel emitted a slightly larger amount of CO compared to the boilers fired with furnace oil and kerosene. NO_x emission was observed to be higher in the boilers fired with furnace oil compared to the boilers fired by diesel and kerosene. Likewise boilers fired by furnace oil emitted the highest amount of SO_2. Among four industrial fuel types investigated in the study, kerosene was preferred fuel for boiler operation to furnace oil. Rich husks were preferred fuel while considering emission of SO_2. Table 2.47 exhibits the emissions from industrial boilers considering the types of fuel used.

Table 2.47: Emissions from Industrial Boilers - g/m^3 (ppm in parenthesis)

Boiler Type	CO Emission		NO_x Emission		SO_2 Emission	
	Min.	Max.	Min.	Max.	Min.	Max.
Furnace Oil	106 (122)	210 (241)	127 (239)	133 (250)	333 (872)	606 (1588)
Diesel	0 (0)	268 (308)	50 (94)	108 (203)	40 (105)	160 (419)
Kerosene	0 (0)	30 (308)	51 (96)	96 (181)	4 (10)	10 (26)
Rice Husk*	36 (41)	6785 (7803)	35 (66)	154 (289)	0 (0)	33 (86)

Note: * Fuel mixed with charcoal
Source: Devkota, 1997

2.11.3 Domestic Sector

Kitchen smoke is another serious air pollutant that is the most common in domestic houses in both villages and cities. In rural areas -- both in terai and hills --, fuel wood, twigs, leaf litter, cow-dung mixed with forage and dried in the form of cakes are the common fuels. Use of coal and kerosene are common in relatively well to do families in rural areas. In cities, addition to these fuels, liquefied petroleum gas is also being extensively used. Most of the traditional stoves are designed in such a manner that a small portion of heat is actually used while the rest goes waste. A large amount of smoke is produced and fills the kitchen room causing indoor air pollution. It causes eye irritation and throat problem to the people who spend most of the time in household cores. Exposure to such a smoke over years causes disease of eyes, throats and lungs. Component pollutant gases in indoor pollution are carbon monoxide and carbon dioxide. In coal combustion, some sulfur dioxide is also released. In gas burners, some atmospheric nitrogen near to flame surface is oxidized and NO_2 is produced.

Reid et al. (1986) monitored exposure to suspended particulate matter during cooking hours. The smoke monitoring was focussed in 60 households in the middle hills of Nepal and was conducted after the monsoon season. The studies were conducted in Gorkha, Myagdi, and southern part of Mustang districts and revealed that emission of airborne pollutants decreased significantly in improved cookstoves in comparison to traditional one. The average emission concentration of suspended particulate matters was lowered by approximately 2.0 mg/m^3 and the CO concentration by 200 ppm. The improved cookstoves decreased exposure to particulate matter by factors of 3.5 and 2.3 when it compared to Agena -- traditional tri-pot cookstove -- and mud stoves, respectively. The flues of improved cookstoves were found to contain lower CO concentration by factors of 3.6 to 5.6. Table 2.48 exhibits TSP and CO concentrations from the use of traditional and improved cook stove.

Table 2.48: TSP and CO Concentration with Using Traditional and Improved Cook Stoves

Location	TSP (mg/m3)		CO (ppm)	
	Traditional Stove	Improved Stove	Traditional Stove	Improved Stove
Gorkha	3.17	0.87	280	70
Beni	3.11	1.37	310	64
Mustang	1.75	0.92	64	41

Source: Reid et al., 1986

Estimation of emission load from the use of fuels in domestic sector is not readily available for the country, however, a few research works were conducted in the Kathmandu Valley. Shrestha and Malla (1993) estimated emissions of air pollutants from the energy use in domestic sector in the Kathmandu Valley. It indicated that about 14 thousand tons of pollutants were released into the atmosphere from the domestic sector. Kerosene and LPG were the major fuel used in urban areas while, kerosene and firewood comprised the major share of the fuels used in rural areas. Firewood as a major household fuel contributed over 50 per cent of the total emission load from the domestic sector in the Valley. Likewise, CO emission constituted about 85 per cent on the total emission load. Table 2.49 exhibits the emission from energy use in domestic sector in the Kathmandu Valley.

Table 2.49: Emission from Energy Use In Domestic Sector in Kathmandu Valley (ton/yr)

Fuel Type	CO	HC	NO_x	SO_2	TSP	Total
Fuelwood	6583	329	389	55	321	7675
Kerosene	1957	4.3	53	75	103	2192
LPG	0.1	0.8	21	0.06		22.3
Dung	29.2		1.6	0.3	4.6	35.7
Agri Residue	4049		261	43.6	450	4804
Total	12619	344	724	174	879	14729

Source: Malla, 1993

Shah and Nagpal (1997) gave slightly different results of that of Malla (1993). The total annual TSP emissions in the Kathmandu Valley were 2328 tons in year 1993, whereas PM_{10} was 1165 tons. Firewood consumption in household sector was found to be one of the major contributors of domestic air pollutants. Table 2.50 exhibits the total annual emissions in the Kathmandu Valley.

Table 2.50: Total Annual Emissions in Kathmandu Valley – 1993 (tons/yr)

Energy Use	TSP	PM_{10}
Fuelwood	1832.0	916
Agri. Residue	454.0	227
Animal Waste	30.0	15
Kerosene/ LPG	2.3	2.3
Charcoal	10.0	5
Total	2328	1165

Source: Shah and Nagpal, 1997

2.11.4 Emission Inventory in the Kathmandu Valley

Industrial pollution survey (IUCN, 1991) revealed that a majority (80 %) of the significant sources of industrial pollution were clustered within three zones: (i) Bagmati Zone (ii) Narayani Zone, (iii) Koshi Zone. Balaju Industrial District (BID) situated in the Bagmati Zone was identified as a pollution hot spot area due to high concentration of polluting industries. Smoke from boiler and diesel plant operation was the main source of air pollution (IUCN, 1992). Dust was emitted from various industrial processes such as milling at the Kathmandu Maida Mill. Overall, the level of air pollution did not appear to be significantly high at BID.

Operation of brick kilns has been considered the major source of air pollution in the Kathmandu Valley. Brick manufacturing by Bull's Trench kilns, owing to their process of material handling, firing technology, energy efficiency and also by virtue of consumption of substantial amount of dirty fuels were potentially significant sources of atmospheric emissions (Sharma et al., 1995). An estimation indicated that an annual emission from a brick factory was at a large of 30 tons of carbon, 80 tons of particulates, 7 tons of NO_x and 5 tons of $S0_x$ (Bhattarai, 1993). A large number of brick kilns were, thus, the main contributor of air pollutants specially the suspended particles. Brick industries utilized about 70 % of the Valley's coal supply. Combustion of fuelwood, coal, saw dust, and oil cakes used in firing process released $S0_x$, NO_x, HC, CO in the form of smoke, fumes, soot and ash into the atmosphere. A single local brick kiln used about 30 tons of coal and 165 tons of fuelwood, and other supplementary energy inputs in one round of firing. Scrap tyre was also used to fire bricks. Sulfur content of rubber in scrape tyre emits very corrosive acid fumes, which condense in and attack flues and chimneys as well as bricks (Devkota, 1993 quoted in ENHPO, 1993b). Emission inventory form the process involved in brick manufacturing was developed by Sharma et al. (1995) and is shown in Table 2.51.

Table 2.51: Emission Inventory from Brick Manufacturing in 1994 (ton/year)

Pollutants	Process Involved		
	Grinding and Drying	Unloading and Storage	Firing and Curing
Particulate	43,200	15,300	4438 – 15862
SO_2	-	-	4.8 – 6435
CO	-	-	1442 – 16384
HC	-	-	405 – 2373
NO_x	-	-	0.8 – 631
Fluoride	-	-	451

Source: Sharma et al., 1995

The number of industries has also gone up considerably right from mere 91 agricultural based in 1965 to 798 in 1986 in the Kathmandu Valley. Besides brick and other industries, Himal Cement Factory was another main contributor of air pollutants, specially the dust particles. In NECG study it was indicated that dust emission from the Cement Factory was about six ton per day (Pradhan, 1993). In another study, Sharma (1994) mentioned that before the expansion of the cement factory, it discharged cement dust of 400 tons per year.

Emission load from the industrial sector was estimated in Shrestha and Malla (1996). Industry sector emitted a total of 12.263 tons of pollutants in year 1993 in the Kathmandu Valley. Brick industries contributed about 64 per cent of the total pollutants and 66 per cent on the total TSP emissions from the industrial sector in the Valley. Table 2.52 shows the emission load from industrial sector in the Kathmandu Valley in year 1993.

Table 2.52: Emission Load from Industrial Sector in 1993 (ton)

Source	TSPs	CO	HCs	NO_x	SO_2	Total
Brick	2,346	3,498	649	426	938	7,857
Cement	615	769	171	127	308	1,990
Others	613	953	672	75	103	2,416
Total	3,574	5,220	1,492	628	1,349	12,263

Source: Shrestha and Malla, 1996

Shah and Nagpal (1997) estimated the amount of emission from the industrial and commercial sector in the Kathmandu Valley. It revealed that TSP emission was about 12 thousand tons on which the share of PM_{10} was 2577 tons. It indicated that cement factory and brick kilns were the major industrial categories for contributing a large share of pollutants into the Valley atmosphere. Coal was major contributor for $S0_2$ emissions. As most of the coal supplied in the Valley was consumed in brick manufacturing and cement factory, these two industries had a major share on pollutant emissions in the Valley. Table 2.53 shows the total annual emissions of air pollutants from the industrial and commercial in the Kathmandu Valley.

Table 2.53: Total Annual Emissions in Kathmandu Valley – 1993 (tons/year)

Activities	TSP	PM_{10}	SO_2
Fuelwood Burning	61.9	31	
Coal Burning	48.0	24	172
Charcoal	20.0	10	
HSD	1.8	2	
Kerosene/LPG	0.1	0	
Agri. Residue	450.0	225	
Brick Manufacturing	5180	1295	4.8 – 4465
Himal Cement	6000	800	615
Refuse Burning	385	190	
Total	12146.8	2577	791.8 - 5252

Source: Shah and Nagpal, 1997

2.12 Environmental Issues and Health Impacts

Impacts on health due to environmental consequences are not precisely known in Nepal. However, there are some facts that hint the extent of air pollution. Air pollution issues have caught much attention in urban areas. However, people residing in rural areas are becoming victim of indoor air pollution due to smoke released from firewood burning in inefficient manner. In comparison to urban people, health condition of the rural people has been much more affected because of poor sanitation, inadequate nutrition, sub-standard living condition and inadequate household facilities. In Nepal, 6.45 per cent of the total population reported to be chronic illness, whereas the rural and urban populations reporting chronic illness were 6.54 per cent and 5.37 per cent of the total urban and rural population respectively. People living in the Kathmandu district were in better health condition as compared to the people living in other parts of the country. Only 4.49 per cent population of the Kathmandu district reported chronic cases of illness. The reported cases of chronic illness were much higher among the female as compared to male population in both urban and rural areas (CBS, 1996a). Table 2.54 exhibits the percentage of population reporting chronic illness by gender and urban rural population in Nepal.

Table 2.54: Percentage of Population Reporting Chronic Cases of Illness by Gender

Area	Male	Female	Total
Nepal	5.89	6.99	6.45
Urban	5.00	5.74	5.37
Rural	5.96	7.09	6.54
Kathmandu	3.67	5.36	4.49

Source: CBS, 1996a.

According to the morbidity health status published by DoHS/HMGN (1997), respiratory came among the top five diseases accounting for eight per cent of population reporting the case of acute respiratory infection (ARI). Respiratory disease has been largely dependent on the prolong exposure of smoke and dust. Diarrhea, fever and skin were the major causes of illness in Nepal, whereas about five per cent of patient had respiratory problems (CBS, 1996a). Acute respiratory infection continued to be the leading cause of death among young children, accounting for more than 30 per cent of deaths in children under five years of age (Niraula, 1998). In 1995, ARI associated deaths in Nepal was estimated to be about 34 thousands for children under five years of age. The maximum number of ARI incidence was reported in the Manang district and the lowest was reported in the Kathmandu district (MoHS, 1997). The causes of death showed that about 16 per cent deaths were due to respiratory infection in rural and about 18 per cent in urban areas of the country (CDPS, 1997). In totality, illness due to respiratory infection was found to be higher in urban as compared to rural Nepal. Table 2.55 exhibits the percentage distribution of types of illness in Nepal.

Table 2.55: Percentage Distribution of Types of Illness

Area	Diarrhea	Fever	Respiratory	Injury	Skin & Others	Total
Nepal	17.00	43.71	5.18	4.41	29.70	100
Urban	20.06	38.22	6.91	2.77	32.04	100
Rural	16.90	43.99	5.07	4.50	29.54	100
Kathmandu	9.85	28.76	4.93	2.13	54.34	100

Source: CBS, 1996a.

A strong co-relationship was found between the prevalence of chronic bronchitis and indoor smoke pollution in Nepal (Pandey and Basnet 1987). It was, further, reported that 31 per cent of the bronchitis cases were due to indoor smoke pollution in Chandannath of Jumla district, 17 per cent in Sundarijal and Bhadrabas of the Kathmandu district, 13 per cent in Parasauni of the Bara district, and 11 per cent in urban Kathmandu. These findings showed that indoor air quality has been affected severely due to smoke pollution in rural areas. Reid et al. (1986), in another study, indicated that twice as many traditional cookstove owners (72 %) than improved cookstove owners (36 %) complained the problems of eye irritation and coughing. Exposure to total suspended particles of average concentration of 7 mg/m^3 during cooking period was common in Nepal, and was 35 time the Japanese one-hour air quality standard (Shrestha, 1986 in Mathema et al., 1992). LEADERS Nepal (1998) stated that the number of urban children reporting respiratory related cases in Kanti Hospital was higher than the number of rural children in the Kathmandu Valley. It further mentioned that one of the possible reasons for the cause could be the deteriorated air quality in urban Kathmandu. This conclusion may not be exhaustive because of a large number of variables, which may have impact on the human health. Sharma et al. (1992) isolated fungi from particulate matters in different localities in the Kathmandu Valley. Among the isolated fungi, species of Aspergillus and Rhizopus were found dominant. Both of these genus consisted of variety of species, which were responsible for various human disease such as otomycosis (disease of ear) and onychomycosis (disease of nail). Brick manufacturing by Bull's Trench kiln, owing to it's process of material handling, firing technology, energy efficiency and also by virtue of consumption of substantial amount of dirty fuels was potentially one of the significant sources of atmospheric pollution (Sharma et al., 1995). Emission of dust particles as well as other gaseous pollutants such as sulfur dioxide, nitrogen oxides, hydrocarbons, fluoride etc. was one of the causes for affecting human health and hygiene of workers and communities living on the vicinity of emission sources. One thing to take note is that a large number of brick kilns exist not only in Kathmandu Valley but also in different parts of the country.

2.13 Air Quality

Assessment for the quality of air has not been carried out systematically in Nepal due to lacking of appropriate and specialized organization to look after the assignment for air quality management. A large number of air quality related information are, however, available in the Kathmandu Valley and few information in other urban centers in Nepal. An attempt has been made here to assess the air quality situation and existing air quality monitoring network in the country.

2.13.1 Monitoring Network

Virtually no air quality monitoring network exists in the country. However, A few institutions were involved in recording air quality from time to time. Information on air quality, so far, obtained from different sources provides generic information on air quality situations. However, these results are inadequate to draw any truth-worthy conclusions for taking any policy decisions. Department of Hydrology and Meteorology (DHM) has been recording physical parameter of air pollutants on its test station situated at its building in Baber Mahal since 1994. It has, so far, not been able to record ambient concentration of gaseous pollutants. Department of Hydrology and Meteorology is an specialized government organization to record climatic and meteorological information in the country. It has well set up stations in different parts of the country to record climate and meteorological related information. A Kathmandu based local non-government organization -- LEADERS Nepal -- has been monitoring roadside and ambient concentration of air pollutants in the Kathmandu Valley for about three years. It recently released results of air quality of different locations in Biratnagar and Nepalgunj. Apart from these two sources, a quite large number of air quality related information were generated during the Urban Air (URBAIR) and Kathmandu Valley Vehicular Emission Control Project (KVVECP) in Kathmandu Valley. Ministry of Population and Environment (MOPE) is being involved in monitoring of ambient air quality in the Kathmandu Valley as a part of ADB/TA project, which is presently being implemented in the ministry. In assistance from the Royal Danish Government, Radio Sagarmatha -- a private FM radio station -- and Nepal Environment and Scientific Service (NESS) -- a private research lab -- have been jointly involved in measuring and broadcasting the air quality related information in the Kathmandu Valley.

2.13.2 Air Quality of the Kathmandu Valley

<u>Lead</u>

Bhattarai and Shrestha (1981) were the first researchers in Nepal to estimate the concentration of lead in dust sample collected from different locations in the Kathmandu Valley. They examined dust samples from 18 locations and found that the lead concentrations ranged from 153 ppm in Tripureswor to 544 ppm in Maitighar. Lead concentrations were, however, quite low in Valley outskirts. It was also revealed that lead concentrations in roadside dust were directly related to the number of vehicular movement. ENPHO (1993a) revealed that the average 24-hours lead concentration in the Kathmandu Valley was 0.32 $\mu g/m^3$ and the highest and the lowest concentrations were 0.53 $\mu g/m^3$ and 0.18 $\mu g/m^3$ in the Royal Palace area and Maharajgunj respectively. Similarly, the average 9-hours concentration was 0.54 $\mu g/m^3$, whereas the maximum and minimum were 1.2 $\mu g/m^3$ and 0.2 $\mu g/m^3$ in Thamel and both in Singha Durbar and Kalanki respectively. Table 2.56 exhibits the number of vehicular movement and corresponding lead concentrations in some of the locations in the Kathmandu Valley.

Table 2.56: Lead Concentration in Kathmandu Valley (ppm)

Location	Vehicle/day	Lead
Maitighar	2200	544
GPO Complex	2000	374
Narayanhity	1600	323
Balaju	< 100	34
Dharmasthali	< 100	51
Budhanilkantha	< 100	10

Source: Bhattarai and Shrestha, 1981.

Lead content in PM_{10} dust particulate matter was recorded in different locations in the Kathmandu Valley in the month of September and October/November in 1993. Concentrations of lead particulate were 4.32 $\mu g/m^3$ at NESS office in Thapathali, 6.08 $\mu g/m^3$ in Bhotahity and 0.23 $\mu g/m^3$ in Jhonche in September 1993. Likewise the concentrations were 0.75 at NESS office in Thapathali, 2.60 in Kalimati, 0.65 in Tahachal, 0.86 at Thapathali in residential area, 0.94 at Thapathali along roadside, 1.51 in Putalisadak, 0.30 in Asan and 1.60 in Bir Hospital in the month of October/November (Sharma and Upadhyay, 1995). In 1996, Japan Acid Rain Monitoring Network (JARN) and LEADERS Nepal conducted a study, in which concentration of lead particles in Balaju Ring Road and Gausala, near to Tilganga, found 91 ppm and 79 ppm respectively (LEADERS, 1998). LEADERS Nepal recorded roadside lead concentration in two locations of the Valley in December 1998. The maximum and minimum lead concentrations recorded at Putalisadak were 0.69 $\mu g/m^3$ and 0.31 $\mu g/m^3$ and at Jorpati were 0.07 $\mu g/m^3$ and 0.24 $\mu g/m^3$ respectively (LEADERS, 1999).

Suspended Particulate Matters

Concentrations of particulate matters in the city area of Kathmandu, Pokhara and Biratnager were first recorded and presented in CEDA (1990). Kalimati in the Kathmandu Valley had the maximum concentration of particulate matters of 18.2 $mg/m^2.h$ followed by New Road and Ratnapark, and the lowest value was recorded at Paknajol with a concentration of 7.2 $mg/m^2.h$. Likewise Sharma et al. (1992) measured concentrations of particulate matters in different locations in the Kathmandu Valley and found that the upper range of TSP concentrations were noted in Maitidevi and Putalisadak, where the concentrations were 775 and 707 $\mu g/m^3$ respectively. Lower levels of particulate concentration were found in Bhatbhateni, Gausala, Naya Bazaar, and Durbarmarg, where the concentrations were in the range of 197-247 $\mu g/m^3$. Ratnapark, Teku and Chhetrapati had a moderate TSP concentration in the range of 400-470 $\mu g/m^3$. Sharma et al. (1992) also studied the seasonal change in the concentration of particulate matters. Pre monsoon concentrations were found higher than post monsoon concentrations of particulate matters in New Baneswor, Teku, and Tripureswor, but except in Gausala. Table 2.57 exhibits the seasonal change in concentration of particulate matters in different locations of the Valley.

Table 2.57: Seasonal Change in Concentration of Particulate Matters

Sampling Site	Particulate Matter ($\mu g/m^3$)	
	June 1992	October 1992
New Baneswor	201	278
Teku	309	443
Tripureswor	289	310
Gausala	313	236

Sharma et al., 1992

In the study report of Devkota (1993), Kirtipur -- which is located in 10 km away in southwest direction from the city core area of the Kathmandu Valley -- was considered as regional background. The 24 -and 8-hours TSP concentrations were 94 $\mu g/m^3$ and 84 $\mu g/m^3$ in Kirtipur area respectively. Among the heavy traffic areas, the highest TSP concentration was recorded in Kalimati, where 24- and 8-hours TSP concentrations were 391 $\mu g/m^3$ and 734 $\mu g/m^3$ respectively. The average 24-hours TSP concentration was 200 $\mu g/m^3$ in residential areas such as Naya Baneswor, Jayabageswori, Maharajgunj etc. Area surrounding Himal Cement Factory had the 24-hours TSP concentration of 430 $\mu g/m^3$ and similarly PM_{10} concentration was 166 $\mu g/m^3$. PM_{10} concentrations were near to 100 $\mu g/m^3$ around residential areas in the Kathmandu Valley.

The average 24-hours TSP and PM_{10} concentrations were found to be 308 $\mu g/m^3$ and 89$\mu g/m^3$ respectively in the Kathmandu Valley in the study conducted by ENPHO (1993a). The highest TSP concentration reported in this study was 465 $\mu g/m^3$ in Balaju and the lowest 155 $\mu g/m^3$ in Chahabil. Likewise, the highest and the lowest PM_{10} concentrations of 127 $\mu g/m^3$ and 59 $\mu g/m^3$ were found in Chahabil and Indrachowk respectively. The average 9-hours TSP and PM_{10} concentrations were 1397 $\mu g/m^3$ and 296 $\mu g/m^3$ in the Kathmandu Valley respectively. A similar type of findings was also revealed in RONAST (1993), which indicated the roadside concentrations of suspended particulate matters were between 197 to 775 ($\mu g/m^3$). Monitoring results of PM_{10} concentrations in over 60 different spots in the Valley showed that the level of concentration ranged from 230 $\mu g/m^3$ in Tahachal to 3790 $\mu g/m^3$ in Lekhanath Marg (Otaki et al., 1995). Concentration of PM_{10} at five different locations of the Valley were illustrated in Sharma (1997). It indicated that the PM_{10} concentrations were 126 $\mu g/m^3$ at north of the Valley, 194 $\mu g/m^3$ at south, 201$\mu g/m^3$ at center, 161$\mu g/m^3$ at east and 154 $\mu g/m^3$ at west from the Kathmandu Valley.

Department of Hydrology and Meteorology (DHM) has been measuring the ambient concentration of TSP at Babar Mahal in the Kathmandu Valley since December 1993. A great difference in the measured values of TSP in each month clearly indicated that there were large variations in the concentrations. Monthly TSP values measured from January to April at Babar Mahal exceed the WHO guidelines value and the frequency of days exceeding the guidelines value was quite high in those months. Concentrations of TSP were relatively lower during the months from July to September. Table 2.58 exhibits the average TSP concentrations in the Kathmandu Valley.

Table2.58: Average Ambient Concentration of TSP at Babar Mahal ($\mu g/m^3$)

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

1994	467	54	202

Source: DHM, 1998

LEADERS Nepal (1999) measured TSP, $PM_{7.07}$ and $PM_{..7.07}$ concentrations at different locations in the Kathmandu Valley in June and December 1998. Kathmandu Valley had an average $PM_{7.07}$ concentration of 175.95 $\mu g/m^3$ during the month of June, while the lowest and highest concentrations were 87.9 $\mu g/m^3$ and 541.1 $\mu g/m^3$ at Airport and Balaju area respectively.

Carbon Monoxide

Ambient concentrations of carbon monoxide were around 5.5 ppm during busy office hours and around 4.5 during off-peak office hours in heavy traffic areas such as Tripureswor, Thapathali and Singh Durbar (Devkota, 1993). It was noted that CO concentrations were less than 5 ppm in low traffic and residential areas such as Chhauni, Thimi and Maharajgunj. The higher level of CO concentrations were noted at bus parks such as Tempo Park near to RNAC building in New Road and Central Bus Park near to Ratnapark, where the concentrations were 10 ppm and 7.5 ppm at busy office hours respectively. ENPHO (1993a) also recorded the average 24-hours and 9-hours CO concentrations in the Kathmandu Valley and were found less than 11 mg/m^3 for both of the cases.

Oxides of Nitrogen

In Kirtipur -- the Regional Background Area --, 24 hours and 8 hours NO_2 concentrations were 18 $\mu g/m^3$ and 33 $\mu g/m^3$ respectively. Twenty-four hours NO_2 concentrations were found to vary from 11 $\mu g/m^3$ in GPO Complex to 37 $\mu g/m^3$ in Singha Durbar. The highest NO_2 concentration was recorded at Himal Cement Company site at Chovar, where 24-hours concentration was 38 $\mu g/m^3$ (Devkota, 1993). In ENPHO (1993a) study, the average 24-hours NOx concentration was 24.2 $\mu g/m^3$, and the maximum and minimum were 36 $\mu g/m^3$ and 12$\mu g/m^3$ in Bir Hospital and Thapathali respectively. Likewise, 9- hours concentration was 38 $\mu g/m^3$, and the maximum and the minimum concentrations were 69$\mu g/m^3$ and 17 $\mu g/m^3$ in Singha Durbar and Kasthamandap area respectively. Sharma measured the concentrations of NOx in different locations in the Valley and found 71$\mu g/m^3$ at north, 58 $\mu g/m^3$ at south, 64 $\mu g/m^3$ center, 25 $\mu g/m^3$ east and 35 $\mu g/m^3$ at west of the Valley (Sharma, 1997). LEADERS Nepal measured 24-hours average NO_2 concentrations in different locations in the Kathmandu Valley in June 1998. The NO_2 concentrations were found to vary from 0.02 ppm in Thamel to 0.04 ppm in Cahabil and with an average of 0.027 ppm for the Kathmandu Valley (LEADRES, 1999).

Sulfur Dioxide

Twenty-four -and 8-hours SO_2 concentrations were 38 $\mu g/m^3$ and 42 $\mu g/m^3$ in Kirtipur -- at the regional background area -- respectively. The highest 24-hours SO_2 concentration was found 77 $\mu g/m^3$ in Kalimati and the lowest 17 $\mu g/m^3$ in Lainchour residential area (Devkota, 1993). The average 24- and 9-hours SO_2 concentrations were 6.5 $\mu g/m^3$ and 12.3 $\mu g/m^3$ and the maximum 9-hours concentration was recorded 19 $\mu g/m^3$ in Kuleswor (ENPHO, 1993a). Sharma (1997) investigated the concentrations of SO_2 in different parts of the Kathmandu Valley and revealed that SO_2 concentrations were 34 $\mu g/m^3$ at north, 65 $\mu g/m^3$ at south, 202 $\mu g/m^3$ at center, 65 $\mu g/m^3$ at east and 77 $\mu g/m^3$ at west of the Valley.

Other Pollutants

In 1996, Japan Acid Rain Monitoring Network (JARN) and LEADERS Nepal conducted a study to determine the concentration of Pb, Zn, Cr, Mn and Ba at two locations; Balaju Ring Road and Tilgnanga. It was found that the corresponding concentrations were 91 ppm, 103 ppm, 22ppm, 302 ppm and 325 ppm at Balaju and likewise 79 ppm, 85 ppm, 41 ppm, 340 ppm and 390 ppm at Tilganga respectively (Quoted in LEADERS, 1998). Various species of air microflora were isolated from the ambient air in the Kathmandu Valley. Air samples from 27 spots were taken and 38 fungal species belonging to 26 genera were isolated. Among them Penicillium (23.68%), Aspergillus (7.89 %), Cladosporium (7.89 %) and Sporotrichum (5.26 %) were observed. The higher prevalence of air-borne fungal genera might be due to high dust and organic nutrient content in air (Sharma and Sharma, 1997). The pH in rain water during the period of June – December 1997 was in the range of 6.4 to 8.1, which showed no incidence of acid rain in the Valley (LEADERS, 1998). Similar types of results were also presented in Upadyaya and Sharna (1995), according to which pH values in rainfall precipitation were in the range of 5.6 to 6.95 during May-July 1995 in the Kathmandu city air.

The low stack height of brick factories coupled with unfavorable meteorological conditions plays a major role in the ground level concentration of air pollutants in the Kathmandu Valley. The Kathmandu Valley due to its thermal inversion makes ground level concentration higher specially in winter months. Inversion is a frequent occurrence in winter months and the accumulation of smoke and other constituents further aggravates pollution by preventing the sun's rays from entering the ground and the adjacent air. Fog is commonly associated with inversions, because the temperature of air at ground falls below the dew point of the water vapour in the air (ENPHO, 1993b)

2.13.3 Air Quality Outside the Valley

Air quality related information for outside the Kathmandu Valley is rarely available in Nepal. Urban centers such as Pokhara and Biratnagar were included in the study conducted by CEDA (1989). It was the first study, which measured the air quality for outside the Valley. The maximum amount of particulate maters was 18.67 $mg/m^2.h$ at Prithivi Chowk and the lowest at 4.01 $mg/m^2.h$ at Phewa Tal area in Pokhara. The highest concentration of particulate matters in Biratnagar was 17.32 $mg/m^2.h$.

LEADERS Nepal (1999) recently released the air quality related information for Nepalgunj and Biratnagar. Monitoring of $PM_{7.07}$ and NO_2 was done in nine different locations in the month of February in Nepalgunj, where $PM_{7.07}$ was found in the range of 228.4 $\mu g/m^3$ to 454.9 $\mu g/m^3$ with the average value of 316.34 $\mu g/m^3$. The highest concentration of PM_{10} was 454.9 $\mu g/m^3$ in Gharbari Tole. Concentrations of NO_2, however, found to be within the acceptable limits in Nepalgunj. The study found that concentrations of $PM_{7.07}$ were higher than that of Kathmandu Valley in Nepalgunj. Table 2.59 exhibits the $PM_{7.07}$ and NO_2 concentrations in different locations in Nepalgunj.

Table 2.59: $PM_{7.07}$ and NO_2 Concentration in Nepalgunj – Feb. 1998.

Sample Station	$PM_{7.07}$ ($\mu g/m^3$)	NO_2 ppm – 24 hrs. average
Bus Park Gate	318.8	0.014
Dhamboji Chowk	430.7	0.015
Gharbari Tole	454.9	
Tribhuvan Chowk	381.9	0.008
Banke Bagiya	245.4	0.007
Bheri Hospital	247.3	
Mahendra Bahumukhi Campus	228.4	0.006

Ganesh Man Singh Chowk	266.4	0.012
BP Chowk	273.3	0.014

Source: Leaders, 1999

Monitoring of $PM_{7.07}$ and NO_2 was done in seven different locations in the month of June in Biratnagar, where $PM_{7.07}$ was found to be in the range of 50.5 $\mu g/m^3$ to 105.4 $\mu g/m^3$ and with an average value of 72 $\mu g/m^3$. Concentrations of NO_2 were also found to be within the acceptable limits in Biratnagar. Table 2.60 exhibits the $PM_{7.07}$ and NO_2 concentrations in different locations in Biratnagar.

Table 2.60: $PM_{7.07}$ and NO_2 Concentration in Biratnager – June 1998

Sample Station	Traffic Volume/10 min	$PM_{7.07}$ ($\mu g/m^3$)	NO_2 ppm – 24 hrs. average
Mahendra Chowk	174	82.4	0.024
Bargachhi	134	66.8	0.019
Tinpaini	154	54.9	0.014
Devkota Chowk	84	50.5	0.008
Gudri Chowk	93	105.4	0.016
Pipal Chowk	0	-	0.014
Road Ses Chowk	0	-	0.012
Average	639		

Source: Leaders, 1999

In conclusion, the last thirty years trend indicated that the Nepalese economy had been shifting from the agricultural to commercial and manufacturing sector, but at a very slow pace. Due to uneven economic development and distribution among the different regions, a major portion of rural populations has been migrating from rural areas to urban towns. According to the latest census conducted in 1991, urban population was 12.32 per cent of the total population in Nepal. About 70 per cent of the manufacturing establishments were concentrated in 10 districts and remaining 30 per cent in 65 districts in the country. The Kathmandu Valley, alone, accommodated 36.7 per cent of the total manufacturing establishments in Nepal. Growth in transport sector and energy consumption was also high in a few urban and industrial centers. As its result, environmental consequences are growing up prominently in limited number of urban and industrial areas.

Annex-5 exhibits the WHO air quality guidelines value and Annex-6 shows the US national air quality standards.

Chapter III

Strategy for Air Quality Management

3.1 Background

Assessment of the quality of air has not been carried out systematically in Nepal due to a lacking of appropriate air quality management system. A large number of air quality related information is, however, available in the Kathmandu Valley. Most of the past studies were confined only to roadside, thereby reflecting comparatively high suspended particulate matters and other pollutants' concentration. Observations made on most of the studies are not inter-comparable. Analysis of historical data on ambient air pollution levels, however, warrants an urgent need for ambient air quality monitoring program to define the status of problems in its true perspective. Reliable information on air quality in urban areas except than the Kathmandu Valley hardly exists. A few past studies have inferred that public health is in assault in urban areas, where the extent of air pollution is high. This chapter analyses the air quality assessment capability of the country and concludes with suggesting a future strategy for managing air quality.

The initial identification of possible air quality problems can be achieved without having formal monitoring capabilities, such as ambient air measurement networks. In many areas, as air quality deteriorates, there are observable impacts from the pollution, such as reduced visibility and dirtying clothes and physical facilities by smoke and dusts. Further indications may include a visual smoke and dusts emission from industries, an increase road congestion and visible smoke from vehicle tailpipe or apparent health evidence such as increased respiratory, bronchitis, or asthma incidences. These observations substantiate the deteriorated air quality. There already exist enough information in the Kathmandu Valley, which indicates the severity of air pollution problems. Lead particles were found as high as 6.08 $\mu g/m^3$ in some locations and foreseen that roadside dusts contained even a higher concentration of lead particles, far exceeding the acceptable limit. Likewise, concentrations of suspended particulate matters have surpassed WHO guidelines value for a prolong duration in most of the sites. Hourly rise or fall of pollutants' concentration have been observed in most of the airsheds because of imbalance between pollution production and pollution dilution rates. Concentrations of other pollutants, such as HC, CO, NO_x, and SO_2 have not noticed exceeding the limit considered unsafe for public health viewpoints in most of the areas. However, concentrations of these pollutants are approaching the threshold limits in many urban airsheds, especially in heavy traffic sites in rush hours. The Kathmandu City has always been compared to the highly polluted cities in the world. These facts recognize that the existing air quality of the Valley is unacceptable on health point of view. These primarily findings indicate that the air quality management capability needs to be developed with urgency in the country.

3.2 Air Quality Management Capability

There are three air quality management capability indicators. These are (i) Stated air quality monitoring objectives, (ii) Adequacy of base information to use in policy decision and (iii) Administrative and legal frameworks. The objectives of the air quality management can be broadly classified into the following five groups. These are to:

(i) Measure the spatial distribution of pollutants,

(ii) Determine trends in concentration for forecasting.
(iii) Identify the contribution of specific emission sources,
(iv) Ascertain likely consequences of ambient exposure of air pollutants,
(v) Ascertain compliance with air quality standards and guidelines value, and
(vi) Provide public information.

Defining objectives is one of the most important and primary steps for any air quality management program. Through there seems to be no defined objectives of monitoring works so far conducted by different organizations in the country. Most of the monitoring works seem to be targeted for providing basic information to further use in decision making or policy formulation. Annex-7 exhibits air quality monitoring objectives of various polluting cities in the world.

A few air quality related information was already generated by the initiation of non-government and private sector organizations. Department of Hydrology and Metrology (DHM) has been recording the concentrations of suspended particulate matters in the air of the Kathmandu Valley since 1994. It is the only one government organization, which has been involved in the measurement of air pollutants' concentration. It has, however, not measured gaseous pollutants so far. Information, thus, generated by the DHM has not been utilized to draw any truth-worthy conclusions for further designing any program targeted to air quality improvement. DHM being institutionalized under the Ministry of Water Resources has not been provided with full responsibility for monitoring air quality systematically. All the infrastructure and expertise that have been developed in DHM suit the monitoring capabilities required for climatic and meteorological information. There exist no formal institutional, administrative and legal frameworks to carry out monitoring assignment in the country. One of the positive signs in this regard is, however, that the monitoring capabilities have already been fully developed in private sector in the Kathmandu Valley. The non-governmental sector has also been actively involved in generating air quality related information. Information regarding the air quality in other urban and industrial centers, except the Kathmandu Valley, is hardly known in Nepal. The need is felt to determine the type and severity of air pollution problems so that to design an effective air quality management plan.

3.3 Air Quality Management

An air quality management plan should consist of the following components.

i) An air quality monitoring network
ii) Emission inventories (Measurement or estimation of emissions from each source type in an area)
iii) Numerical prediction models
iv) Air quality standards
v) A range of cost-effective emission control policies and measures together with the resources and power to impose them

Almost all of these components are lacking in the country. In the absence of a well-defined monitoring network with specified monitoring objective, information so far obtained can not be further used to establish air quality standards and to develop model for predicting concentrations of air pollutants in different meteorological conditions. A well-defined emission inventories, which include the comprehensive information on fuel statistics, emission factors for vehicles and domestic fuel combustion, measurement of emissions form industrial sources, and re-suspension emission factors is indispensable for designing a range of cost-effective emission control policies and measures. Air pollution models can be developed after analyzing scattered or time series data on air quality along with other variables such as meteorological information and pollution characteristics.

3.4 Strategy for Air Quality Monitoring

There exist potentials to alleviate the air pollution problems but it necessitates the formulation and execution of effective management plan and strategies. Assessment of ambient concentration of pollution is an indispensable component of any air quality management capability. Even if air quality seems to be acceptable at present, there is an urgent need to continue monitoring to assure that it will remain so. Measurement and evaluation of ambient concentrations of pollutants should be initiated first in the Kathmandu Valley and should gradually be expanded in other urban centers in Nepal. The objective of air quality monitoring should be to generate enough information for the formulation of air quality management strategies and to monitor the progress of the plans once implemented. Monitoring capabilities are essential in providing information to assist decision-makers in formulating appropriate responses to reduce emissions of pollution. Monitoring capabilities are required to produce data enabling the identification of air quality problems, range of pollutants, pollution sources and methods of imposing emissions controls. The following steps are fundamental elements on any air quality monitoring plan.

i) Decide the institutional framework
ii) Air quality monitoring network design
iii) Adoption of cost effective instrumentation

3.4.1 Institutional Framework

One of the most essential components of the air quality management strategy is to determine or setup organization for undertaking the monitoring assignment. It is very much essential to have an independent organization to coordinate activities and organizations, develop strategies and implement various programs for improving air quality. In this regard, it is highly recommended for setting up one independent organization[4] to take overall responsibilities of air quality management and pollution control. At present, there exist two alternative institutional arrangements that can handle the monitoring assignment in the country. These are (i) Department of Hydrology and Meteorology, and (ii) Private Laboratory. In the both cases, the proposed organization should act as an apex center and coordinate the monitoring activities.

Department of Hydrology and Meteorology (DHM) has been involved in measuring the suspended particulate matters since four years in Nepal. It has been instituted to record climatic and meteorological information. Air quality recording assignment resembles quite similar to the recording of climatic information. This organization if provided mandate can effectively handles the air quality monitoring assignment. DHM has been designated as a national center for monitoring air quality under the framework of GEMS/AIR (Global Environmental Monitoring System) program. There exist facilities for data handling, analyzing and transmitance to international agency in DHM. Furthermore, it is also handling meteorological data, which is one of the most important components of such monitoring program. The cost-effective monitoring capabilities can be developed in DHM and for that reason it seems to be the most appropriate organization within the government sector for handling the air quality monitoring assignment. Responsibilities of interpreting the air quality related information and designing air quality management plan, however, should rest with the proposed center.

[4] Discussed in details in Section 5.6.17 of this report

The another alternative could be the monitoring work done through the private laboratories. In this case, the proposed organization should involve in designating laboratory to act as national center for monitoring of air quality. The presence of many good laboratories in Kathmandu is a definite advantage and the proposed organization could take into account the possibility of avoiding investments in procurement of laboratory equipment and training of specialist humanpower.

3.4.2 Network Design

There are three factors involved in designing of any air quality-monitoring network. These are; (i) Selecting monitoring site (ii) Determining frequency of sample collection, and (iii) Deciding criteria pollutants for monitoring.

The following criteria should be considered for selecting monitoring site.

i) Pollution hot spot such as traffic congestion, city centers and industrial locations
ii) Sites where measured concentrations should be representative
iii) Sites where the limit or guidelines values are likely to approach or exceed
iv) Sites sensitive for human exposure such as school and hospital locations
v) A few urban background sites

The validity of a few fixed sites to provide an indication of community exposure can be questioned so it is appropriate to use other monitors for short-term periods at various urban locations to assess the degree to which the few sites are indeed representative. Such a strategy establishes which parts of the urban area are not representative and so may need monitoring. The use of a mobile monitor may be another way of verifying the representation.

The decision on the frequency of sample selection should consider the budgetary constraints. However, the frequency of monitoring should be determined to generate at least the following information.

i) Seasonal variation of pollutants' concentration
ii) Time of the day variation of pollutants' concentration
iii) Concentration on different weather conditions

Knowledge on ground level concentrations of a wide range of pollutants throughout the urban areas is desired. In practice, SO_2, suspended particulate matters (including PM_{10}), CO, NO_2, VOCs (e.g. benzene), Ozone and airborne lead pose the most common threats to the human health of the community and it is, thus, these pollutants should be the focus in most of the urban pollution monitoring networks. Toxic chemicals (e.g. ammonia, fluoride) or toxic metals other than lead (e.g. cadmium) can cause localized health problems around individual industrial sources such as chemical industries, waste incinerators and metal processing plants and require small-scale monitoring networks to be established around the point source in question.

3.4.3 Instrumentation

A large variety of instruments are available in the world for monitoring air quality. India has also developed different types of air quality monitoring instruments. There are four types of methods used in air quality monitoring. These are (i) Passive Samplers (ii) Active Samplers (iii) Automatic Analyzers, and (iv) Remote Sensors. All these methods have certain advantages and disadvantages. Passive samplers are low in cost and simple but unproven for some pollutants. It collects an integrated sample of pollutants by diffusion with collection on a tripping medium, which is subsequently analyzed. An active sampler is very popular because of simplicity, low cost and reliability. Automatic analyzers are complex and expensive to operate and require high skills to maintain and operate. Remote sensors have many advantages but are very expensive to operate. Annex-8 and –9show the instrumental air monitoring techniques, their advantages and disadvantages and capital cost per sampler. Methodologies used for particulate matter monitoring in different cities in the world are shown in Annex-10.

3.5 Air Quality Standards

The main stages in the formulation of air quality standards are the scientific stage – "criterion" establishment and the policy or decision stage –"standard" setting. The adoption of air quality standard requires the weighing up of many different interests and therefore a policy decision. The air quality criteria are primarily based on laboratory findings and hence change as new scientific information and evidence become available. Air quality criteria are determined based on cause-effect relationship of the effects of air pollution on human health, animal, vegetation, material, and environment itself. The term "air quality standard" applies to an allowable quantity of measures of an air pollutant established by authority with the intent of requiring compliance. In establishing air quality standards, in addition to the above-mentioned effects, impacts of air pollution on climate, esthetic, social, cultural and economic values should be considered. To decide the standards; a knowledge of technical, social, financial, legal and institutional implication is also required. One should ideally have available a complete set of dose-response curves for the different types of populations exposed.

The following basic approaches are suggested on deciding the standard: (i) deciding the types of pollutants for standard setting, (ii) deciding the best criteria for establishing standard, and (iii) specifying the types and range of standards. Owing to the uncertainty of the dose-response relationships, the use of a safety factor is necessary even when standards are based on relevant and time series information. The magnitude of such safety factor will depend upon many considerations. These may be political considerations with the main emphasis on cost-benefit analysis (WHO, 1976). One of the major considerations on deciding the air quality standards for the developing countries is that most of the required information are non existent. It costs a significant amount of resources and times to acquire the information necessary for establishing air quality standards. It is therefore, the standard may not be necessarily promising, nor based on sound scientific knowledge and information at the beginning. Therefore, it should be established somewhat arbitrarily, at the beginning, based on inadequate technical data together with a cautious safety factor. A set of interim standards to be established for a few years and another set of long-term goals should be established as and when reliable information become available. The long-term goal should be targeted to protect against all effects relevant to human health, esthetic, cultural, and social considering the economic cost benefits.

3.6 Conclusions

Once the air quality management framework exist, then modeling work can be undertaken effectively to assess the effectiveness of various pollution control policies and measures applied. The information to be made available is to include the area affected, forecast of the duration of the episode, and advice the health precautions suggested. The information should also be supplied to the media for inclusion in weather bulletins. This will help public to escape and adopt voluntary measures to protect them from air pollution.

Chapter – IV

Air Quality Management Plan

4.1 Transport Sector

Transport sector has emerged as the largest sector for contributing a large amount of pollutants into the atmosphere especially in urban areas. Policies and technologies that target to reduce emissions from the vehicular sector are keys to address air pollution problem in urban areas. It is furthermore essential to develop a management plan based on functional strategies to persuade the conceived policies into the reality. Fuel quality and engine condition significantly influence the level of vehicle emissions. To arrest this escalating problem, a concerted effort with public involvement is essential. Awareness of the issues, proactive policies, economically affordable standards and technologies and effective enforcement program are fundamental elements in an air quality management plan.

Leaded, substandard and adulterated fuels, poor traffic management, a large number of old vehicles with inadequate infrastructure to accommodate them, and a poor state of vehicle maintenance are consequential reasons for a high level of vehicular emission in urban Nepal. The goal of vehicular emission control program is to reduce emissions from motor vehicles in-use to the degree necessary to achieve ambient air quality of a city or the country to the practical limits of technological, economic and social feasibility. In order to accomplish this goal, emission standards for the motor vehicles require to be established, monitoring program should be designed and executed to enforce acquiescence with these standards, and to check vehicle usage wherever is practicable. The emission reduction goal should be achieved in a manner, which is equitable with respect to the population group affected, and where direct trade-offs between alternative cost-effective approaches exist. Consequently, to bring the vehicular emissions at the desired national level, a multi pronged strategies needs to be developed and implemented with active participation of government, non-governmental and private sector as well. Emission control program focussed on the "end-of-pipe" technologies along with the introduction of cleaner vehicles needs to be focussed in order to obtain the desired results.

4.1.1 Appropriate Emission Standards

There exist slight variations on the emission standards established by different countries in the world. Information on ambient air quality, emission sources and their magnitudes, meteorological characteristics and the extent of public exposure are the key factors required for the establishment of motor vehicle emission standards for cities. Except in Kathmandu Valley, these factors are not precisely known in all other urban, urbanizing and industrial areas of the country. Kathmandu Valley Vehicular Emission Control Project (KVVECP) conducted emission tests for diesel and petrol vehicles in the Valley and suggested emission limits for diesel and petrol vehicles. Test result of petrol vehicle showed that 51 per cent four-wheelers, 77 per cent three-wheelers and 62 per cent two-wheelers were found to be within the limit of three per cent (by volume) CO exhaust emission (Joshi, 1993). It was found that only 4.8 per cent diesel vehicles were within the smoke level of 65 HSU and 13.8 per cent in the range of 66 –75 HSU. Based on these findings, the project recommended emission limit of 75 HSU for diesel vehicle under free acceleration condition and three per cent CO by volume for gasoline vehicle during idle condition (Mathur, 1993). Limits for vehicular emission, however, were introduced to 65

HSU for diesel and three per cent CO for gasoline vehicle and enforced for the first time in June 1995. Smoke limit for diesel vehicle was later relaxed to 75 HSU for the vehicles manufactured till 1994 and CO limit for gasoline vehicle to 4.5 for four wheelers manufactured till 1980 in 1998. As this relaxation came quite recently, it is impractical immediately to lower the emission standards to the previous limits. However, there should be a periodic program to re-evaluate the limits due course of time and set limits accordingly. The emission limit of CO from two wheelers vehicle has been fixed to 4.5 per cent by volume.

Information on air quality, extent of vehicular emissions, and vehicle characteristics are not readily available in other urban centers such as Biratnagar, Birgunj, Pokhara, Nepalgunj and Janakpur, where a significant number of motor vehicles have already been entered. Infrastructures for emission testing and monitoring facilities are yet to be developed in those and other urbanizing centers in Nepal. Without having sufficient base information, emission limits should not be decided and enforced in an ad hoc bàsis. It is, thus, suggested for other urban centers in Nepal that the prerequisite factors like air quality, types and extent of pollutants, emissions inventories, vehicle characteristics and meteorological parameters should be assessed first in order to decide whether the time has reached to start emission monitoring program. Emission limits should be decided taking local operating conditions in accounts. Testing mechanism should be developed and monitoring program designed accordingly.

Regulations governing the test of emissions are limited to Three- and Four- wheelers in the Kathmandu Valley. Unless emissions from Two-wheelers are monitored, it may be inadequate to have meaningful impacts on the improvement of air quality. His Majesty's Government of Nepal has already passed regulation for undergoing monitoring of Two-wheelers starting from August 1998 in the Kathmandu Valley, however, no such action was undertaken to date because of inadequate infrastructure for testing facilities and lack of procedural arrangements. Emission of HC from the gasoline vehicle is equally hazardous to human health. A preliminary groundwork, however, was already initiated during the Kathmandu Valley Vehicular Emission Control Project and further exercise is required for establishing HC emission limit for the Valley. Annex-11 shows the emissions limits and emissions monitoring in different cities in the world.

4.1.2 Institutional Structure Required

An especialized and responsible organization with a clear mandate and sufficient resources for air quality management is lacking in the country. An independent institution[1] should be established with sufficient authorities to coordinate activities and organizations, develop strategies and implement various programs for improving air quality and to prevent, control or abate air pollution from the different sources in the country. The proposed organization should be made responsible for carrying out the following functions.

- To work as an expert cell to monitor air quality (or to designate organization for monitoring work), regulate emission level of pollution sources, and lay down air quality standards.
- To lay down emission standards for vehicles and evaluate emission limits periodically.
- To qualify, coordinate, monitor and support private sector to undertake emission-testing work.
- To support program aimed at development of emission control devices/ techniques/ measures/ policies/ strategies and R&D efforts in collaboration with academic institutions, private firms, non-governmental organizations and international non-governmental organizations.
- To help organizing training and awareness program targeted to air quality improvement

[1] Details on Section 5.6.17

- To mobilize public opinion and generate public awareness and participation
- To plan and initiate futuristic pilot studies on the use of "Cleaner Fuel" and "Cleaner Vehicle" being tried/introduced in other countries
- To advise the government on air pollution control policies
- To designate air quality control regions and develop implementation plans for such regions
- To support, coordinate and run research and development projects
- To work as information center and publish annual reports of its activities
- To investigate public complaints and detect violations of regulations

Organization structure for the proposed organization should be small, swift and profesionalized. The composition of the board should have representation from various related governmental organizations such as Ministry of Industry, Transport, Health, Housing and Physical Planning. Experts in the field of air pollution, non-governmental, business and transport organization should have representation on the board. The Managing Director for the proposed organization should be appointed from free competition among the people who meet the pre-established criteria such as, excellent academic qualification at least post graduate in the related field of study, proven experience in the field, etc. This will help the organization functioning more on professional manner. The proposed organization should open its branch offices in other urban center as when and where need arises.

The following organizations are, at present, involved directly or indirectly to take part in transport related air pollution control and management activities.

- Traffic Police
- Municipalities
- Department of Transport Management
- National Bureau of Standard and Meteorology
- Royal Nepal Academy of Science and Technology
- Universities (Institute of Engineering)
- Non-government Organizations
- International Donor Agencies
- Private Organization and Private Workshop

After the establishment of the proposed organization, it should play a central role in coordinating and communicating the various activities and organizations for implementing different tasks, wherever it seems to be necessary and possible.

4.1.3 Analysis of Available Control Options

Using policy and technological options can control vehicular emission. The solution to the vehicular air pollution problem has to follow a multi-pronged approach, as it is a multi-dimensional problem. The followings are a few widely used and proven options on addressing vehicular air pollution problems. These options are equally important and appropriate in Nepalese context.

4.1.3.1 Catalytic Converters and Unleaded Gasoline

Unleaded gasoline (ULG) was introduced in the Kathmandu Valley in 1997. Only a single petrol station used to sell ULG in the Valley. Apart from that, no other gas stations used to sell ULG in other parts of the country. Sale of ULG was negligible compared to the total gasoline consumption in the Valley.

Use of ULG eliminates lead emission from the gasoline vehicle because ULG does not contain lead on it. Unleaded gasoline is necessary for the vehicle that is equipped with Catalytic Converter (CC). A good three way CC can reduce the vehicle emissions of HC, CO, NOx up to 80 per cent as compared to similar vehicle without it. Equipping CC in old vehicles causes problem especially in those places like Nepal, where skills for its repair and maintenance are yet to be developed. Taxis and cars make a significant share on total vehicular fleets in the Kathmandu Valley and, as well in other urban centers. Past vehicular growth trends show that the situation is expected to continue in future. This option has a large potential to mitigate vehicular emission problem. Nevertheless, it is important to make sure that CC is always used with ULG, otherwise lead compound on petrol causes damage to the catalyst present on the converter.

4.1.3.2 Inspection and Maintenance Program

The effectiveness of the inspection and maintenance (I/M) program depends largely on the age of vehicles and pollution control technologies used. Control of exhaust emission in new vehicles equipped with CC offers an important advantage of low emission. As a matter of fact, older and more polluting the vehicles, more effective the I/M program is. There is a large number of vehicles older than ten years in Nepal. Vehicles' test result showed that a large number of vehicles did not meet required emission limits in the Valley (MOPE, 1997). It infers the potency of the I/M program in nepalese context.

Mathur (1993) examined the effect of maintenance on diesel vehicles in the Valley and came out with a conclusion that a substantial amount of smoke reduction was achieved with simple and inexpensive maintenance measures such as changing or cleaning air filter, oil filter and adjusting injection nozzles pressure settings. Thapathali campus, Institute of Engineering (1993) during the Kathmandu Valley Vehicular Emission Control Project (KVVECP) also obtained similar results. It indicated that the national standard of smoke level for diesel vehicle could, therefore, be easily achieved by providing a proper and regular maintenance service. As in the case of smoke, I/M program was also found to be effective in reducing a significant amount of CO and HC emissions from the exhaust of petrol vehicle (Thapathali Campus, 1993). Proper maintenance not only reduces emissions but also economizes fuel consumption.

The practice of vehicle maintenance is almost similar in all other urban centers in Nepal. A well-run I/M program is, therefore, capable of achieving a significant amount of emission reduction from the transport sector. Successful I/M program is required for ensuring the catalytic systems continue to function properly during the entire vehicles' life period.

Vehicle inspection program has already been started in Kathmandu Valley; however, no emphasis has, so far, given for maintenance aspect of the program. In its result, no remarkable achievement of emission reduction has been noticed. One of the great achievements of the program is, however, that the Valley people have shown their support to the program and are obeying the rules for undergoing vehicle testing for the emission. This much of achievement has a great value, which is enough for further designing more businesslike and effective inspection and maintenance program. There exists a large emission reduction potential on effectively designed and implemented I/M program compared to other emission control measures especially for the cities in Nepal because of a large number of old vehicles. Involving private sector in this program can create market for emission reduction in one hand and creates employment opportunities to cater the increased demand for vehicle maintenance. Executing an effective I/M program is always a challenging task and its success depends largely on the strong commitment of the implementing authority on the program.

4.1.3.3 Fuel Quality Improvement

Fuel quality has direct impacts on the emission level and correspondingly on the quality of air, as emission from the different sources is the direct consequence of energy use. Fuel quality improvement is one of the pre-requisites for executing an effective I/M program. There are several measures suggested for reducing emissions from the improvement of fuel quality. These are;

- Eliminating of lead content in gasoline without decreasing octane rating,
- Reducing sulfur content in diesel fuel,
- Supplying high cetane diesel fuel, and
- Prohibiting adulteration and contamination of fuel.

There has been an agreement reached between the Nepal Oil Corporation (NOC) and the Indian Oil Corporation (IOC), according to which NOC purchases finished petroleum products from the international market and sells to IOC. Nepal Oil Corporation in return uplifts various required petroleum products from IOC depots located near to Nepal-India border (Gautam and Associate, 1994). The petroleum products supplied by the NOC are exactly what the IOC delivers. It means that NOC receives an automotive fuel of Indian Standards (IS) and confirming to its quality. The Indian side is handling quality of petroleum products; therefore, NOC has a very little say on the first three matters mentioned above. These-days, some of the Indian refineries have stated producing unleaded gasoline and low sulfur content diesel fuel. Nepal receives unleaded gasoline from the Barauni Refinery, which is located near to the Nepalese boarder. So all the gasoline Nepal receives is unleaded. Though, the Nepal Oil Corporation has not made it public, it has been supplying unleaded gasoline in the country for quite recently.

Nepal Oil Corporation can only solved the in-country problems like adulteration in petroleum products effectively. Fuel adulteration appears to be an issue, though to date no comprehensive studies have dealt with this aspect seriously. It is not known at what point in the transportation or distribution process fuel is adulterated. Kerosene and diesel are both substantially subsidized, while gasoline is heavily priced in Nepal. The large price differentiation provides enough incentives for an individual to adulterate fuel. However, a step has already been undertaken to colour kerosene in order to reduce possibilities of adulterating gasoline with kerosene. Nepal Oil Corporation has maintained a quality control squad and has a provision of taking action against those who sell the petroleum products that cross the tolerance limit. Adulteration prohibits perfect combustion and deteriorates engine life further attributable to higher emissions. The objective of air quality improvement can be successfully achieved to some extent by supplying unadulterated petroleum products to consumers because it is one of the prerequisites for perfect combustion. The government owned Nepal Oil Corporation is the main and perhaps the single actor, which can play a lead role to control fuel adulteration.

In many cases maintaining fuel quality has lower cost implications and is far easier to implement than to modify fuel type. As a rule, improved fuel quality does not involve any engine modification and may even help to lengthen the equipment life.

4.1.3.4 Introduction of Cleaner Vehicles

Trolley bus, electric three-wheeler and LPG three-wheeler are alternative to the existing conventional diesel or gasoline vehicles. These vehicles are considered cleaner compared to the conventional ones and have already been introduced in the Valley. Technical feasibility of using electric vehicles depends on two major factors. The first is whether the electric power generation system has sufficient spare capacity to recharge batteries without building new power stations or disturbing the present generation capacity. The another is whether the current travel patterns are compatible with the characteristics of electric vehicles. Since hydropower supplies the major share on electricity in Nepal, zero tailpipe emission can be considered from the electric vehicles.

Technical feasibility of electric vehicle is ascertained with having a large portion of surplus off-peak electric power supply for recharging the batteries of the vehicles. Electric vehicles suit in most of the nepalese urban centers because of their short travel distance requirements and limited urban settlements. Kathmandu and Pokhara are, especially, suited for electric vehicles because of their driving patterns and geo-physical characteristics. Battery operated buses are being introduced in the United States of America and are operating in their fleet in some areas. India has also been operating electric powered buses. Bharat Heavy Electrical Limited (BHEL) has been manufacturing electric buses for about 14 years. Shaja Yatayat was considering adding a few electric buses on its passenger fleet in the Valley. This could be successfully operated financially if the government allows the private parties or Sajha Yatayat to decide the fare on actual cost-plus basis. Such type of tariff structure can replace a portion of traffic demand, which is being presently met by conventional vehicles.

Various types of electric vehicles, which can serve the transportation needs of the people, are available. These include electric three-wheeler to replace the diesel and gasoline three-wheelers, electric shuttle buses, electric minibuses, electric 3- or 4-wheelers for cargo, electric delivery vans, electric courier vehicles, and hybrid trolleys. The trolleys that could allow to use overhead wires where they are available and to extend their route using battery operated power.

LPG run Tuk-Tuks have been operating in Bangkok since a long time. LPG cars and buses are also being operated in some of the countries, such as Japan, Canada, etc. World has more gas reserve than that of liquid fuel. Now efforts are being made to convert liquid fuel vehicles into the gas-run vehicles or hybrid vehicles for two reasons. The first is that the liquid fuel resources are shrinking from the world and the second is that gaseous fuels emit lower concentration of pollutants than that of liquid fuel. Tuk-Tuks have been operating since the last three years in the Valley. LPG-run vehicles are, however, not zero emission vehicle and emit definitely more pollutants than that of electric vehicles. It means that electric vehicles are preferred to the LPG vehicles in general in emission ground but the battery disposal has also certain environmental implications. However, LPG vehicles are definitely better option than gasoline or diesel vehicles on emission ground.

Electric and LPG run three wheelers are operating successfully in the Valley. The economics of these vehicles' operation indicate that LPG three wheelers can compete easily with gasoline or diesel three wheelers at the prevailing price and tax system. Electric three-wheeler is a costlier option than the LPG and conventional gasoline and diesel three wheelers. Government can effectively control, encourage or discourage certain vehicle type with fiscal instruments. Rate liberalization could encourage the speedy dissemination of electric and other vehicles, which could displace personalized vehicular options to some extent. It is noteworthy to mention that additional supports and encouragement are essential to make the cleaner vehicle program a success, so that it would displace or replace the position that has been occupied by the polluting vehicles. The ground level air pollution problem is localized mainly in the city core where the traffic density is high. Policy that obliges only cleaner vehicle to operate in those areas can reduce the localized and ground level concentration of air pollutants from the highly polluting areas.

4.1.3.5 Cleaner Fuels

Emission of alcohol blended fuel is much lower in comparison to gasoline. Containing the oxygenated compounds on alcohol blended fuel, ensures better combustion. Nepal has huge amount of molasses, which is the by-product of sugar factories and it can be used for ethanol production. Ethanol is being used as a vehicle fuel in the different countries since a long time. Alcohol blended fuel has good future in Nepal, however, there is no concrete technical, environmental and economical studies conducted in this field. Thapathali Campus has been involved in the experimental research on ethanol since a few years. The primary findings of the study showed that Ethanol blend as a fuel was technically viable for the Kathmandu Valley and a substantial reduction of pollutants could be achieved.

4.1.3.6 Four Stroke Two-wheeler

Two-wheelers are the dominant vehicle type in Nepal and comprise about 55 per cent of the total vehicle. Among 2-wheelers, two-stroke vehicles are still the dominant types. Emission of pollutants from the two and four stroke vehicles is not the same. Concentration of HCs and CO in two-stroke engine is about ten and two times more than that of four-stroke engine respectively. Concentration of NOx in two-stroke engine is about one-half to one-fourth of the corresponding four stroke engine. There are almost similar customs duties and sales tax applicable for the two and four stroke two wheelers and consequently there is no marked price differentiation for two and four stroke two-wheelers. Two-wheeler has the largest share on total vehicle fleet and is expected to dominate even in future. It means that emission reduction from motorcycles can have a great impact on total emissions reduction from the transport sector.

Discouraging two wheeler with two stroke engine at one hand and at the same time encouraging two wheeler with four stroke engine has no additional national as well as personal cost, at the same time it saves the fuel consumption. Government policy regarding the permits and taxation system can regulate the use of proper type of two-wheelers.

4.1.3.7 Program for Workshop Strengthening

There are a large number of but insufficient and ill-equipped automobile workshops in the country. The quality of workshop is substandard in the Kathmandu Valley and as well in other urban centers. The survey work conducted by RONAST (1993) substantiated the fact, indicating that only eight to 10 per cent workers were skilled in automobile workshop in the Valley and about 17 per cent of workshops in the Valley didn't have a single machine to repair (Giri, 1996). The situation has not improved even these days. A large number of workshops are unregistered and operating without obtaining any permission from authorized agency. Repair and maintenance services are limited to cleaning the vehicles just from outer surface in many cases. Inspection and maintenance program can not be effectively implemented unless there are sufficient infrastructure for undergoing proper vehicle maintenance services.

vehicles. The ground level air pollution problem is localized mainly in the city core where the traffic density is high. Policy that obliges only cleaner vehicle to operate in those areas can reduce the localized and ground level concentration of air pollutants from the highly polluting areas.

4.1.3.5 Cleaner Fuels

Emission of alcohol blended fuel is much lower in comparison to gasoline. Containing the oxygenated compounds on alcohol blended fuel, ensures better combustion. Nepal has huge amount of molasses, which is the by-product of sugar factories and it can be used for ethanol production. Ethanol is being used as a vehicle fuel in the different countries since a long time. Alcohol blended fuel has good future in Nepal, however, there is no concrete technical, environmental and economical studies conducted in this field. Thapathali Campus has been involved in the experimental research on ethanol since a few years. The primary findings of the study showed that Ethanol blend as a fuel was technically viable for the Kathmandu Valley and a substantial reduction of pollutants could be achieved.

4.1.3.6 Four Stroke Two-wheeler

Two-wheelers are the dominant vehicle type in Nepal and comprise about 55 per cent of the total vehicle. Among 2-wheelers, two-stroke vehicles are still the dominant types. Emission of pollutants from the two and four stroke vehicles is not the same. Concentration of HCs and CO in two-stroke engine is about ten and two times more than that of four-stroke engine respectively. Concentration of NOx in two-stroke engine is about one-half to one-fourth of the corresponding four stroke engine. There are almost similar customs duties and sales tax applicable for the two and four stroke two wheelers and consequently there is no marked price differentiation for two and four stroke two-wheelers. Two-wheeler has the largest share on total vehicle fleet and is expected to dominate even in future. It means that emission reduction from motorcycles can have a great impact on total emissions reduction from the transport sector.

Discouraging two wheeler with two stroke engine at one hand and at the same time encouraging two wheeler with four stroke engine has no additional national as well as personal cost, at the same time it saves the fuel consumption. Government policy regarding the permits and taxation system can regulate the use of proper type of two-wheelers.

4.1.3.7 Program for Workshop Strengthening

There are a large number of but insufficient and ill-equipped automobile workshops in the country. The quality of workshop is substandard in the Kathmandu Valley and as well in other urban centers. The survey work conducted by RONAST (1993) substantiated the fact, indicating that only eight to 10 per cent workers were skilled in automobile workshop in the Valley and about 17 per cent of workshops in the Valley didn't have a single machine to repair (Giri, 1996). The situation has not improved even these days. A large number of workshops are unregistered and operating without obtaining any permission from authorized agency. Repair and maintenance services are limited to cleaning the vehicles just from outer surface in many cases. Inspection and maintenance program can not be effectively implemented unless there are sufficient infrastructure for undergoing proper vehicle maintenance services.

4.1.3.8 Vehicle Phase Out Program

Nepal has a large share of vehicles operating for more than ten years. Older vehicles operating specially on passenger services emit a large amount of pollutants into the atmosphere compared to the newer vehicles. Therefore; passenger bus, minibus, three wheeler and taxi should be allowed to operate for a specified period. However, older vehicles operating for personal use may not be emitting a large amount of pollutants if maintained properly. Emission level of personal vehicles is largely dependent on mileage covered, maintenance and driving practice and vehicle type. Therefore, vehicle phase out program for the vehicles operating on passenger services is the most necessary for reducing emissions from the transport sector in a meaningful manner. The vehicles owned by the government and corporation are generally not maintained properly and should target vehicles for phasing out from the pollution prone areas.

4.1.3.9 Emission Control Device

Emission control using control devices is relatively new and not widely demonstrated in Nepal. It is, hardly, known not only to the general people, but also to the people who deal automobile parts and run repairing and maintenance services. On initiatives of few private organizations, a few emission control devices have already been introduced and demonstrated in the Valley. One of the control devices is the Magnetizer, which powers up fuel and air by inducing opposite magnetic charges on air and fuel line in automotive engine respectively. Magnetizer has been marketed for about half a decade in Nepal. One of the one-time users of this device is Sajha Yatayat, which was able to reduce smoke level from its test-bus from 60 HSU to 28 HSU after using Magnetizer. The Royal Nepalese Army and the Telecommunication Corporation of Nepal also reported similar achievements in their test vehicles. The Royal Nepal Academy of Science and Technology (RONAST) tested Magnetizers in Kathmandu road conditions and reported that it reduced CO emission from 1.5 per cent to 1.2 per cent and HC emission from 1200 to 700 ppm. This product was also tested and certified by the California Air Resources Board (CARB) of United States of America in 1988. Magnetizer could reduce the smoke of diesel engine up to 80 per cent. In addition to emission reduction, it also economies fuel by 20 per cent of diesel use and 35 per cent of gasoline use. Apart from Magnetizer, there are some other emission control devices such as Fuelmax, ICM Petrol Shaver, Fitch Fuel Catalyst, etc. have already been marketed in the country.

4.1.3.10Urban and Transport Planning

Level of emission from the vehicular sector is also dependent on the road condition, traffic infrastructure and traffic management practice in the country. Planning on these aspects is largely determined by the urban planning practice of the country. Urban planning is related not only to a single sector, but related to the macro economic practice and plan of the country. Then the government should consider the air pollution aspects while planning an urban area. Since urban planning practice has yet to be effectively initiated in urban and urbanizing centers of the country, emission reduction through the land use and traffic planning may not be possible in near future. Emission reduction through the urban planning aspects is not within the capability alone of the specialized organization, which is proposed here for establishment.

The high dust levels in many urban center make a major contribution to air pollution, both directly and indirectly. Construction plays a part in dirtying the air. Dust problem is severe in many locations where roads are just graveled and not tar sealed. In many areas even blacktop roads are not well maintained or well sealed from the sides. Unless and until roads are properly cleaned, there will not be a marked reduction of air pollution caused by dust. The high level of dust affects the automobiles and further contributes the increased vehicular pollution indirectly. The clogging of air and fuel filters on vehicles, which has been shown through the practical research to be the most common cause of excess emissions. Overloading on the vehicle is also a major reason for higher vehicular emission.

Table 4.1 exhibits the comparative assessment of the different vehicular emission control measures.

Table 4.1: Comparative Assessment of Emission Control Options

Measure	Target Vehicles	Present Status	Effectiveness of Emission Reduction	Cost Effectiveness
1. CC	Passenger cars and taxis	ULG already introduced in Kathmandu Valley	Reduce about 80 % CO, HC, and NOx	Additional national cost for catalytic converters.
2. I/M Program	All	Emission limit has been fixed for 2-,3-, and 4-wheeler vehicles	Dependent on enforcement and monitoring program, effective if properly implemented	Significant amount of cost is required to implement effective I/M program.
3. Fuel Quality Improvement	All	Kerosene has recently been coloured	Prerequisite for effective emission control program	Almost no additional cost
4. Cleaner Fuels	Gasoline Vehicles	Research is going on	Substantial emission reduction potential	Ethanol could be cost-effectively available
5. Cleaner Vehicles	Three wheelers and minibuses	Electric and LPG 3-wheelers have already been introduced in the Valley. Trolley bus has been operating for about 26 years	Effective	Electric vehicles are costlier than conventional diesel and gasoline vehicles, but LPG vehicle is cost competitive.
6. Four Stroke Vehicles	Two and three wheelers	4 – and 2 – stroke have no different price for similar types	Effective to reduce CO and HC	No additional cost but cost effective due to fuel economy
7. Workshop Strengthening	-	No attention has given yet	Prerequisite for effective I/M program	Required some program cost but this cost is offset by longer vehicle life
8. Vehicle phase out program	Vehicles operating on passenger services such as bus, minibus, three wheeler and taxi, government, and corporation vehicles	No attention has given yet	Effective as new vehicles are environment friendly these days in general	Costly but cost may be offset by the fuel economy in general
9. Control Devices	All	Few devices are available in market	Yet to be verified in Nepalese condition	Additional cost of the devices, in many cases additional cost is offset by fuel economy
10. Urban and Transport Planning	--	Yet to be initiated effectively	Facilitate smooth vehicular operation	Associated with development cost

4.1.4 Implementation Strategies and Arrangement

In the preceding section 4.1.3, assessment on different emission control options has been made. A few of these emission control options have already been initiated in the Kathmandu Valley. Some of the programs have shown good results to some extent in mitigating emission from the vehicular sector and making public aware on emission control program. Some of the present programs, however, seem to be ineffective in reducing emissions from the transport sector. In this section, assessment is made on the implementation approaches and suggestion is made for formulating effective and workable strategies for the different urban centers of the country.

4.1.4.1 Catalytic Converter and Unleaded Gasoline

Unleaded gasoline has already been introduced in the Kathmandu Valley for two years. Initially it was sold through a single station in the Kathmandu Valley. There were a few reasons why it was not become so popular in the Valley at the time it was first introduced. These reasons were:

- It was supplied through only one station.
- Many people didn't know about ULG and its availability in the market
- People were free to choose between the two (leaded and unleaded gasoline) and there was no incentives for using ULG
- Unleaded gasoline was two rupees costlier than the leaded gasoline and the people feared that ULG was always costlier commodity
- CC was not readily available in the market

In comparison to other options, Catalytic Converter can indubitably be put in to use because ULG, one of the pre-requisite for CC, has already been introduced in the Kathmandu Valley. The government should come up with the rule that obliges the vehicles to use CC for the cars. The government regulation will create demand for CC in the market. Once the demand for CC rises, then there will be more and more dealer start supplying car with CC. It has the least implementation cost for the government as the market force itself adjusts with the requirements.

There are four types of vehicles namely; car, taxi, three wheeler and two wheeler that use petrol as fuel. Use of CC is not feasible for three and two wheelers, as catalytic technology is not well proven for these vehicles. There exists a large emission reduction potential from the cars and taxis fitted with CC. The regulation should come for all new cars and taxis registering inside the Kathmandu Valley. This regulation should not be enforced for the whole country at a once because it is not possible to have workshop to maintain CC in other urban centers. The Kathmandu experience can be gradually replicated in other urban areas such as Biratnagar, Birgunj, Pokhara, when and where the need arises. However, encouraging local dealer to sell CC definitely helps people to voluntarily use CC on their cars and taxis in other urban areas.

4.1.4.2 Inspection and Maintenance Program

The Valley Traffic Police (VTP) has been playing a vital role in inspection and monitoring of the vehicular emission in the Valley. Green stickers are issued to the vehicles that pass emission test and red stickers for the vehicles that fail to meet the emission standard. Vehicles with a red sticker are denied entry to government office complex and some of the city areas in the Valley. It is practically a single agency for implementing the entire I/M program. There is no other organization to look after the shortcomings of the program. One of the weakest points of the program is that the vehicle-testing program is totally isolated from the maintenance program. It is not within the capability of an organization like Valley Traffic Police, which is not specialized in pollution control and to handle such a big program alone. It will be inappropriate to handle emission control program, alone, through the Traffic Police in a long run. Traffic police can contribute significantly on emission reduction from better traffic management.

There should be three major components in any I/M program:

(i) Emission testing
(ii) Vehicle maintenance, and
(iii) Monitoring of vehicular emission.

It will be appropriate to separate the organizations for emission testing and monitoring of the program effectively and efficiently. It is pragmatic to delegate emission-testing authority to the private sector. The automobile servicing workshops should be encouraged to take emission-testing task. This will help to tie up vehicle testing program with their maintenance services. The present convention of green and red stickers should be continued. Vehicles, which pass the test, should get a sticker valid for a specific period. The proposed Pollution Control and Prevention Organization should control and coordinate the quality of private testing services. In this way, the proposed organization need not measure the emissions from a very large number of vehicles, but rather can ensure the quality of work of a very small number of authorized private testing centers is satisfactory.

Provision for a system of punishment, incentives, support measures, training and education to private testing centers and general mass as a whole would be a useful complement to this approach. A vehicle with red sticker should oblige to purchase permit from the center on renewable basis for a specified period. Under this arrangement, the proposed organization, in coordination with the traffic police, should stop vehicles with green stickers on suspicion or random basis to test their emission levels. If the vehicle with green sticker is found to be emitting an exorbitant amount of emission, then a justifiable and judicious penalty system should be developed.

The following procedures should be adopted to implement the effective I/M program.

- Establish emission limits for vehicles
- Qualify and license private testing centers to undertake emission testing task
- Give orientation and provide guidelines to carry out the task
- Decide price for the permit and issue permit for the vehicles with red sticker
- Conduct random spot checking for the vehicles with valid sticker whether testing is made properly
- Develop punishment and incentives scheme for the private testing centers

4.1.4.3 Workshop Strengthening Program

Inspection and maintenance program can not be effectively implemented unless there are sufficient infrastructure for undergoing a proper maintenance service. Workshop strengthening program is prerequisite for implementing an effective I/M program. It is largely dependent on the active participation of private workshops. Creating a market for vehicle maintenance can encourage the private workshop to strengthen their capabilities. Government support in terms of policy is required to improve the quality of service of the private workshop.

The following strategies will require for strengthening the quality of private workshop.

- Capability assessment of private workshop
- Grading of workshops depending on their capabilities
- Provide training and other supports to enhance their capabilities

There is not sufficient information on the number and nature of services being provided by the private workshops. The workshops should be graded according to their capabilities in terms of skills, equipment and infrastructure. They should be liberalized to set price for their services. Maintenance and servicing guidelines need to be developed and training programs should be conducted to impart them with knowledge and information on recent technological development. Experience on maintaining Catalytic Converter is non-existing in Nepal. The private workshop should be trained to maintain vehicle equipped with Catalytic Converter effectively.

4.1.4.4 Emission Control Devices

The vehicle owner has to invest additional cost depending on the vehicle type and the types of control devices used. Additional cost required for the device is offset by fuel economy and is justified financially for the users. Use of such devices depends on awareness program and the support of government sector on marketing of these products. Regulations required to maintaining vehicles below the prescribed limit encourage the vehicle owners to search and use such type of components. The emission reduction potential from the use of control devices is not precisely known and is largely depend on the types of the devices used.

4.1.4.5 Vehicle Phase of Out

Two types of strategies are recommended for implementing the vehicle phase out plan. These are:

- Automatic vehicle phase out at a specified time period
- Introduction of progressive tax system

Vehicles operating on passenger services relatively cover a longer distance compared to the vehicles of individual mode. A survey conducted in the Kathmandu Valley revealed that passenger bus, minibus; taxi and three wheelers cover on an average about 45000, 50000, 25000 and 30000 km annually. The privately owned car and two wheelers, on its contrary, cover on an average about 10000 km annually. Therefore, it is necessary to have regulations that makes passenger bus, minibus, three wheeler and taxi automatically phase out after 10-15 years of their operation from the cities which are prone to air pollution. The vehicle phase out program should be introduced in the cities like Kathmandu Valley, where air pollution has reached at the level of public concerned. Similar type of phase out plan should be introduced in other urban centers after carefully studied severity of the problem.

Generally, older vehicles emit more pollutants than newer vehicles. The vehicle phase out program may not be suitable for the vehicles owned by an individual and operating as an individual mode. This program does injustice to the owners who maintain their vehicles carefully and cover relatively a short mileage. A progressive tax system will be an effective instrument on discouraging running of old vehicle from the cities, which are prone to air pollution.

4.1.4.6 Fuel Quality Improvement

It has already been mentioned that nepalese side can only control fuel adulteration and contamination in the transmission and distribution system. Coloured kerosene is one of the solutions, which has already been initiated by Nepal Oil Corporation recently. The proposed organization should test the quality of the petroleum products and published report regularly so that the public will know about the actual situation of the fuel quality. This helps user to boycott the petrol stations that sell adulterated and contaminated fuels.

4.1.4.7 Cleaner Vehicle Program

Electric and LPG three wheelers are already being operated in the Kathmandu Valley. Electric minibus can be introduced to take a part of traffic load. The present level of government support and encouragement has been proved insufficient to attract large number potential investors. The following two types of strategies will be instrumental to attract a large number of cleaner vehicles in urban areas.

- Rate liberalization, and
- Declare cleaner vehicle zone

Rate liberalization will provide enough incentives for investors to operate electric three wheeler and electric mini bus services. In this arrangement, the operators should be allowed to fix the fare on their actual cost-plus basis. It relieves the government from providing additional supports such as tax holiday and subsidy in encouraging these vehicles. Operational cost of the electric vehicles is higher than the LPG vehicles, tax incentive for electric vehicles should, therefore, be provided initially for a few years time. LPG three wheelers are already proven cost-effective in prevailing conditions; however, establishment of standards taking safety consideration should be necessarily looked into before allowing operating in the urban areas.

Another strategy should be to declare cleaner vehicle zone only for electric vehicles in some of the city core and high-risk areas. Areas such as New Road and Putali Sadak, for example in the Kathmandu Valley, should be declared as cleaner vehicle zone. In such areas, no passenger vehicles (taxis, bus, minibus and three wheelers operating other than electric) should be allowed to operate. The area coverage under this zone should be expanded taking in account of number of people exposure, severity of the problem and furthermore feasibility of the scheme. This strategy may not be popular especially among the local resident of such locations at the beginning and may cause some inconvenience.

4.1.4.8 Cleaner Fuel

Sugar manufacturing is an important industry in the economy of Nepal. There are nine operational sugar industries (Parajuli and Dorfman, 1998). Sugar is manufactured in Nepal from sugarcane. Molasses, the by-product of the sugar factory can be used to manufacture ethanol, which can be used as an additive to gasoline. There requires two types of strategies to promote its use. These are;

- Techno-economic research to validate its use in nepalese context
- Awareness program to promote its use.

4.1.4.9 Promotion of Four Stroke Two Wheeler

Two wheelers are the most preferred transport option in urban Nepal. The Kathmandu Valley, alone, has more than sixty thousand two wheelers. The leading manufacturers in the world have stopped manufacturing two stroke and started manufacturing of four stroke two wheelers. Most of the two wheelers in Nepal are imported from India. Some of the Indian metropolis have restricted operating two stroke two wheelers on emission grounds. A few measures encourage the people to choose four stroke in between the two types of two wheelers. These are:

- Completely banning two stroke two wheelers
- Imposing higher tax rate on two stroke two wheelers

In comparison on these two options, the first is the more effective than the latter option. The banning of further registration of gasoline and diesel three wheeler was the most effective and cost effective policy option. Tax differentiation may not be effective in case if the sellers decrease the price exorbitantly low. The trend has been observed as most of the manufacturers want to dump their two stroke two wheelers at whatever the price they can get. The ban should be for urban centers only because two stroke are generally more powerful than the four stroke. The two wheelers, which shall be used in agriculture sector especially in terai region, should be given permission.

4.1.4.10Urban Planning

The short-term gains in the air quality are expected to arise from the application of the technical and policy options. However, the benefits of technical and policy options will operate effectively for a limited period before traffic growth counteracts the benefit. Concentration of suspended particles in air may not only relate to vehicular emissions. A recent study indicated that the concentration of TSP in Nepalgunj far exceeds the level of the Kathmandu Valley. Dust control and better traffic management strategies should be developed to address the air pollution problems in many urban centers. The local authority should integrate transport and land use planning which should emphasizes the need to reduce growth in the number and length of motorized journeys, encourage more environment friendly means of travel and reduce reliance on private car. Therefore, it is essential that the responsibilities of the government and municipality such as land use planning, transportation planning and economic development should be effectively integrated into a unified planning and decision making process for the urban areas. It is necessary for achieving a long-term gain on improving the air quality of the urban centers of the country.

Dust control from the street, better traffic management such as avoiding overloading in the passenger vehicles are some of the major measures seem to be necessary for reducing air pollution from the urban areas.

Table 4.2 summarizes the different emission control options alongwith the strategies for emission reduction, organization responsible to handle or implement the program and target vehicles for the respective options.

Table 4.2: Emission Control Options and Strategies for Emission Reduction

Control Option	Strategy	Responsible Organization	Target Vehicles
1. CC	1. Regulation urging vehicles to use CC	1. The proposed organization	Cars and taxis
2. I/M Program	1. Set emission limits and qualify testing centers 2. Random spot checking	1. The proposed organization 2. The proposed organization in collaboration with Traffic Police	All
3. Workshop Strengthening	1. Capability assessment 2. Grading the workshops 3. Provide training and supports	1. The proposed organization 2. The proposed organization 3. The proposed organization	-
4. Emission Control Devices	1. Promotion and awareness	1. The Proposed organization in collaboration with dealer, and suppliers	-
5. Vehicle Phase-out Plan	1. Automatic phase out 2. Progressive tax	1. The proposed organization 2. The proposed organization	1. Passenger bus, minibus, taxi and three wheeler 2. Individual vehicles, such as car and two wheeler
6. Fuel Quality Improvement	1. Testing fuel sample for petrol station	1. The proposed organization	-
7. Cleaner Vehicle	1. Rate liberalization 2. Declare clean vehicle zone	1. The proposed organization 2. The proposed organization in collaboration with municipalities	Electric vehicle
8. Cleaner Fuel	1. Promotion and awareness	1. The proposed organization in collaboration with academic institute and NGOs	Gasoline vehicles
9. Four Stroke	1. Banning further registering of two stroke 2. Imposing progressive tax system	1. The proposed organization in collaboration with the Transport Management Office 2. The proposed organization	Two wheeler
10. Urban and Transport Planning	1. Integrate with urban planning 2. Dust control 3. Traffic management	1. The government 2. Municipality 3. Traffic Police	-

4.1.5 Air Pollution Control Components

Emissions from the diesel vehicle contain mainly the total suspended particles (TSPs), carbon monoxide, hydrocarbons, oxides of nitrogen and sulfur dioxide. Addition to these pollutants, gasoline vehicle emits lead compound from their tail pipe. The level of emissions on these two vehicle types is different and is dependent on the modes of their operation, age, driving characteristics, road and the loading conditions. The effects of these pollutants on physical properties of atmosphere, animals, people, vegetation and economy depend on the level of their concentration and exposure duration. Table 4.3 shows the type of pollutants and their effects on human health and Annex-12 exhibits the details of health impacts from the air pollution.

Table 4.3: Air Pollutants and Their Health Effects

Pollutant	Health Concerns
Airborne particulates	Eye and throat irritation
Carbon Monoxide	Cardiovascular, nervous and pulmonary systems
Hydrocarbons	Various compound specific health hazards
Sulfur dioxide	Respiratory tract
Nitrogen oxides	Respiratory illness and lung damage
Lead	Retardation and brain damage in children

Source : United Nations (1994)

The emission reduction target should be directed to the pollutants, whose concentration has crossed the limit or approaching towards the limit. Smoke and carbon monoxide have already fixed for the air pollution control components from the transport sector in the Katmandu Valley as the concentration of these pollutants have already exceeded or are approaching to exceed in many locations.

Suspended particles that include the lead compound and carbon monoxide should be the target air pollutants in first category in the context of the Kathmandu Valley. As basic information required for undergoing emission control and prevention program are yet to arrive, it is too early to determine the air pollution control components for other urban centers in Nepal.

4.1.6 Public Involvement and Awareness Program

Emission reduction program can not be effectively launched or implemented without the active participation and support from the private and NGO sectors. General people are usually neglected on emission reduction program. In many cases, general people are not well informed on the technological choices, emission control devices, measures and options that help controlling emission from the transport sector. A large number of people in the Valley are, still, ignorant about the unleaded gasoline and its availability in the Valley. For many people there is no difference for two and four stroke two wheelers in terms of emission. A lack of awareness among the both private and government vehicle operators of the adverse environmental and economic effects of poor maintenance was also revealed by the study conducted by the Thapathali Campus (1993). The awareness program that conveys the message that it pays to maintain vehicles helps implementing effective I/M program. For successful environmental protection work, the public must be both informed and involved. It is, therefore, that information regarding the environmental matter must be made widely available. Information on environmental matters is mostly disseminated through the press, radio and television. It is an important duty of the proposed organization to supply the various information sources with factual material. The authority must take part in the public debate on environmental issues.

Non-governmental organizations can effectively monitor the loopholes of the program. There are an NGOs involved in monitoring of air quality in different urban centers. Even some of the NGOs are involved in informing the people about the severity of problems and educating on various environmental aspects. Sagarmatha Radio and Nepal Environment and Scientific Services (Pvt.) Ltd. (NESS) are involved in informing the air quality of different places of the Kathmandu Valley. Leaders Nepal, an NGO, has recently published results of air quality monitoring of different locations of the Kathmandu Valley, Biratnager and Nepalgunj.

The following awareness program is important for implementing effectively the air pollution prevention and control program.

- Make the people aware on use of unleaded gasoline and Catalytic Converter
- Make the people aware on availability of unleaded gasoline in the market
- Convince the people for the need of inspection and maintenance program
- Make the people aware on choosing the workshop, which maintain the vehicle properly
- Make the people aware on maintaining their vehicles as per maintenance schedule
- Make the people aware on emission control devices available in the market and on their emission reduction potential
- Make the people aware on the petrol stations that sell the unadulterated fuel
- Make the people aware on promoting electric vehicles
- Make the people aware on the level of emission in two and four stroke two wheeler

The proposed organization in collaboration with non-governmental sector should be responsible for conducting awareness programs. Non-governmental sector should involve in monitoring of fuel quality of petroleum products sold by different petrol stations and make people aware on their quality. This will help general people to understand the quality of petroleum product sold by the different petrol station and to boycott the stations that indulge in fuel adulteration. NGOs have to play a remarkable role in the vehicle I/M program.

4.1.7 Further Research and Development Requirements

Air pollution control and prevention program is dependent on the information and knowledge base of many related parameters. There are a few activities undertaken before in the Kathmandu Valley and consequently a large number of base information are available for designing air pollution control and prevention program. There exist almost no substantial information on air quality related parameters in other urban and urbanizing centers in Nepal. A further research and development work should be targeted to generate adequate and reliable information to decide the level of program required implementing for combating the problem.

The following research studies will be helpful for implementing effective program related to attempt the air pollution problems.

- Information on air quality, vehicle parameters, transport characteristics, driving parameters and meteorological parameters
- Research on air pollution effect on health, physical and biological parameters
- Assessment of damage and its costs
- Suitability or appropriate scale for the mass transit system for the urban areas to abate the pollution control potential.

- Inventory of newly developed abatement measures
- Indoor air quality/pollution study
- Determine emission factor of different sources, review and update
- Establish appropriate dispersion model for major urban centers
- Study the possibility of alternative fuels such as ethanol, methanol, CNG, LNG, LPG, etc.

4.1.8 Educational and Training Program

Environmental awareness program should starts from the top creating awareness among the policy and decision-makers. Environmental protection subjects should also be incorporated with general education program. Elementary information on environmental protection should be provided as a part of education program at all levels to create an enduring awareness. The main purpose of introducing environmental education at university level is to equip young specialist with the knowledge that will enable them in their future work. Awareness among the personnel in operating level is equally important. Training for the administration of environmental protection programs and to enable personnel to consider environmental aspect of their work is also necessary. Most of the private workshops are facing severe problems with inadequate knowledge and information required for maintaining vehicles properly.

Training program on auto exhaust control policies, which include auto exhaust control strategies, monitoring network designs, criteria for air pollution standard, air resources management strategies and experiences sharing of other countries should be included in the training package.

4.1.9 Fund Raising Policy

Sustainability of the air pollution control program depends on the availability of financial resources to implement various activities targeted to emission reduction. Establishment of organization and developing management strategies, on itself, may not necessarily contribute significantly to implement the program practically in actual field. Fund raising for the program execution is pre-requisite for any workable management plan. Air pollution prevention and control program should, always, not depend on supports from external sources. The government may not be able to support full cost required for the program execution. Therefore, the program at least should be able to generate some part of its execution cost.

Internalizing environmental cost on vehicle operations and obliging polluters to pay for sharing the cost of air pollution control are justifiable policy measures to collect fund for executing the program. Determining actual cost of damage due to air pollution is very difficult and sometime may result exorbitantly high cost if every aspect is included. If unbearable cost is imposed directly to the polluters at the beginning of the program, it may impacts adversely on the success of the overall program and furthermore on the overall development process. It is, therefore, suggested to establish cost to attract increasingly number of people in the main stream of pollution reduction program. The following funds raising schemes is, thus, suggested.

- Selling of permit for the vehicles that obtain red sticker
- Progressive tax for old and two stroke vehicles

One of the good features of the program is that if there are more polluting vehicles in the street, more revenue collection is possible. The revenue, thus, collected can be further utilized to strengthen the program and in its result more effective program can be implemented. On other hand; if there are less polluting vehicles in the street, it automatically helps to achieve emission reduction objectives.

The funding mechanism should be made simple so that the polluters find easy to pay cost of the pollutants if they emit into the atmosphere. This program should be tied up with I/M program. The private testing centers should simply issue the red and green stickers depending on the level of vehicles' emissions. The vehicles, which get the red sticker, should be obliged to buy permit for running in the street for a specified period. On receipt of the payment, the proposed organization should issue yellow sticker. Emission levels of the vehicle depend on the maintenance practice, so the validity of the green and yellow stickers should be extended for six months. The validity period, however, can be periodically reviewed and decided taking the practicality of the program. Selling of the permit could generate a substantial amount of fund on one hand and on another hand discourage the polluting vehicles to operate and encourage the vehicles undergoing maintenance. The revenues, thus, collected directly help the proposed organization to meet some part of its regular operation costs.

The another mechanism for fund raising should be the progressive tax. The progressive tax should be applicable to the two stroke two wheelers that are already in operation, and old vehicles other than passenger bus, minibus, three wheeler, and taxi. The progressive tax should be applicable not in the whole country, but should be applied for the urban centers which are severely affected from the air pollution problems. The fund, thus, collected could help government to invest for the air pollution mitigation program.

4.2 Industrial Sector

4.2.1 Background

Air resource management strategy is still not included in the economic development criteria like plan, policy and program of His Majesty's Government of Nepal, despite localized problem of air pollution like in Kathmandu, is increasing throughout the country. Problems of air pollution have been realized at different levels but magnitude and extent of problems at national scale is still unknown due to data gaps. Even in the Kathmandu Valley complete information on damage due to air quality is lacking. Nevertheless, available information through sporadic monitoring reveals that urban air quality is inferior due to presence of suspended particulate matters. Continuos emission of unabated fumes comprising SO_2, CO and Pb emitting through either mobile or stationary sources is further aggravating the situation.

Risk of ambient suspended particulate matter to local communities needs to be timely considered at various level, particularly at planning and policy levels. Chemically such particulates may contain carcinogenic, mutagenic, or teratogenic elements or compounds such as trace metals, polycyclic aromatic hydrocarbons, and others. Sources of all these carcinogenic compounds are believed to the combustion of fossil fuels. Since they have a large latent period of carcinogenic symptoms on humans, people at the late age may have to allocate a huge amount to reserve the situation. Henceforth air resource management should be an integral process of economic development.

As of now, despite lack of management strategy for industrial air emission at governmental level, few industrial entrepreneurs have been initiating to manage or control their stack emissions. This may be due to (i) Public out cries against the dirty stacks, or (ii) Energy saving options. Nevertheless, initiation at industrial level is definitely an excellent example of industrialists' commitment to conserve air resources.

To this regard, Ministry of Industry's (MOI) two-fold strategy (Devkota et al., 1996) on industrial pollution management is still to be delivered. First strategy is known as pre-investment scheme, which comprises issuing of a license for industries to be established in definite area(s) – industrial siting mechanism. This is coupled with execution of environment assessment. The other strategy is environmental permit system – a prototype of command and control approach. However, the second strategy is in the state of confusion due to promulgation of environmental protection Act and Regulation. Both strategies are diluted with environmental Act and Regulation.

4.2.2 Air Pollution Control Technologies

Air pollution controlling system is a very complex because no single emission control strategy is a cure-all, equally able to control all types of emissions. Since both fuel and combustion processes are critical factors in the generation of emissions, no "one design fits all" technology can satisfy the diverse clients. However, today's air pollution controlling technologies fall into three broad categories;

- Pre-combustion
- In-situ, and
- Post-combustion

4.2.2.1 Pre-combustion Technologies

Pre-combustion refers to the characteristics of fuels before burn, which comprises using of the cleaner fuels. To this regard two possibility exists, either switching of fuels from dirty to clean: or modifying the fuels from pollution prone to non-polluting. In some cases, fuel preparation techniques like sorting, will help to minimize the undesired emission of fumes from the stack.

4.2.2.2 In-situ Technologies

In-situ emission control techniques aim to minimize or check the emission of stack exhaust by two ways, modification of either combustion equipment/technologies or processes. This may include cogeneration, fluidized bed combustion, low-NOx burner etc. In-situ technologies would server in dual concurrently. Reduction of emission and increment of burning efficiency are the major advantages of this sort of technologies.

4.2.2.3 Post-combustion Technologies

Since pre-combustion and in-situ technologies would provide partial solution to the emission of air pollutants, post-combustion technologies are evolving to comply the regulatory requirements. New breeds of technologies require to control or regulate the emission of different toxic materials. As of now, post-combustion technologies are developed according to the nature of pollutants, which include;

- Electrostatic precipitators - Particulates
- Fabric filters (bag house) - Particualtes
- Mechanical collectors - Particualtes
- Wet-scrubbing system - SO_2 + others
- Semi-dry scrubbing system - Acid gases + metals
- Dry-scrubbing system - Particualtes
- Non-catalytic/selective

Catalytic reduction system - NO_x control

4.2.3 Air Pollution Control Strategies

4.2.3.1 Conceived Scenarios

The country is progressing without any comprehensive air pollution control polices and strategies which, in fact, should comprise of integrated strategies to manage the entire sources of air pollution, such as vehicular and industrial sectors. Existing legislation simply mentions not to pollute air or should not exceed the designated standards. The conventional wisdom of so far enacted government Acts and Regulations is guided by the philosophy of " I say you do". This approach is not only costly and process oriented but also shifting the responsibility to other line agencies. Both regulations and regulatees need a long exercise to satisfy the processes, but output is rarely achieved or achievable.

The contemporary Acts and Regulation dealing to abate air-polluting sources is not only very superficial but also lack of comprehensiveness vis-à-vis co-ordination. Both Nepal Standard Act and Environment Protection Regulation are seeking to control air pollution by means of command and control approaches. Further working modalities are yet to publish. Nevertheless, the conceived scenario is that any of government authorities will set the so-called stack emission standards, and industries are expected to comply them. Otherwise, industries will be a subject of penalty.

Standard setting might not be a Herculean task because one can import neighboring standards without reckoning the local conditions. To this, a remark in Nepal Environment Policy and Action Plan is noteworthy. The Nepal Bureau of Standard and Metrology has developed a set of water quality standards. They are very similar to WHO standards, which are generally considered to targets for countries to strive to attain better than practical and implementable standards (EPC, 1993). However, the important question is compliance of these ready-made standards. In case of industries, it may cost hundreds to thousands Rupees to comply them. Otherwise, another easy way would be to externalize the cost of compliance to consumers. Henceforth, the ultimate victim of environmental standards would be the general people. The present thinking of command and control approaches is leading to this scenario. Subsequently people will suffer from both ways, i. e., ecologically and economically. In other words, in present context, cost of the desired products will be high if industries set the pollution control technologies; otherwise, people will suffer from the undesired products of industries, i.e.; industrial wastes.

4.2.3.2 Appropriate Policy and Strategy

<u>Policy</u>

The current state of confusion regarding to regulate the air polluting sources like industries is a result of lack of appropriate policy and strategies to manage industrial environment vis-à-vis other sources of environment pollution. Similarly, confusion exists in standard making, enforcing, legal responsibility and capability of the expected agency. Henceforth, a comprehensive policy cum strategy is anticipated in order to streamline the existing anomalies to regulate environmental pollution, particularly for industrial pollution management which should comprise of the following entities (Table 4.4). As of now, the only conceived approach is formulation of standards. This of course, will not be panacea of environmental ills in the country. In order to heal the wound it is imperative to develop and enforce both standards and market mechanisms concurrently.

Table 4.4: Entities of Environmental Policy

Policy Instruments	Coverage
Environmental Standards	e.g. air, water and physical standards
Regulating mechanism and institution	e.g. permission and independent institute
Market tools	e.g. charges, subsidies, taxes, refund, tradable permits etc.

In addition to these, the policy component should need;

- A fair political commitment to improve environmental quality,
- Consensus among different stockholders, and
- Healthy macro-economic status in the country

Strategies

Future strategies should aim to increase industrial productivity vis-à-vis to control environmental pollution. To this regard, a rational strategy is expected. The incoming strategy should realize that past mistakes and share international experiences. Macro-strategies include;

i) **Win-win approach**

The rationale behind the win-win approach, a preventive action, is to enhance the positive relation between development and environment, and those that break the negative links. In case of industry, energy, and environment; there are ample opportunities to be exploited for the betterment, despite energy pricing in country has not been benefited environmentally (Devkota, 1998). The philosophy of win-win situation can be translated into industrial energy use, which is the principal input for air pollution. For example, from the emission point of view, rice husk is a better fuel than fossil fuels because combustion of rice husk basically emits carbon monoxide and particulate matters; whereas that from fossil fuel releases a series of criteria air pollutants like Particualtes, oxides of carbon, nitrogen and sulfur plus other toxic elements or compounds. It is imperative to encourage relatively clean fuels like rice husk, which is also cost-effective to adjust pollution control technologies. In case of oil fired boilers, priority should be given to low-sulfur containing fuels and private market should be allowed to import such cleaner fuels. Otherwise, it would be irrational to think on sulfur tax if state monopoly is to continue to import the fuels.

ii) **Emission trade in a bubble**

The bubble concept is aimed to attract certain industries in a particular area, and then start the marketing of pollution within the limit of a bubble. In industrial districts, this system can be easily introduced, provided the full fledges enforcement of environmental rules in other parts of the country. The basic objective of bubble is to meet environmental goals at less cost. The scope of bubble may limit to the criteria pollutants, and not for the toxic or new types of pollutants.

iii) **Polluter-pays to Green Bank or Clean Air Fund**

First polluter pays should not be aimed to license for pollution. Otherwise, one should be ready cleanse them, which is virtually impossible. Henceforth strategy of polluter-pays is a penalty not to complying the Rules. The other crucial factor to levy the charge is not to increase the center revenue of the government. This amount generated in the name of environment should be exclusively for environmental purpose, particularly for industrial pollution management. To this end, a Green Bank would heal the wound, which would receive fund from all sorts of activities such as taxes, charges, deposits, etc. Obviously the Green Bank will be managed as a cooperative principle and major stakeholders should be the industrial entrepreneurs (50 per cent) along with government share (one third) and individual (25 per cent).

Further more, on national level, environmental taxation should not be guided to generate revenue only. Otherwise the system may be corrupted by the dishonest practice, and ignore pollution damage. Henceforth, a pollution taxation system needs to be tied up with other incentives such as subsidies (grants, soft loans or tax allowances) so that both the regulator and polluter will have a win-win situation (Devkota, 1998).

4.2.3.3 Agenda for Action

Managing the environmental quality is necessary, so is industrialization. Environmental issues should not be inhibiting factors for industrial productivity. The old-fashioned development versus environment paradigm needs to be substituted by a new environmentalism (World Bank, 1995) which recognizes economic development and environmental sustainability as partners. The hallmarks of new environmentalism are;

i) Set priorities carefully because not all problems can be addressed at once. Involve both citizens, and experts along with scientific norms.
ii) Explore win-win options, by adopting appropriate policies.
iii) Promote cost effectiveness
iv) Use market tools where feasible.
v) Economize on administrative and regulatory capacity.
vi) Set realistic standards and enforce them in order to avoid undermining the credibility of government.
vii) Work with private sector.
viii) Recognize the value of public involvement
ix) Build constituencies for change through education and awareness program.
x) Prevention is usually cheaper than cure, so incorporate environmental concern from the outset like economic policy making, including tax and regulatory policy, and even the national accounts.

4.2.4 Environmental Governance

4.2.4.1 Regulating Governance

Environmental degradation now looks quite different more complicated more intractable, subtler than it thought or assumed. Although the problems are most pressing, the contemporary efforts of the government are on zigzag routes. The spirit of Environmental Act and Regulation seems deviating from the main tract because of lack of a proper regulating agency. For instance, Ministry of Population and Environment simply set Rules and Regulations, and is dependent up on the line ministries to implement them. On the other hand, line ministries will try to implement with cautiously as it would not harm their primary objectives. Questions will arise, if Ministry of Industry (MOI) tries to be a regulating agency for industrial pollution because it may not be equally able to treat equally to both private and public enterprises. Since MOI owned public enterprises are dirty and environmentally inefficient, it is hard to believe that MOI's role will be fair. On top of these, NBSM one arm of MOI is designing industry specific discharge standards, and Department of Industry another arm of MOI is anticipating to issue environmental permit. In the prevailing context, role of environmental agency, i.e., Ministry of Environment is nowhere. There is no doubt that industrialization in Nepal's a must prerequisite to alleviate the existing mass poverty, and it is a top priority of MOI to advocate for this rather than environmental protection. Ministry of Industry as well as allied governmental agencies should not forget that, as of now, industries in Nepal are enjoying a state of frontier economy, which provides free resources and waste sinks. The disparity between means and ends of industrial pollution vis-à-vis maintaining the environmental quality must be checked. Henceforth, to streamline all existing anomalies on environmental crises on pollution, an independent environmental regulating agency should be established. The agency should be comprising of at least four fifth technical humanpower such as environmental engineers/ scientist, mechanical and automobile engineers, chemist/chemical engineers, ecologist etc. Its, mandate needs to be enacted by the parliament. It is suggested that the proposed regulating agency will be responsible to execute the following two basic tasks:

i) Monitoring the environmental quality and
ii) Enforcing the so-called environmental and allied Rules/Acts.

Other supplementary activities of this independent institute should comprise of:

- Working mandate with private sector in order to ease its work load and
- Research and development on technological reforms to abate pollution

4.2.4.2 Role of MOPE

There might be bureaucratic tussles in the central ministries to initiate an independent regulating agency on environmental pollution affairs. The mandate for new institute is limited to monitor environmental quality and to enforce environmental laws. Therefore, it will also serve as a technical arm of MOPE rather than competing with each other. Responsibility of MOPE will be enhanced, if it could be able to perform a role of national environmental manager in the country. This should be guided by the philosophy of transparency in total environmental governance. which includes consensus and confidence building in both rules making to enforce mechanism. MOPE, as an environmental manager should maintain a well-coordinated mechanism with line ministries. It should avoid too much ambition and too little achievement. On the other hand, it should not totally dependent on line ministries also. For example, MOPE would have trusted the line ministries to review EIA by themselves, and it should have taken the monitoring responsibility instead. However, the current practice is reverse of that. MOPE, similarly should have developed the working strategy with private sector and civil society.

4.2.5 Action Program

4.2.5.1 Standard

Air resource management actions are lagging behind due to gaps in many factors such as lack of comprehensive policies and strategies. Nevertheless, the piecemeal approach of different sectors is trying to pacify the public outcry. To this end, standards also act as a public satisfying tool regardless of their nature and enforcement. There is a temptation to copy stringent standards without further assessments like their enforceability, cost association, trade off between and among the parameters to control etc. The limited information available on the conditions of local industries compels to rethink the green campaign against them. A continuous emission of back soot from the stack of an industry is a paining factor to them regardless of its quantum and character. On the other hand, industrialists are also reluctant to realize their environmental nuisances. The common responsibility of all stakeholders to conserve environment is action-less either knowingly or unknowingly.

The dilemma of stack emission versus ambient air quality standards should be amicably settled by involving the concerned stakeholders. It is imperative to develop ambient air quality standards for criteria air pollutants like suspended particulate matter, oxides of carbon, nitrogen and sulfur based on the result of rapid monitoring at different airsheds. Industries would be better off to complying ambient air quality standards than the copied stack emission standards. In addition to the ambient air quality standards, industries should comply the following additional criteria.

i) Minimum stack height according to the type and nature of industries that may range 15 to 35 meter.
ii) Stack loss of industries should not exceed:

- 5 % for oil fired boilers
- 7 % for coal fired boilers, and
- 10 % for biomass fired boilers

Stack characteristics plus ambient air quality standards will undermine the need of stack emission standards for the time being, unless the country is self reliant to develop stack emission standards. The overall guiding principle of implementation of air quality standards is to encourage the resources efficient industries.

4.2.5.2 Target Oriented Awareness

Mass awareness is an integral process of any development programs. In case of industrial sector, awareness on resource efficient industrial operation techniques such as energy efficient boilers, albeit low stack loss, good housekeeping practices, cleaner production and waste minimization etc should be encouraged. Industrialists may campaign for further economic tax holidays if they internalized their waste.

4.2.5.3 Private-Private Partnership

Private-private partnership is an evolving strong force in order to manage industrial environment. This is a partnership between environmental professionals and industries. Industries requiring professionals' services on waste auditing, energy efficiency, cleaner production mechanism, environment assessment, end of pipe or top of the stack control technologies would obtain expertise from the market rather than in governmental corridors. Government should not hesitate to streamline the market on this regard. Moreover, there might be some temptations in governmental offices to establish a semi-governmental consulting agency in environmental discipline such as environmental assessment, energy related services, industrial waste auditing activities etc. This would be another misadventure because government should not duplicate its efforts that private sector is willing or providing the services. It would be better to the government to regulate or monitor than compete with private sector. Similarly, government should encourage the private sector to intervene the burgeoning problems. To this, government should have developed incentive as well as accreditation provisions so that there will not be any crises of confidence among the private sectors.

There are many areas where private sector would substantially contribute for maintaining good air quality vis-à-vis environment. For example, promotion of research and development of environmentally sound technologies is one prime area. As mentioned earlier, foreign technologies are unexpectedly expensive to our local economy, it would be better off for industries, should they be able to devise them locally. Naturally, government authorities may not finance for such activities. It is a question of trade-off among private sectors, and government is expected to mobilize them effectively and efficiently.

In sum, a new vision is required to manage industrial air emission as well as total industrial environmental quality management. It is imperative to develop a comprehensive policy cum strategy with definite responsibility of the line agency. On national scale, rules making may not be a problem but regulating them an essential concern. It is suggested to establish an independent environmental regulating agency with a clear mandate comprising the following entities (Table 4.5)

Table 4.5:- Emission Control Strategies for Industry Sector

Policy	Strategy	Relevant sectors/actions
Command and control plus market tools should be introduced concurrently	• Standards and charges, subsidies, taxes, refund etc. should be supplementary to each other	• Air pollution minimizing technologies or equipment • Energy efficient boilers • Stack loss should not exceed the designated level
Marketing of pollution	• Emission trades in an airshed bubble	• Industrial zones • A definite airshed
Polluter-pays to Green bank	• Polluter pays to revolving fund to be managed by industrialist	• Pollution prone industries. Encourage them to be resource efficient
Win-win philosophy	• Promote cleaner energy sources or relatively clean energy than dirty sources of energy • Encourage preventative measures • Ambient air quality standard in particular airshed	• Tax relief to clean sources energy like rice husk, and taxation to dirty energy like coal • Provide incentives to resource efficient industries • Convince the industries between difference of ambient and individual stack emission standards
Encourage private-private partnership	• Entrust the private sector for environmental services • Government agencies should limit to regulate them • Streamline the distorting market	• Environmental expertise requiring for industries such as boiler tuning, waste minimization etc. should be available from the market. Government shouldn't be tempted to establish a consulting agency of its ownership to compete with the private sector
Streamline on environmental regulating agency with clear mandate	• Established an environment protection board/authority	• An independent technical arm with total responsibility for monitoring pollution and regulating the polluting sources

4.3 Domestic Sector

Indoor air quality is determined by the type of fuel used and provision made for ventilation inside the kitchen. In urban areas, kerosene and LPG supplied about 80 per cent of the total cooking energy requirements and hence indoor air pollution has not become a major problem. In contrary to it, wood and biomass such as animal waste and agricultural residues contributed about 95 per cent of the total cooking energy requirements in rural areas. Indoor air pollution has, therefore, become a major problem in rural areas of the country. Studies have confirmed that Improved Cook Stove (ICS) could remarkably reduce the concentration of air pollutants by facilitating burning of wood and biomass fuels efficiently.

Indoor air pollution problems can be brought down through the following two measures;

- Cooking fuel substitution and
- Improving fuel efficiency

Application of the first measure is largely dependent on the economic status of the people. As the economic level rises, people start using kerosene and LPG and abandon using wood and other biomass fuels. A major portion of heat goes waste in traditional cook stoves and hence there exists potential for improving the fuel efficiency of traditional cook stoves. Different models of improved cook stoves have already been developed and introduced in rural areas of many developing countries, however, it has not been successful in Nepal because of the following reasons.

- Additional cost for ICS, which is sometimes beyond the capacity of rural household
- Belief of sacredness of fireplace
- Reduction in space heating requirements specially in winter
- Agena (Tri-pot Cook Stove) serves as a place for social gathering and which is not possible from ICS
- Difficulties for preparing animal food
- Limited scope for a diversified biomass consumption as ICS does not fit for different type and size of biomass fuels
- Reduction on smoke for preserving grain, rope, thatch roof, and elimination of smoke for keeping insects, and flies away
- Requirement of additional work and time for cleaning of stove and chimney.

Developing sustainable frameworks and strategies for making ICS program technically, socially and economically acceptable are challenging job. There needs a wide spread awareness and information of the advantages of ICS among the potential users. Alternative Energy Promotion Center (AEPC) has been instituted under the Ministry of Science and Technology (MOST) and formulating ICS promotion program on the assistance support of the Royal Danish Government. The proposed organization so in this regard can work together with AEPC to promote ICS dissemination program in rural Nepal.

Chapter-V

Legal Framework on Air Pollution Prevention and Control

5.1 The Government's Initiation

The problem of air pollution is not new in the country. It was well understood in 1972 in Stockholm Nepal's country paper points out the need to clean the air pollution of the city.[1] After the Earth Summit on Environment and Development at Rio De Jenerio in Brazil, Nepal has formulated and has been implementing several policies for the protection of environment at the national and local level. Accordingly, Environment Protection Council (EPC) is formed under the leadership of Rt. Honorable Prime Minister. The Council has initiated the formulation of various policies on environment protection and planning including pollution control program.

Nepal has been also participating in several international and regional meetings relating to wildlife conservation, national heritage protection, solid waste management; ozone layer protection; and environment conservation. In order to fulfill international environmental commitments, Nepal developed EIA guidelines for various sectors, enacted the Environment Protection Act and regulations as well as implementing various program and policies related to air pollution.[2] However, the situation has not changed, in fact the air quality is being worsened. Despite the government's recognition of the seriousness of the environmental pollution, commitment in international environmental commitments, formulation of the Eighth and the Ninth Five Year Plan, by and large there has been negligible efforts to control air pollution and to provide institutional arrangements to prevent and control air pollution.

5.2 Policy Measures Related to Air Pollution

It is hard to find specific policy formulated for prevention and control of air pollution in Nepal. Policies formulated for the purpose of protection of environment provide some provision for prevention and control of air pollution. The existing government policies related to air pollution are discussed and analyzed below.

5.2.1 National Conservation Strategy 1988 (2045 B.S.)

The National Conservation Strategy (NCS) recognized that increasing urbanization and an expanding industrial base are major contributors to air, noise and water pollution, and the quality of human life and health are adversely effected by such pollution.[3] In 1988, the NCS identified that no government policy or legislation exists concerning air, noise or water pollution. Ironically, the government has not enacted air, noise and water pollution prevention and control legislation even after the ten years of adoption and implementation of the NCS. The NCS recommends that the policy and legislation with respect to air, noise and water pollution include issues such as the following:

- Industrial effluent discharge, noise abatement standards, and correlative mitigating and/or preventive measures, and
- Establishment of an air and water quality monitoring and evaluation system.

The NCS strongly recommends that the National Council for the Conservation of Natural and Cultural Resources (the present Environmental Protection Council) develops, as a matter of

1 Keshav Poudel (1998), *Choking Under Smoke*, Spotlight, Dec. 11-17, 17.
2 Economic Survey (1996), Fiscal year 1995-96, (HMG, Ministry of Finance), 61.
3 *Cf.* Narayan Belbase (1997), *The Implementation of International Environmental Law in Nepal*, 81.

priority for early consideration and adoption by HMG, a policy and supporting draft legislation concerning air, noise and water pollution. Although the NCS does not specially mention ozone-depleting substances like CFCs, the air and water pollution recommendations cover every kind of pollutant, including GHGs. Nothing yet has been done, however, to implement these recommendations of the NCS.

5.2.2 The Eighth Plan 1992-1997 (2049-2054 B.S.)

The 'Environment and Resource Conservation' chapter of the *Eighth Plan* stipulates that studies on assessment of the existing situation will be undertaken in terms of water, air, noise and soil pollution in order to control them, for which basic indices will be prepared. Action programs involving appropriate technology will also be carried out to control pollution form various sources.[4] One of the policies of the Plan includes the formulation of air, water, noise and land-related pollution control management plans.[5] The Eighth Plan, like its predecessors, was implemented partially. Consequently, it could not contribute much in the area of prevention and control of air pollution. The vehicular emission standard was fixed during the Eighth Plan period but it has not been enforced stringently yet.

5.2.3 The Ninth Plan 1998-2003 (2054-2059 B.S.)

The Ninth Plan has identified the air pollution as a serious problem due to the rapid urbanization and has given attention to eliminate this problem. It has stressed upon the sheer need required for initiating environmental programs by generating people's participation and implementing existing legislation in order to enforce for national need.[6] The policy has also stated about the preparation of environmental health program to provide preventive health service and to disseminate knowledge to the public by minimizing the adverse impacts arising out of the environmental pollution.

Further, it has mentioned the establishment and implementation of emission standards on air pollution and appropriate management plan to check emission from industrial premises for the development of environment friendly industry. Likewise, it has stressed the need of making effective prevention and control program for air pollution caused by vehicles. The Plan further states the commitments for specifying air pollution standards (water, air and land), establishment of voluntary and mandatory policies and essential legal arrangements for the enforcement of previously mentioned standards.[7]

5.2.4 National Budget for 1998/99 (2049 B.S.)

In the National Budget Statement for the fiscal year 1998/99 has addressed the problem of air pollution and tried to take some measures to prevent and control it as suggested are, conversion of existing diesel three wheelers in electric (SAFA) and LPG (Tuk Tuk) tempo. For this purpose, government was to provide certain percentage subsidy and impose restriction on such diesel three wheelers within two years for the Kathmandu Valley. Despite these commitments, the government had allowed the license to import and register 500 diesel three wheelers. After the heavy pressure from public, government has withdrew the decision later.

5.2.5 Nepal Environment Policy and Action Plan (NEPAP)

Nepal Environment Policy and Action Plan (NEPAP) recognized that a growing number of people were exposed to pollution from industrial enterprises. NEPAP identified the following factors as contributing to this process:

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4 National Planning Commission (1992), *The Eighth Plan (1992-1997)*, HMG, Nepal, 635-640.
5 Ibid.
6 National Planning Commission (1992), *The Ninth Plan (1998-2003)*, HMG, Nepal, 249.
7 National Planning Commission (1992), *The Ninth Plan (1998-2003)*, HMG, Nepal, 255

- industrial plants inappropriately sighted close to population centers,
- insufficient emphasis given to fuel efficiency,
- little, if any pollution abatement equipment used for reducing emission, and
- lack of industry pollution standards.[8]

Moreover, investors often opt for the cheapest and the most polluting technology in an effort to maximize profit.[9] Similarly, vehicular pollution is hazardous to public health, and is increasing. Action plan of the urban and industrial section of NEPAP recommended the following, among others:

- encourage industrial enterprises to relocate industries away from population centers to special industrial districts,
- implement proposed pilot projects to improve industrial boiler efficiency, and introduce cleaner brick kiln technology,
- investigate mechanisms for setting up regular pollution testing of vehicles, and
- set up air and water pollution monitoring stations.[10]

Ironically, the above mentioned action plans have remained rhetoric only. If the policies, action plans and programs enshrined in the NCS, the Eighth and Ninth Plan, and NEPAP been implemented effectively, the air quality of Kathmandu and some other urban areas would have been much better.

5.3 Legislation Related to Air Pollution

Law plays an effective role in preventing and controlling pollution in a country. The question arises whether the prevailing Nepalese legislation is appropriate for prevention and control of air pollution. Are these laws stringent enough to cope with the present problems? The provisions of the legislation related to air pollution are discussed and critically analyzed below.

5.3.1 The Constitution of the Kingdom of Nepal, 1990 (2047 B.S.)

The Constitution of the Kingdom of Nepal -1990 envisages social, political and economic justice and protects life, liberty and property of the citizens. The values enshrined in the Constitution will materialize only if legal provisions and social requirements go hand in hand. The Constitution of the Kingdom of Nepal 1990 has various provisions related to the environment protection.

Article 26(4) stipulates that the State shall give priority to the protection of environment and shall take special measures for preventing further damage due to physical development activities and shall also make special arrangements for the protection of rare wildlife, forest and vegetation. Although Article 26(4) does not specifically mention pollution or air pollution, it indirectly refers to pollution prevention and control by stipulating "shall take special measures for preventing further damage due to physical development activities". The Directive Principles are only guidelines to the State and are to be implemented in stages through various legislation within the limits of the resources and means available in the country if the government wishes to do so. If the state does not enforce or implement these Directives Principles and Policies, any court cannot enforce them.

8. Narayan Belbase et.al.(1993), Nepal Environmental Policy and Action Plan Integrating Environment and Development, His Majesty's Government, Environment Protection Council, 38.
9. Ibid, 38.
10. Narayan Belbase et. al.(1993), Nepal Environmental Policy and Action Plan Integrating Environment and Development, His Majesty's Government Environment Protection Council, 55.

Similarly, Article 64 of the Constitution empowers the House of Representatives to constitute various committees such as "Human Rights, Natural Resources, Environment and Population. These committees have been set up and are functioning at present. However, the Natural Resources and Environment Committee of the House of Representatives is ineffective compared to other Committees. It has the potential to provide effective legal measures and monitor the effectiveness of the government program for prevention and control of air pollution.

5.3.2 Civil Aviation Act, 1959 (2016 B.S.)

Section 3(2)(3) of the Act empowers government frame Regulations to regulate, prevent and control air pollution from aircraft. It states that government may frame any regulations to prevent environment from noise and air pollution from the aircraft. HMG has neither framed regulation nor used any discretionary power. However, the Act gives government extra power to act if it wishes to do so.

5.3.3 Nepal Mines Act, 1996 (2023 B.S.)

The objective of the Nepal Mines Act, 1996 is to organize mines and minerals and to maintain the economic welfare of the public. Sec. 13 of the Act provides that if the HMG deems fit in the national interest, it may make special arrangements for the excavation of minerals and their purification, sale and transfer instead of issuing a license to any person. The licensee is prohibited the excavation of mines and the construction of any building, factory or go-down within the range of fifty meters from the places demarcated for public and national welfare, town, burial places, cremation grounds, roads, embankments, cantonments, temples, mosques, churches, residential building factories etc.[11]. It also provides a special power and responsibility to HMG to ensure that the mining activities are performed without jeopardizing the interest of the local peoples. If the government feels that the mines, queries are not in favor of public interest, the government can break the contract by issuing a public notice, one-month prior.

Despite such broad powers of HMG, it has been found that the government has not acted in the best interest of public. A glaring example is Godavari Marble query, which has not been closed down even after public's opposition about the serious negative effects of the mining activities.

5.3.4 Nepal Petroleum Products Act 1983 (2040 B.S.)

His Majesty's Government may, from the point of view of national security, public welfare, historical significance or tourism development declare any area as a restricted area for petroleum works or permit petroleum works by prescribing terms and conditions. Section 5(1)(b) stipulates that petroleum works must be operated giving special consideration to security of life and property of peoples and without damaging forests and natural heritage and causing environment pollution. It clearly states the concern over the life, property and health of the public may caused by the petroleum products.

5.3.5 Mines and Minerals Act 1985 (2042 B.S.)

This Act was enacted in 1985 but to date the government has not issued a commencement notice. The Act has many provisions similar to the Nepal Mines Act 1966. It also contains significant provisions in favour of the public. The Act empowers the Department of Mines and Geology to restrict mining activities in any area of historical importance or where public welfare so demands. Environmental protection may be a precondition for the grant of mining lease. Departmental orders to control soil erosion, pollution etc. may be issued to existing mining operations. Sec 28 of the Act permits the government to frame rules to implement

11 Mines Regulations, 1961 (B.S. 2018), Rules 23 (b).

environmental control. This piece of legislation is probably the only legislation in the world, which was amended after of years of enactment without entering force. The Act was amended in 1992 but it has not entered into force yet.

5.3.6 Town Development Act, 1988 (2045 B.S.)

This Act aims at developing and extending existing towns with provision for necessary facilities and services. Section 4 of the Act provides for the constitution of the Town Development Committee. This committee is entrusted with the power of formulating and approving policy for town planning, making plans for the reconstruction and development of towns and determining land utility zones. For the purpose of the formulation of Town plans, the committee may, by public notification restrict the fragmentation of land and its physical change for a period not exceeding two years at a time, except with its prior approval.[12] Among the many other rights of the committee, it has the right to regulate, control and prohibit the use of agricultural lands, natural resources, and flora and fauna; to construct and extend building, settlements or housing complexes, provide recreational facilities establish markets and industries, maintain natural beauty and promote tourism; to check activities having adverse effects on public health, to contain environmental pollution and to manage roads, bridges, vehicles, forestation etc.[13].

5.3.7 Kathmandu Valley Development Authority Act, 1988 (2045 B.S.)

The Act has a provision of Kathmandu Valley Development Authority having authority to develop Kathmandu into a principal administrative, tourist, cultural and economic center. For execution of the physical development plan, the Authority may, from time to time by public notification restrict the unauthorized fragmentation and physical change of immovable property for a period of up to three years in the planned area.[14] Section 18 of the Act further stipulates that in order to execute the physical development plan, the authority may by notification regulate, control and prohibit the utilization of natural resources, archaeological, religious and historical places, Ailani land (Govt. land) and immovable properties; pollution of the atmosphere and adverse effects on public health, scenic beauty and tourist places. However, the Act is yet to come into effect.

5.3.8 Labour Act, 1992 (2048 B.S.)

The Labour Act provides security for a healthy, safe and secure environment for workers. It also tries to ensure solid waste management, control of air and noise pollution in the work area. It is required that five percent of the gross profit of any enterprises must be set aside each year with the purpose of arranging healthy places of residence for workers, such residences must gradually be developed.[15] However, it has been hardly monitored that how many enterprises have complied with this legislative requirement.

5.3.9 Pesticides Act 1992 (2048 B.S.)

To deteriorate the quality of the air, pesticides also play a vital role. As an initial step to control the unsystematic and unhygienic use of pesticide, the Pesticide Act, 1992 (2048) has been enacted. The Act has provisions to regulate, import and export, production, sale, purchase and use of pesticides. Similarly, the Pesticide Regulations 1994 (2050) has also been promulgated. The Act outlines the functions and duties of the Pesticide Committee. Among others, it includes the formulation of a national policy for pesticides, coordination between private and government sectors in the production and distribution of pesticides, and the establishments of quality control standards. The Act also provides for penalty of

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12 Sec. 8.

13 Sec. 9.1.4, 10

14 The Kathamndu Valley Development Authority Act, 1998, Sec. 7.

15 Sec 27. Labour Act, 1992 (2048 B.S.).

maximum Rs 5000.00. But the ineffective implementation of the Act has not been able to address the improper use, unsafe handling and disposal of date expired pesticides have making adverse effects on public health and poisoning and polluting the environment including air.

5.3.10 Vehicles and Transport Management Act, 1993 (2049 B.S.)

The Vehicles and Transportation Act is of prime importance and can play crucial role in controlling air pollution caused by motor vehicles. The Act has been enacted with a view to managing and regulating the traffic and providing convenient and effective transportation facilities to the public. Pollution has been defined to mean the pollution caused by smoke and sound emitted from vehicles.

Sec 14 (1) of the Act has made compulsory that any vehicles purchased or imported must be registered with the proper authority within fifteen days. Sec 14 (2) of the Act prohibits the use of vehicles without registration. Similarly Sec 17 of the Act requires the authority to test the vehicles, according to the criteria prescribed under section 23 of the Act, whether it is road worthy or not. Only after making confirmation, if it is roadworthy then the certificate of roadworthiness shall be provided. Section 23 of the Vehicle and Transportation Management Act, 1993 empowers HMG to determine standards in the following areas in order to ascertain whether a vehicle is roadworthy:

- mechanical conditions of the vehicle,
- length, breadth, height, make or appearance of the vehicle,
- amount of pollution discharged by the vehicle, and
- life span of the vehicle.

Under section 24 (c) the government is empowered to determine vehicular emission standard and enforce the emission standards so fixed. It is not essential to amend the Act for this purpose. Existing legal provision is adequate, provided the government is committed to prevent and control air pollution caused by vehicular emission.

Section 24(1) of the Act empowers concerned officer to refuse registration of vehicles in case when the previously mentioned criteria are not fulfilled. The Department of Transport Management (DoTM) may issue an order to any or all Transport Management Offices to withhold the registration of vehicles. This order may be issued when it deems that the registration of any vehicle should be withheld, pursuant to section 14, for the interest of the public with respect to environmental pollution, traffic congestion, road conditions or any other reasons specified under Section 24.

The powers, functions and duties of the DoTM are, inter alia, to conduct research into the economic and technical aspects of operation of an organized and effective transport service; to issue directives for proper management of transportation; to determine routes, fares and charges; to establish traffic signs according to international standards; and to determine the speed and weight of the vehicles. Sec. 157 also requires HMG may appoint a Transport Inspector to determine whether vehicles are driven in accordance with this Act.

Pursuant to Section 23, the government has set a emission standards to check vehicular emissions in the Kathmandu Valley. The government specified the following standards for diesel and petrol engine vehicles in order to control vehicular pollution in the Kathmandu Valley[16]:

- smoke density of diesel engine vehicles should not exceed 65 Hartridge smoke units (HSU), and

16 Nepal Rajpatra (Nepal Gazette), 2051/4/17 (Aug. 1, 1994)

- carbon monoxide emitted by petrol engine vehicles should not exceed 3 per cent by volume.

However, the aforementioned limit has been brought down to 75 H.S.U. and 4.5 respectively by the notification of HMG.[17] But the situation is different, the every two vehicles out of five fail the emission standard set by the DoTM but such smoke - bleaching monsters run freely in the streets of Kathmandu Valley unhinderdly. Non of three wheelers Vikram Tempos tested in March/ April 1996 passed the emission test conducted by Kathmandu Valley Traffic Office but these tempos can also be seen running along the road carrying the green stickers.[18] There is lack of coordination between DoTM and Traffic Police Office. There are several provisions in the Act to control and regulate the vehicles. However, ineffective management and implementation of law are the main barrier to achieve the aforementioned goal of the Act.

As long as the government relaxes the emission standards arbitrarily without scientific backing, one cannot expect effective control of air pollution caused be vehicular emission in the Kathmandu Valley. Similarly, the government needs to curb all the malpractice in the transport sector. In this regard, HMG has decided to impose ban on diesel three wheelers (tempo) within the valley effective from September 18, 1999, which is a significant step to reduce burning condition of air pollution that the government has taken.[19]

5.3.11 Industrial Enterprises Act, 1992 (2049 B.S.)

If industries are not located properly, their existence could be problematic to environment and hazardous to public health. Taking into account this fact, Industrial Enterprises Act was promulgated to regulate and develop industries in a systematic manner to create employment, development, economic prosperity, protect public and national interest. The Act is applicable throughout the country and its provisions can be applied to control the establishment of unwanted and hazardous industries in the country. Section 9 of the Act requires the Industries under the schedule 2 obtain license for the establishment, expansion and modernization. The Act categorizes such industries as affecting public health and the environment. Industries producing cigarettes, beer and alcohol, pulp and paper, cement, bitumen, fertilizer, pesticides, petroleum products and leather goods fall under this category. Although the Act requires the promoters of the industries mentioned above to acquire a license before establishing such industries, it does not require the preparation of an environmental impact assessment, and impact management plan.

Sec 12 of the Act establishes a high-level Industrial Promotion Board under the Chairmanship of the Minister of Industry. The responsibilities of the Board include the promotion of ways and means for the prevention of environmental pollution by emphasizing the avoidance of negative effects on the environment and public health. Despite its broad power, the Board is ineffective and unable to regulate the air pollution caused by industries. To date, industries are not required to establish treatment plant and emission control devices to treat emission and waste discharge. However, Section 15 (k) of the Acts provides that if any industry invests in equipment or process necessary for controlling and minimizing effects on environment, 50% of such investment may be reduced from the net taxable income. If this provision is implemented properly it can make significant contribution to control and regulate the air pollution caused by the industries.

The Industrial Promotion Board Chaired by the Minister for Industry and Labour (in its 105th meeting held in August 1994) pronounced serious reservations regarding the centralization of industries in the city areas. These guidelines are as follows:

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17 Nepal Rajpatra (Nepal Gazette) 2054/9/28 (Jan.14, 1998).

18 Poudel, above, note 8, 16.

19 This decision was made from the Cabinet meeting dated July 20, 1999.

a) The industries to be established inside and outside the Kathmandu Municipality are specified in Schedule 1 and 2. Only four categories of industries are permitted in the municipalities of the Kathmandu Valley such as:

- cottage industry, excluding dyeing and tanning;
- service industry;
- tourism industry; and
- manufacturing industry, food processing and electronic assembling.

b) Polluting industries other than those mentioned in the schedules can be established only outside the Kathmandu Valley and in other municipal areas, with proper pollution control mechanisms. However, such industries can be established at least 500 meters away from the places of tourism, religious, archaeological, and historical importance.

The Industrial Promotion Board in its 111th meeting, held on 6 Baisakh 2052 (19 May 1995), announced guidelines for establishing industries in the Kathmandu Valley. Five categories of industries are permitted in the municipal areas of the Kathmandu Valley such as:

- cottage industry, excluding tanning;
- tourism industry like travels, trekking and hotels;
- food processing;
- construction and transport industry like fly over bridge; office, commercial and residential complex; trolley bus excluding workshop and garage;
- service industry excluding chemical laboratory; workshop with machinery worth Rs. 200,000, wielding, cold storage, and hauling mills.

HMG required to take any of the following actions against any person for establishing any industry without obtaining permission required to be obtained under this Act or for non-compliance with the terms and conditions set forth in the license or certificate of registration or for violating any other provision of the Act:[20]

- to impose a fine in an amount not exceeding one hundred thousand rupees;
- to cancel the registration or the permission of the industry;
- to cause to close down the industry.

The Act provides very positive and progressive provision, which helps to control and regulate the air pollution caused by industries, if implemented properly. It states that "permission shall be granted for a reduction of up to 50 percent from the taxable income for the investment of an industry on process or equipment, which has the objective of controlling pollution or which may have a minimum effect on the environment. It further states such remission may be deducted on a lump sum or an installment basis within a period of three years.[21]

The Industrial Enterprises Act tries to control and regulate air pollution caused by Industries. Unfortunately, the implementation and monitoring part of the Act is very weak, ineffective and unsatisfactory.

5.3.12 Water Resources Act, 1992 (2049 B.S.)

The Water Resources Act 1992, for the first time in Nepal, makes an environmental study a mandatory prerequisite for water resource and electricity projects. Section 8 of the Act requires any person who desires to use water resources to submit an application to the

20 Section 25, Industrial Enterprises Act.
21 Section 15 (k).

prescribed authority along with an economic, technical and environmental study report. Unless the economic, technical and environmental study report is submitted to the prescribed officer, the proponent will not be granted a license to construct and implement a water-related project.

Under Section 18, HMG may fix and maintain quality standards of water resources with various uses. Section 19(1) empowers HMG to prescribe a pollution tolerance limit for water resources. Section 19(2) prohibits the proponent for use from exceeding the set pollution tolerance limits, pursuant to sub-section (1), with any discharge of waste including, among other things, industrial effluents, poisons, chemicals or toxic materials.

Section 20 stipulates that soil erosion, flooding, landslides or any significant impact on the environment must be avoided in all uses of a water resource. Under Section 22, penalties may be imposed for any breach of the Act or Rules made under the Act.

5.3.13 Electricity Act, 1992 (2049 B.S.)

Section 24 of the Electricity Act 1992 forbids causing any negative effect such as soil erosion, flooding, landslides, and air pollution, while generating, transmitting or distributing electricity.

5.3.14 Financial Act, 1993 (2049 B.S.)

The Annual Budget of 1993/94 approved by the Parliament has prohibited the import of more than seven years old vehicles in order to control environment pollution caused by vehicular emission and does not state the impose tax syllables for the same. It shows that the good intention of the legislature and HMG if implemented properly.

5.3.15 Environment Protection Act, 1996 (2053 B.S.)

The enactment of the Environment Protection Act is milestone step for the conservation of the environment. It is a comprehensive Act, which definitely help to regulate and control the pollution level of the country. The Act has defined the terms such as environment, pollution prevention and waste very broadly. It defines pollution means the activities that significantly degrade, damage the environment or harm on the beneficial or useful purpose of the environment by changing the environment directly or indirectly. "Wastes" means a liquid, solid, gas, slurry smoke, dust, radiated element or substance or similar other materials disposed in a manner to degrade the environment and 'Disposal' means the act of emission, storage or disposal of sound heat or wastes.

The Act does not define the terms air pollution separately but the definition of pollution, wastes and disposal are broad enough to include air pollution. Under section 7(1) of the Act, proponents are required not to cause pollution or to allow pollution to be caused in a manner which is likely to have significant adverse impacts on the environment or to harm human life or public health, and not to emit or discharge sound or radiation from any machine, industrial enterprise or from any other place where such pollution is above the prescribed standard. However, there is no time limit for the government to set environmental quality standards and to enforce them. Other government agencies are also empowered by this Act to impose appropriate conditions or to prohibit any activity that has caused significant adverse effects on the environment or which is likely to cause significant adverse impacts on the environment. [22] or which is likely to cause significant adverse impacts on the environment. If these provisions coupled with others relating to concessions and incentives are enforced properly, existing industrial facilities will be more willing to abide by the requirements of the Act and there will be little danger of them losing their comparative advantage and competitiveness. Further, MOPE is empowered to prohibit the use of any matter, fuel, equipment or plant which has

22 Environment Protection Act, 1996 s. 7(2) (Nepal).

significant adverse affects upon the environment or is likely to have significant adverse impacts on the environment.[23]

Ironically, the Act contains only one section dealing with pollution and this sole section aims to prevent and control pollution of air, water, land and noise pollution. It would be incorrect to say that the new regime reflects a blatant breach of a commitment to sustainable development and a disregard of environment conservation and the precautionary principle.[24]

The provisions and policies regarding EIA are also important in relation to clean air. The government endorsed National EIA guidelines 1993. Furthermore, sectoral EIA guidelines for industry, forestry and water resources (hydropower and irrigation) sectors have been finalized and are being reinforced. With the enforcement of the Environment Protection Act. 1996, EIA in Nepal is now legally mandatory. However, the first amendment of the Environment Protection Regulations has weakened the EIA provision of the EPA through exempting certain large-scale industries from conducting EIA.

Rules 15 of the Environment Protection Regulations, 1997 requires that no person shall emit or cause the emission of noise, heat, radio-active material and waste from any mechanical means, industrial establishment or any other place in contravention of the standards prescribed by the Ministry by notification published in the Gazette. Rules 16 states that all-operating industries must submit an application and obtain a Pollution Control Certificate within one year from the date of commencement of these Rules.[25]

After receiving an application, the concerned body must conduct investigations. If it is found that the operation of such industry shall cause no substantial adverse impact on the environment, or in case if there is a possibility of reducing or controlling such effect, the concerned body must issue a provisional certificate to the applicant within ninety days from the date of receipt of the application prescribing for the period of one year.

The first amendment of the regulation has made the provision of provisional and permanent pollution control certificate. It further states that all operating industries must submit an application within 90 days after the commencement of these rules and those industries which had already registered but production yet not started or registered later must submit an application within 60 days to obtain provisional pollution prevention certificate after the commencement of these rules. While issuing the provisional or permanent pollution control certificates, the concerned body may prescribed or impose all or any of the following conditions.

- to install equipment needed to reduce or control pollution within the specified time-limit;
- to make a proper use of the pollution-control equipment that have been installed;
- to operate the industry during the prescribed hours only; to adopt specific measures to stop the concerned activity in cases where any activity within the premises of any industry is causing pollution;
- to adopt specific measures to control the concerned activity in cases where any activity within the premises of any industry is causing pollution outside its premises;
- to make available within the specified time-limit equipment needed for undertaking monitoring activities;
- to perform such functions in accordance with the other conditions as prescribed by the concerned body as essential in the light of the nature of the industry.

Rules 17 empowers the individual, institution, Village Development Committee (VDC) or Municipality affected by such action may lodge a complaint with the concerned body in cases

23 Cf. Narayan Belbase, *Asia Pacific Journal of Environmental Law* (1998), 69.
24 Ibid.
25 Environmental Protection Regulation (No. 16), 1997.

where any individual institution or industry does not control pollution or emits waste in contravention of the conditions or standards prescribed under the Act or these Rules. After the investigation, in cases the concerned body finds that any individual, institution or industry has not controlled pollution or has emitted waste in contravention of the conditions or standards prescribed under the Act and these Rules, it shall immediately issue a notice to control pollution or not to emit waste according to the prescribed conditions or standards.

The Rules also empower the concerned body to issue a notice to the concerned individual, institution or industry to take all or any of the measures to be adopted immediately for controlling or reducing pollution, or for not emitting waste; to use, operate, or improve any device or equipment; not to use all or any of the equipment currently being used or operated; to adopt the specified monitoring programs and submit a report to it; to adopt various alternative measures for controlling pollution and avoiding emission of waste; to develop an environment management system and furnish information thereof and to perform other functions which are deemed appropriate for controlling pollution and prohibiting waste emission activities.

In case any individual, institution or industry emits waste in contravention of the conditions or standards prescribed in the Act or these Rules even after being issued a notice prohibiting such action, and such action causes an adverse impact of the public, Rules 20 empowers the concerned body may remove such waste at its own cost and cost incurred from the violators with additional charge of 25 %.

5.3.16 Local Self-Governance Act, 1998 (2055 B. S)

The Local Self-Governance Act, 1998 (LSGA) entrusts municipalities with various responsibilities and rights with respect to environment protection. It clearly stipulates that municipality "must assist in the task of controlling water, air and sound pollution in the municipal area and protect the environment."[26] Except this provision, the LSGA does not mention specifically anything about air pollution but the Act has various provisions related to air pollution or environment. If the municipality wishes to apply some provisions of the LSGA, it can use those provisions to control the air pollution of the municipality. In particular LSGA requires the municipality to:[27]

- manage disposal of solid wastes and rotten things, keep courtyards and lanes clean and encourage ward residents to maintain sanitation;
- manage the public convenience and parking system;
- restrict or remove the public use of objects harmful for public health;
- restrict the sale or use of consumers goods for public health;
- plant trees in both sides of the roads and necessary area;
- fix the sites of the slaughter houses and manage them; and
- launch programmes for controlling river pollution.

5.4 International Convention Related to Environment

There are about 20 environment related convention to which Nepal is party. The following are the major conventions related to environment conservation:

- Treaty Banning Nuclear Weapon Test in Atmosphere in Outer Space and under water, Moscow, 1963, (Nepal ratified on 7 Oct. 1964).

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26 LSGB. Sec., 96.
27 Ibid. Sec., 96.

- Convention Concerning the Protection of World Cultural and Natural Heritage, 1972 (Nepal accepted, 1978).
- Vienna Convention on Protection of Ozone Layer, 1985.
- Montreal Protocol on Substance that Deplete the Ozone Layer, 1987.
- United Nations Framework Convention on Climate Change.
- Convention on Biological Diversity 1992.

There is no separate national legislation for implementing the international convention, which Nepal has ratified or acceded to. The Vehicles and Transport Management Act, Industrial Enterprises Act and Environment Protection Act provide the general framework. The government has always been reluctant to enact separate legislation for implementing international environmental conventions. If separate legislation is enacted to assure national implementation of conventions like Vienna Convention on Protection of Ozone Layer and the Convention on Climate Change it would certainly contribute to prevent and control air pollution.

Section 9(i) of the Nepal Treaty Act (NTA), 1991 concerns all matters in a treaty to which Nepal is a party by having ratified, acceded to, approved or accepted by Parliament. Section 9(1) of NTA specifies that when a provision of a treaty is inconsistent with the existing domestic laws, these laws shall be void to the extent of the inconsistency, and the provision of the treaty shall prevail as the law of Nepal. Section 9 (ii) of NTA also states that when any treaty to which Nepal has become a party, but which has not been ratified, acceded to, approved or accepted by Parliament, creates an additional obligation or burden on the Kingdom or HMG that requires the enactment of legal provisions, HMG shall, for the implementation of such a treaty, initiate timely processes to enact such laws.

International environmental treaties have contributed substantially to the development to environmental law in many countries at the national level. NTA explicitly provides for the primacy of international treaties over national law. International environmental commitments hardly make any sense to countries like Nepal. We are very willing to ratify international conventions but rarely fulfill the obligations arising from those conventions.

5.5 Issues and Problems

On revision of the existing legislation, it is realized that many agencies or institutions have been authorized or made responsible to prevent and control the air pollution, but there is a lack of coordination among these institutions. This, however, has created confusion among the authorities and provided an easy way for them to shift their responsibilities to others. The pathetic condition of the valley and urban areas due to air pollution is because of lack of commitment to enforce the existing rules, regulations, guidelines and the standards formulated.

Legislation is only the start, however. Regulations that govern the enforcement of laws also have to be developed and enforced. Those that are not properly enforced will have little impact, while those that rely on undue coercion will be either circumvented or incur high social costs in the form of popular opposition.

Environment policy is largely concerned with changing individual behaviour to discourage activities that pollute and degrade the environment. Legislation is the tool for implementing environmental policies, whenever special powers, rights or responsibilities need to be defined in law. It is necessary to clearly define what constitutes a polluting or damaging activity and what the punishments are for those who transgress. Laws are, however, only a tool; how laws are enforced is equally important.[28]

28 Nepal Environmental Action Plan, HMG/ EPC (1993), 63.

- Convention Concerning the Protection of World Cultural and Natural Heritage, 1972 (Nepal accepted, 1978).
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28 Nepal Environmental Action Plan, HMG/ EPC (1993), 63.

However, in the case of *Gyanu Chapagain vs Chief of the Excise office Bhairahawa and others*, the Supreme Court of Nepal has denied the petitioner's demand to refrain from the order issued by the Chief of the Excise Office, Bhairahawa prohibiting the import of more than seven years old vehicles in order to control air pollution caused by the vehicular emissions according to the Fiscal Act, 1992.[29]

There is no coherent legislative framework to control air pollution. Rather, air pollution control is spread over various statutes. For example, the Civil Aviation Act of 1956 contains a provision for the control of sound from aircraft. However, HMG is yet to formulate regulations to control aircraft sound. Even the Industrial Enterprise Act of 1979 had empowered the government to issue directives to industries in relation to environmental pollution and protection of public interest. However, neither environmental quality standards were developed for the industries to follow, nor, have any directives been issued to any industry. The Industrial Enterprise Act of directives has been issued to any industry. The new Industrial Enterprise Act of 1992 requires the Industrial Promotion Board to follow the ways and means for the prevention of environmental pollution with emphasis on the avoidance of effects on the environment and public health. Further, some of the very progressive pieces of legislation enacted have not been enforced even after 12 years of enactment. Examples are the Mines and Minerals Act of 1985 and Kathmandu Valley Development Authority Act of 1988. It is very surprising that Parliament has enacted the pieces of legislation with various aims. Amongst them to control and regulate the air pollution is also one. However, it has been not enforced yet.

5.6 Essential Elements for Clean Air Act

Like many other environmental issues, clean air is an extremely emotional matter, with people especially concerned about health impacts. Individuals who are exposed to or believe they have been exposed to carcinogenic chemicals have heightened worries. To a lesser extent, people become emotional because of concerns about the impact of air pollution on the environment.[30]

Human health is the driving force behind air pollution regulation. For example, over the centuries, the impact on human health and the fatalities resulting from the uncontrolled burning of coal have been enormous. Other air pollution similarly has significant health impacts. Thus, the primary objectives of clean air regulation should be promoting standards, which protect human health.[31]Human health protection should be the primary objective of air pollution regulation, until adverse health impacts are adequately controlled and should be clearly recognized as the governing force.[32]

In enacting Clean Air Act or Regulation, parliament or government should choose a technology forcing strategy which embodies a policy that polluters must invent (if necessary) the necessary control technology to meet applicable emission standards or close down.[33] It must be recognized technological or economic unfeasibility is not a legitimate basis for setting aside an implementation plan, which is otherwise sufficient to attain national air quality standards. However, the prerequisite should be to fix and enforce air quality standards. It has already been mentioned that existing Nepalese legislation do empower the government to fix and enforce air quality standards.

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29 Bhoj Raj Ayer (1999), *Law and Policy related to Air Pollution and Transport Management*, Nyayadoot, 29 (7), 49.

30 Timothy A. Vanderavers, Jr. (Editor-in-Chief) (1992), *Clean Air Law and Regulation*, The Bureau of National Affairs, Inc., USA, 3.

31 Timothy A. Vanderavers, Jr. (Editor-in-Chief) (1992), *Clean Air Law and Regulation*, The Bureau of National Affairs, Inc., USA, 3-4.

32 Ibid, 4.

33 Timothy A. Vanderavers, Jr. (Editor-in-Chief) (1992), *Clean Air Law and Regulation*, The Bureau of National Affairs, Inc., USA, 3-4.

5.6.1 Definition of Air Pollutant

The Act should broadly define air pollution. The definition should include: any solid, liquid or gas: energy including heat, radioactivity and electromagnetic radiation: any organism (whether alive or dead), including a virus; a combination of pollutants and others. The definition should help to identify such pollutants and regulate them. If the definition is limited, it will limit the scope of the legislation.

5.6.2 Sources of Air Pollutants

Source of air pollutants includes both stationary sources, typically industrial facilities such as power plants, and mobile source, typically automobiles and trucks. Historically, the problems of air pollution were almost exclusively associated with stationary sources. It is only with the expanded utilization of automobiles, airplanes, and other 'mobile' sources, that the current distinction became necessary. The stationary sources included any buildings, structure, facility or installation, which emits or may emit any air pollution. A system of vehicular emissions controls virtually requires a corresponding system regulating mobile source fuels and fuel additives. Unless both mobile and stationary sources of air pollution are addressed effectively, there may not be significant improvement in the air quality of Kathmandu valley.

5.6.3 Major Source

Any stationary source or group of stationary source that emits or has the potential to emit certain amount of pollution per year or more of any hazardous air pollution or more of any combination of HAPS. The Act should address and specify major sources of air pollution reflecting the condition of the said area to protect further pollution.

5.6.4 Air quality Standards

The Act should establish two kinds of national standards - called National Air Quality Standards (NAQS)- that should be designed to limit permissible concentrations of air pollutants: Primary and Secondary National Air Quality Standards. Primary NAQS are supposed to protect human health and Secondary NAQS are public welfare protection measures. These standards should be established after preparing necessary analyses to determine appropriate nation's air levels for various pollutants; and should be reviewed at specified intervals. The NAQS must identify the boundary of the area to which it applies; the beneficial uses to be protected; the quantifiable indicators or criteria to be used in measuring and defining air quality and the ambient air quality goals to be achieved.

We can set primary NAQS for sulfur dioxide (So_2), ozone (O_3), Carbon monoxide (Co), Lead (Pb), Nitrogen (No_2) and particulate matter (PM_{10}).

5.6.5 Local Air Quality Standards

The legislation should also provide for setting local air quality standards (LAQS), which need to be specified for the purpose of protecting local air quality where National Air Quality Standards do not suit to the air quality because national quality standards usually covers and suits for whole nation where air quality and air pollution level is in the serious stage. To protect the local air quality from preventing further decrease, LAQS is necessary.

5.6.6 Tailpipe Standards

Tailpipe standards are permissible emissions from a variety of new vehicles. These include cars, light duty trucks, and heavy-duty trucks. There should be also separate sets of standards that must be met after a vehicle has been driven for so many miles or for so many years. In addition, a number of ancillary requirements, such as emissions warranties and onboard diagnostics complement tailpipe standards.

A number of other elements are required to round out the statutory scheme for schemes. These include a system of penalties. testing and certification requirements. emission warranties, and manufacturer recalls. There should be also provisions concerning non road-engines and vehicles.

5.6.7 New Source Performance Standards

New source performance standard (NSPS) impose more stringent regulation on new and modified sources on the theory that such sources can meet standards that are more stringent. The statutory standard for such new and modifies sources is the best system of emission control.

5.6.8 Lowest Achievable Emission Rate (LAER)

LAER is the rate of emissions which reflects the most stringent emission limitation contained in the implementation plan of any district, village or municipality or the most stringent emission limitation achieved in practice, whichever is more stringent. No new or modified major stationary source can be located in a non-attainment area unless, among other things, it can achieve LAER. For this purpose, the Act need to contain provision of LAER, Maximum Achievable Emission Rate (MAER) and Average Achievable Emission Rate (AAER) to regulate all area of the country where the air quality may vary according to their sources. It will be disastrous to apply simply an uniform emission rate or standards to all because uniformity of emission standards will certainly check, prevent and control from further pollution in the most vulnerable areas but will permit to pollution unless exceeding the standard which will lead towards the further decrease in air quality posing serious health risk to the people of those areas.

5.6.9 Air Pollution Zone (APZ)

Air Pollution Zone refers to the area where air pollution level is worse and significant measures need to be taken to prevent from further decreasement of air quality, and improve the condition and limit the air quality within the tolerance limit. The Act should identify such air pollution zone and take necessary steps, measures setting emission standards. restricting entrance of air pollutants either stationary or mobile sources.

5.6.10 Air Pollution Free Zone (APFZ)

APFZ covers such areas where air quality is clean, healthy or still clean rather than APZ. If such areas are at the high rate of air pollution or is likely to cause further decreasement, Act should empower HMG in the recommendation of Central Air Pollution Prevention and Control Board (CAPPCB) to declare such areas as an air pollution free zones taking essential measures.

5.6.11 Nonattainment Area

Those areas whose pollutants exceed national standards should be designated as nonattainment areas. The essential feature of the nonattainment programme is its requirement for a permit to construct and operate new or modifies major sources in nonattainment areas. Air quality control region or a portion thereof, for which one or more of the National Air Quality Standards have not been met is nonttainment area and the Act should contain the provision of NAA.

5.6.12 Prevention of Significant Deterioration (PSD)

The objective of PSD is to protect areas having high quality air and to discourage the exportation of pollution from nonattainment areas to relatively clean ones.

The purpose of an air quality plan is to specify [illegible] applies is to be managed and improved, with the emphasis, to the greatest extent possible, on management of air quality of the region. An Air Quality Plan (AQP) may be the National Air Quality Plan, or a District Air Quality Plan, or Village Air Quality Plan, or a Municipality Air Quality Plan, or a Village or Municipality Air Quality Plan. The legislation should specially provide power to the Central Board to formulate and implement AQP.

5.6.14 Prevention and Control of Air Pollution

Main purpose of the Act should be the prevention and control of air pollution. For this purpose, various measures and models can be applied. Among them, fixing general duty to mitigate air pollution in which a person may only carry out an activity that causes, or is likely to cause, air pollution if he or she takes all reasonable and practical measures to prevent or minimize the pollution. The legislation should also prescribe activities that must obtain works approval and environmental permit, which requires various sets of requirements to be fulfilled.

5.6.15 Continuous Emissions Monitoring System (CEMS)

Monitoring equipment "used to sample, analyze, measure" should provide information on a continuous basis for recording a permanent record of emissions and flow. Such equipment should require for all" affected sources" unless it can be shown that an alternative monitoring system will provide information with the same precision, reliability, accessibility, and timelessness CEMS. The Act should include the provision of keeping continuous emissions monitoring system.

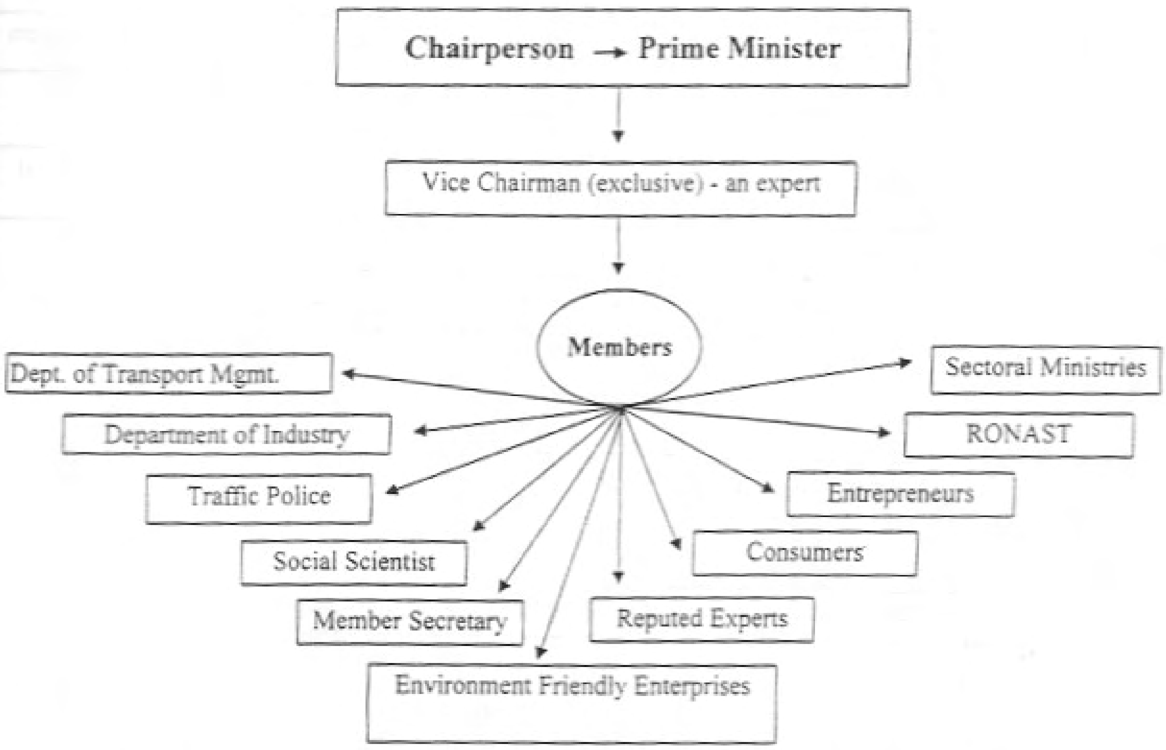
5.6.16 Strong Monitoring and Regulating System

For effective monitoring and evaluating system to the air pollution, Act should contain certain measures for effective implementation of the Act. For this, Act should specify the timeframe (period) to perform a duty or a responsibility laid down in the Act. Specifying the time period would compel responsible officials to fulfill such duties on time which will prevent further decrease of air quality, unwanted delay and further disaster that may happen or likely to happen from such inaction. Alongwith, specifying period for prescribed action or duty, officials should be made responsible for the damage or pollution caused from their negligence or recklessness or irresponsible activities. A provision of punishment should be incorporated in the Act making authority liable to punishment for their activities. And equally reward system should be incorporated in the Act for the better performance and effective compliance. In Nepal, we do not have compliance and monitoring system. It is pertinent to include some provisions for enhancing compliance and enforcement.

5.6.17 Organizational Setup

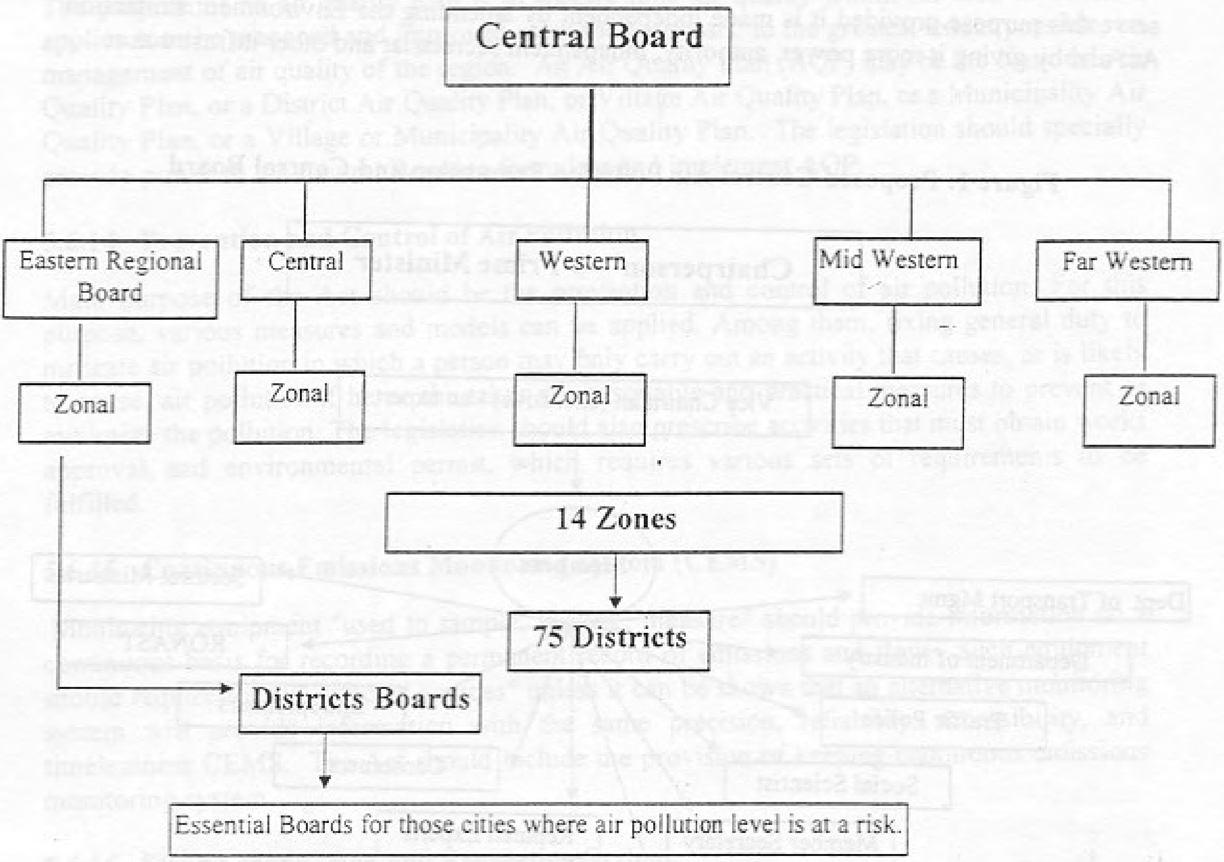
An independent, powerful and efficient institution should be setup in the center to monitor air quality; fix air quality standards; and establish coordination among the sectoral ministries, agencies, and other groups or organizations. The institution should develop strategies and implement them to maintain air quality with the view to ensure public health. It should be consist of experts, government authorities representing their sectoral ministries, departments, councils, RONAST, NGOs, and other individual experts. It should be clear that an institution under an existing ministry could not serve the purpose. Air pollution covers various spheres of life. So one sectoral ministry could not work effectively without the cooperation of others. An integrated approach should be adopted. So that, an institution not under any ministry but with representation from different relevant ministries, independent experts, NGOs and other stakeholders should be established. The Environment Protection Council (EPC) will probably serve this purpose provided it is made independent by amending the Environment Protection Act and by giving it more power, authority, independent secretariat and other infrastructure.

Figure 1: Proposed Central Air Pollution Prevention and Control Board



Prevention and control of air pollution is a regular process. It therefore requires regular functioning institutions at different levels mainly focused on those areas where air pollution level is high or is likely to be high. By its geographical complexity, Nepal inherits many problems, such as, availability of technology, information and expertise. For this reason, principles of decentralization should be applied in the air pollution related matter and existing geographical division should be followed. The proposed institutional set up is mentioned in figure 2. The figure follows the existing political and geographical divisions. Besides the Central Board, HMG should be empowered to set up boards where such boards are actually necessary to abate air pollution on the recommendation of the Central Board. It will be impractical to make mandatory to establish all the boards at once. Establishment of a board at regional and/or zonal level should be on the basis of seriousness of air pollution in the respective region and/or zone. However, the Central Board needs to be established immediately.

Figure 2: Air Pollution Prevention and Control Boards



The Central Board should make policy decisions, formulate policies, programs for prevention of air pollution and monitor and evaluate the functioning of regional, zonal or district level boards, as the case may be. The government should be willing to provide required human and financial resources including equipment and other infrastructure. It must be kept in mind that part time or voluntary board members appointed by political decisions will not to contribute to effective functioning of the Board(s).

Rights and duties of Central Air Pollution Prevention and Control Board

Undoubtedly, it is crucial to set up institution, which is fully responsible and empowered to prevent and control air pollution. No such institution exists today, which is solely responsible for the same. It is recommended that the powers and functions of the Board shall include:

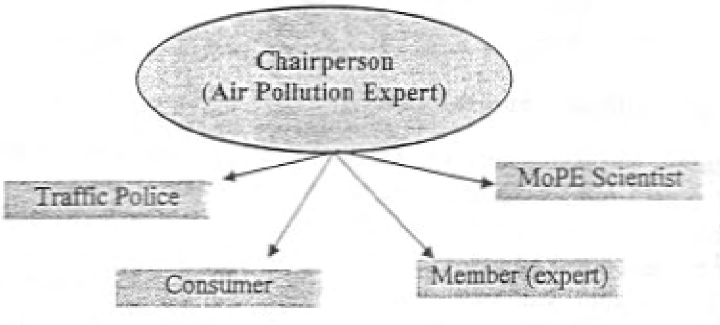
- declaring specified area as a clean area;
- declaring certain area as a vulnerable area for air pollution and restrict activities that may cause or likely to cause further damage, prohibit entrance of stationary sources of air pollution;
- setting air quality standard and enforce it;
- setting detecting mechanisms for compliance of those set standard;
- monitoring, evaluation, and assessment of those standards and compliance at regular intervals;
- identifying sources of air pollution and recommend for necessary action. If it is identified that certain industrial enterprises are likely to cause significant air pollution, in such case the Board should recommend to the government not to issue or renew license of those industries unless they adopt best available control technology (BACT) to reduce pollution level. If BACT is unable to prevent the problem the Board should recommend for closure of such enterprise;
- collecting and disseminating information related to air pollution;

- suggesting land zoning system for industrial area where the emission from industries could minimally harm to human beings and environment;
- empowering to prescribe emission limits separately for separate things like emission standard for vehicular emission, brick kilns, industries and so on;
- providing authority to set and enforce minimum, average and maximum air quality standards which to the extent possible, be consistent with WHO standards;
- working as an air pollution prevention and control central authority and regulating subordinate air pollution prevention and control boards, monitoring their performance and making them effective;
- imposing fines and punishment;
- settling disputes;
- promoting public participation in all activities;
- hiring experts for over all activities and monitoring compliance;
- recommending fuel quality for vehicle, industry, brick kilns and others, and prohibiting certain fuels which are highly polluting or likely to pollute;
- developing air quality plan and recommending it for enforcement;
- developing vehicle phase out programme;
- providing power to enter in any premises or places the board or inspector thinks that air pollution is at the vulnerable rate or thinks necessary to enter; and
- Developing and recommending incentives and disincentives; and
- Etc.

Expert Cell for Vehicle Pollution

Air pollution scientist should head the Expert Cell and other members should be from the MoPE, Traffic Police, Department of Transport Management and Consumer Organization to look after the overall activities of the vehicular pollution.

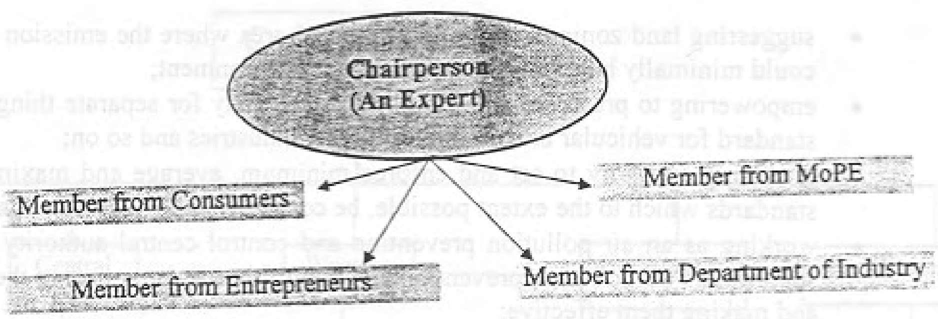
Figure 3: Expert Cell for Vehicle Pollution



A five member expert cell should be established for vehicular pollution under the Central Air Pollution Prevention and Control Board and other cells at different levels where boards are set up to abate, monitor, enforce and prepare programs to prevent air pollution from different sources. Among five members of the expert cell, representation should be different according to the focus of the cell, for example, if the cell for prevention and control of vehicular air pollution representation of Traffic Police and Department of Transport Management is essential and for industrial and pesticide pollution, Department of Industry and other related agencies need to be included.

While setting up expert cell for air pollution from industrial sector, preference should be given to members having scientific expertise.

Figure 4: Expert Cell for Industries



The Expert Cell for air pollution from industries should be made responsible for carrying out the following functions:

- work as an inspector to monitor air quality, regulate emission level of pollution sources;
- assess emission standards periodically;
- evaluate the existing programs and their compliance;
- conduct regular monitoring;
- promote public participation in emission check up and other program;
- provide technical know how through training and awareness programs to educate general public;
- advise and suggest appropriate air pollution control programs for the particular areas;
- recommend the Central Board to prohibit or impose restriction on such activities which are causing or likely to cause air pollution with the reasons thereto;
- provide technical support to the programs launched by NGOs or agencies for prevention and control of air pollution;
- take other activities to prevent and control air pollution; and
- Etc.

5.6.18 Offences and Penalties

The Act should identify and recognize such acts prescribe as offence which seriously damage air quality and long term and short term impacts on air quality and public health which include: causes or permit air pollution; intentionally, recklessly or negligently cause or permit air pollution; breach an industry specific, vehicular or other emission standards; breach an air pollution approval; carry out a prescribed activity without obtaining a works approval or environmental permit before doing so; fail to comply any requirements of direction or notice issued by board or HMG or Expert cell etc. Likewise penalties should be prescribed for those actions which are set in the list of offences in a practical manner which could be implemented and applicable for all, and not becoming over ambitious which is far from the implementation. However penalties should always be appropriate enough to deter potential offender.

5.6.19 Appeals

Anybody who doesn't accept the decision made by Board or authority and wants to seek further remedy to satisfy him, should have the right to appeal and challenge the decision on the legal and factual ground within 35 days of the decision in Appeilate Court. Under this right, an applicant may make appeal on works approval or environmental permit; temporary environmental permit, against a failure by the authority to make decision within the specified time frame; or penalties imposed by the Board.

5.6.20 Citizen Suit Provision

Act should include and recognize the citizen suit provisions to comply, and implement the legal provisions; to activise or fulfills specified duties to be performed by boards, expert cell or other concerned authority. In this context, it is noteworthy to say that CSP has been incorporated in the Article 88(2) of the Constitution of the Kingdom of Nepal 1990, and the Supreme Court of Nepal has recognized *locus standi* over the matter of public concern and interest, and several petitions have been lodged with the Supreme Court. So containing citizen suit provision in the Act will increase the prospects of the implementation of the act effectively.

5.6.21 Incentives and Awards

Act should incorporate the provision of incentives and awards (I&A) for the betterment of the environment and air quality and public health. I&A system encourages the polluters to reduce air pollution and promote environment friendly industries and vehicles. I&A automatically increases the rate of compliance of requirements and provisions laid down by the Act and other legislation.

5.6.22 Clean Air Fund (CAF)

A Clean Air Fund should be established at the center to act as a reserve fund. Donation received from various sources should be deposited in the fund. Government should also be required to provide certain amount from budget annually. The amount collected in the fund should be spent in such programs aimed at preventing and controlling air pollution and securing public health. In the long-run, the fund should also used to provide incentives to environment friendly industries.

5.7 Conclusions and Recommendations

With a historically low level of industrialization, Nepal has to had to concern itself with issues of air pollution; however, an increasing number of industries are being developed in sectors that do pose a threat to public health if emissions are not properly controlled. The Nepalese environmental legal system is yet to provide a regulatory framework and various incentives for pollution prevention. The legal system needs to:

a) promote pollution prevention as the principle of first choice in the governments regulatory activities,

b) encourage building a national network of prevention programs among government agencies, the private and public sectors,

c) develop partnerships, technological innovation and technology transfer, and

d) focus on pollution prevention rather than pollution control.

The following are some of the suggestions to prevent and control air pollution:

- Fix air quality standards, and more importantly put in place an effective enforcement system.
- Identify and specify air quality standards (minimum, maximum and average).
- Adopt cleaner technology and promote such technology, and identify alternative measures to reduce air pollution from existing industrial plants, vehicles and pesticides use;
- Implement and enforce the existing sectoral legislation that imposes some responsibilities to the government which government has not performed or fulfilled yet.
- Establish strong monitoring and assessment system for the effective compliance.

- Enact a separate Air Pollution Prevention and control Act or promulgate Air Pollution Prevention Protection Act 1996 by incorporating essential elements discussed in this report.

Enactment of a separate Air Pollution Prevention and Control Act or promulgation of a separate Air Pollution Prevention and Control Regulations under the Environment Protection Act 1996 will not be sufficient. The Bruntland Report has aptly stipulated that:

> The law alone cannot enforce the common interest. It principally needs community knowledge and support, which entails greater public participation in the decision that effect the environment this is best secured by decentralizing the management of resources upon which local communities depend, and giving these communities an effective say over the use of these recourses. It will also require promoting citizens' initiatives, empowering people's organizations, and strengthening local democracy.

Pollution control-related legal provisions are unlikely to be enforced effectively unless the local governments are involved in this process and incentives to pollution prevention and disincentives to polluting activities and processes are introduced. Pollution prevention in the most efficient way to environmental protection and to increasing efficiency of business. It must be remembered that pollution prevention also means moving way from the costly command and control regulation. Both the environment and industry stand to benefit immeasurably by preventing pollution at source. However, putting such a program into place requires improving existing laws and enacting new laws to enable business to recognize and obtain the rewards of pollution prevention.

A policy and legal framework for air pollution prevention should be developed and to assist industrialists in understanding the benefits of prevention of air pollution and adopting environmentally sound technologies that will enhance their productivity. The air pollution prevention and control legislation based on the principle of pollution prevention should be enacted and effectively implemented.

Chapter –VI

Conclusions and Recommendation

Population growth and economic development were two primary human related reasons that further contributed urbanization and industrialization. A large number of motorized vehicles and industrial enterprises were concentrated in a few urban and industrial centers. Use of different forms of energy increased in Nepal because of relatively a large number of industrial and vehicular operations clustered in certain locations. Though, air pollution problems have not caught much attention in other parts of the country, a few urban centers such as the Kathmandu Valley are severely facing the air pollution problems. Past trends showed that share of energy consumption in domestic sector was declining while the share of energy consumption was increasing on industry, commerce, transport and agriculture sectors in Nepal., A major portion of energy was used for cooking purpose in domestic sector. Biomass was the main energy source used in rural areas for meeting cooking energy requirements. Due to the result, indoor air pollution has become the major problem in rural areas. Industrial sector became the second largest sector besides the domestic sector on consuming a major share of total energy. A major share of petroleum products was utilized in transport and industrial sector. About 70 per cent of the total petroleum products consumed in Nepal were utilized in the Kathmandu Valley. Brick kilns, which used about 70 per cent of the total coal supplied in the Valley, contributed remarkably on air pollution problems in the Valley.

The overall annual growth rate of manufacturing establishments was 8.42 per cent from 1964 to 1996 in the country. The Central Development Region was the most prominent in manufacturing activities with a concentration of 56.76 per of the total manufacturing establishments. Kathmandu ranked first with 24.99 per cent of the total manufacturing establishments. Brick kilns, cement and marble factories were among the major polluting industries in the Valley. There were altogether 174 manufacturing establishments engaging 200 or more people and 72 establishments having the fixed assets of more than 50 million rupees in the country. About 70 per cent of the manufacturing establishments were concentrated in 10 districts and remaining 30 per cent in 65 districts in Nepal. A majority of pollution prone industries were located in nine districts of three zones namely, Bagmati, Koshi, and Narayani. Cement, leather, tanning, paper, pulp, soap, chemicals, sugar, khandsari, and textile industries fell into high priority categories of air polluting industries. It can be concluded that industrial establishments were concentrated in certain areas in Nepal and hence industry related air pollution issues were also confined into the certain areas or localities.

The population growth rate was 2.11 per cent in the country. The urban population was 2.28 million in 1991, which represented 12.32 per cent of the total national population. Population of the Kathmandu Valley increased from 0.25 million in 1971 to 0.662 million in 1991. The growth rate of Valley population was about 6.0 per cent, which was higher as compared to the national average growth rate of 2.11 per cent per year. Besides Kathmandu Valley; Pokhara, Birgunj and Biratnagar were among the fast growing urban centers in Nepal.

Transport sector was one of the largest sectors for contributing air pollutants especially in urban areas. There were 218,632 vehicles registered up to October 1998 in Nepal. The Kathmandu Valley occupied about 56 per cent of the total vehicles. Car and two-wheelers have been dominating the total vehicle fleet in Nepal and comprised about 22 and 51 per cent on the total vehicles respectively. Emission inventories from the transport and industry sector were not precisely known in Nepal. However, a few past studies estimated emission from the transport sector in the Kathmandu Valley. The yearly emissions of the total pollutants were in tune of about 40,000 tons in the Valley from the number of then operating vehicles. Carbon monoxide and hydrocarbons had the major share on total emission from the transport sector.

There already exist enough information on air quality in the Kathmandu Valley, which indicates the severity of air pollution problems. Lead particles were found as high as 6.08 $\mu g/m^3$ in some locations and foreseen that roadside dusts contained even a higher concentration of lead particles, far exceeding the acceptable limit of WHO guidelines value. Likewise, concentration of suspended particulate matters have surpassed WHO guidelines value for a prolong duration in most of the sites. Hourly rise or fall of pollutants' concentration has been observed in most of the airsheds because of imbalance between pollution production and pollution dilution rates. Concentrations of CO have surpassed WHO guidelines value in most of the locations in the Kathmandu Valley. Concentrations of other pollutants, such as NO_x, and SO_2 have not noticed exceeding the limit considered unsafe for public health viewpoints. However, concentrations of these pollutants are approaching the threshold limits in many urban airsheds, especially in heavy traffic sites in rush hours. Kathmandu City has always been compared to the highly polluted cities in the world. These facts recognized that the existing air quality of the Kathmandu Valley was unacceptable on health point of view. Concentrations of suspended particulate matters were also found higher in Nepalgunj. Consequently, environmental consequences are growing up prominently in limited number of urban and industrial areas.

Assessment of the quality of air has not been carried out systematically in Nepal due to lacking of appropriate air quality management system. In the absence of a well-defined monitoring network with specified monitoring objective, information so far obtained can not be further used to establish air quality standards and to develop model for predicting concentrations of air pollutants in different meteorological conditions. One of the most essential components of the air quality management strategy is to determine or setup organization for undertaking the monitoring assignment. It is very much essential to have an independent organization to coordinate activities and organizations, develop strategies and implement various programs for improving air quality in Nepal.

Leaded, substandard and adulterated fuels, poor traffic management, a large number of old vehicles with inadequate infrastructure accommodating them, and a poor state of vehicle maintenance were consequential reasons for a high level of vehicular emission in urban Nepal. Consequently, to bring the vehicular emissions at the desired national level, a multi pronged strategies needs to be developed and implemented with active participation of government, non-governmental and private sector as well. Emission control program focussed on the "end-of-pipe" technologies along with the introduction of cleaner vehicles needs to be focussed in order to obtain the desired results. The followings are a few widely used and proven options and measures for addressing vehicular air pollution problems. These options and measures are equally important and appropriate in Nepalese context.

a.) Catalytic Converters
b.) Inspection and Maintenance Program
c.) Workshop Strengthening
d.) Emission Control Devices
e.) Vehicle Phase-out Program
f.) Fuel Quality Improvement
g.) Cleaner Vehicles

h.) Four-stroke Two-wheelers
i.) Cleaner Fuels, and
j.) Urban and Transport Planning

Air pollution controlling system is a very complex because no single emission control strategy is a cure-all, equally able to control all types of emissions in industry sector. Since both fuel and combustion processes are critical factors in industrial pollution. However, air pollution controlling technologies fall into three broad categories. These are (i) Pre-combustion, (ii) In-situ, and (iii) Post-combustion. Success of the industrial air pollution prevention depends on the formulation of appropriate policies and strategies. The Nepalese environmental legal system is yet to provide a regulatory framework and various incentives for pollution prevention from industrial sector.

The major conclusion of this study is that air pollution problems are increasing in urban centers gradually in Nepal. However, in the absence of systematic air pollution monitoring, prevention and controlling system, no action so far has been effective in combating air pollution problems. Using policy and technological options can prevent air pollution problems. Using policy and technological options can prevent air pollution problems. One of the most important constraining elements is the policy and legal frameworks, which are almost completely lacking in the country. The long-term goal of reducing air pollution can be achieved by the following strategic considerations. These are:

i. To decide the institutional framework for air quality monitoring
ii. To establish air quality standard arbitrary at the beginning and revised periodically as the data becomes sufficient to establish more precise standard
iii. To formulate separate and comprehensive policy and legal framework, and
iv. To establish an specialized and responsible organization with clear mandates, legal authority to take overall responsibility of air pollution prevention and control program in the country.

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Nepal Standard Industrial Classification (NSIC)

NSIC	Manufacturing Sector
15	Manufacture of food products and beverages
16	Manufacture of tabacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel, dressing and dyeing of fur
19	Tanning and dressing of leather, manufacture of luggage, handbags, saddlery, harness and footwear
20	Manufacture of wood and of products of wood and cork, except furniture, manufacture of articles of straw and plaiting materials
21	Manufacture of paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Manufacture of coke, refined petroleum products and nuclear fuel
24	Manufacture of chemicals and chemicals products
25	Manufacture of rubber and plastic products
26	Manufacture of other non-metallic mineral products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products, except machinery and equipment
29	Manufacture of machinery and equipment n. e. c.
31	Manufacture of electrical machinery and apparatus n. e. c.
32	Manufacture of radio, television and communication equipment and apparatus
34	Manufacture of motor vehicles, trailers and semi-trailers
36	Manufacture of furniture, manufacture of n. e. c.

Source: CBS, 1998a

Table: Number of Vehicles in Nepal By Type. Ownership and Yearwise in Nepal

Vehicle Type	Ownership	Year								
		1998	1997	1996	1995	1994	1993	1992	1991	1990
Bus	Tourist		105	85	69	40	7			
	Government		122	121	119	115	41	39	38	36
	Corporation		77	74	69	69	69	67	65	64
	Private		356	331	311	294	273	261	229	186
	Commercial		6414	5856	5416	4616	3576	2993	2615	2203
	CD/UN		4	2						
	Total	8336	7078	6469	5984	5134	3966	3360	2947	2489
Minibus	Tourist		26	26	26	11	3			
	Government		83	73	68	68	68	59	54	47
	Corporation		43	39	39	38	34	31	30	30
	Private		601	513	493	476	464	430	393	333
	Commercial		1687	1642	1557	1507	1454	1318	1203	1054
	CD/UN									
	Total	2577	2440	2293	2183	2100	2023	1838	1680	1464
Truck	Tourist		26	16	11	8	2			
	Government		1350	1297	1227	1182	1141	1122	1091	1060
	Corporation		719	685	627	603	551	513	502	483
	Private		2695	2565	2314	2141	2039	1803	1409	1211
	Commercial		11997	11392	10676	9292	7753	6557	5469	4917
	Total	18765	16787	15955	14855	13226	11486	9995	8471	7671
Dozer	Tourist		3							
	Government		63	63	63	63	63	63	63	60
	Corporation		24	16	6	6	2	0		
	Private		161	151	95	95	90	57	46	42
	Commercial		142	16	11	11	9	9		
	Total	0	393	246	175	175	164	129	109	102
Car/Jeep	Tourist		101	72	37	29	23			
	Government		5976	5826	5646	5404	5097	4911	4817	4489
	Corporation		1510	1475	1437	1327	1221	1125	1061	980
	Private		28201	26609	22807	20521	18182	16371	14786	13635
	Commercial		6725	5655	4599	4202	3911	3761	3389	3056
	CD/UN		267	167						
	Total	47541	42780	39804	34526	31483	28434	26168	24053	22160
3-Wheeler	Tourist									
	Government		153	153	153	141	141	141	141	140
	Corporation		37	37	37	37	37	37	37	35
	Private		589	574	562	445	345	314	302	246
	Commercial		4402	4235	4127	4015	3961	3930	2735	1938
	CD/UN									
	Total	5605	5181	4999	4879	4638	4484	4422	3215	2359
2-Wheeler	Tourist									
	Government		4548	4298	4031	3860	3622	3394	3364	3197
	Corporation		2247	2079	1909	1833	1675	1553	1498	1447
	Private		90987	78887	65468	56397	48140	40908	32839	28103
	Commercial		110	110	110	27	27	1	1	1
	CD/UN		114	62						
	Total	115868	98006	85436	71518	62117	53464	45856	37702	32748
Tractor	Tourist									
	Government		332	332	332	329	324	316	304	303
	Corporation		194	194	194	193	190	183	180	165
	Private		10819	9672	7829	6277	5211	5031	4539	4191
	Commercial		3069	2869	2619	2361	2039	1972	1931	1507
	CD/UN									
	Total	16327	14414	13067	10974	9160	7764	7502	6954	6166
Other	Tourist									
	Government		45	20						
	Corporation		17	6						
	Private		259	7						
	Commercial									
	CD/UN		3272	3257	3257	2922	2561	2215	1877	0
	Total	3613	3593	3290	3257	2922	2561	2215	1877	0
Total	Total in Nepal	218632	190672	171559	148351	130955	114346	101485	87008	75159

Table: Number of Vehicles in Nepal By Type, Ownership and Yearwise in Bagmati Zone

Vehicle Type	Ownership	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989
Bus	Tourist			133	130	36	6	5	0	0	0
	Government			73	72	69	30	30	28	26	25
	Corporation			45	35	34	34	34	33	32	32
	Private			251	249	238	214	209	204	200	148
	Commercial			781	756	668	563	514	453	405	355
	CD/UN			0	0	0	0	0	0	0	0
	Total	1487		1283	1242	1045	847	792	718	663	560
Minibus	Tourist			96	96	19	4	3	0	0	0
	Government			58	55	54	53	53	45	41	34
	Corporation			18	18	16	13	13	11	11	11
	Private			378	377	364	353	341	329	295	254
	Commercial			1008	1003	975	970	942	892	821	725
	CD/UN			0	0	0	0	0	0	0	0
	Total	1567		1558	1549	1428	1393	1352	1277	1168	1024
Truck	Tourist			46	46	10	3	2	0	0	0
	Government			687	681	635	603	597	586	570	560
	Corporation			280	275	246	209	202	193	181	172
	Private			1230	1171	1084	1037	958	851	730	574
	Commercial			2375	2315	2089	1773	1584	1320	1150	986
	Total	5090		4618	4488	4064	3625	3343	2950	2631	2292
Dozer	Tourist			0	0	0	0	0	0	0	0
	Government			0	0	0	0	0	0	0	0
	Corporation			0	0	0	0	0	0	0	0
	Private			0	0	0	0	0	0	0	0
	Commercial			0	0	0	0	0	0	0	0
	Total	0		0	0	0	0	0	0	0	0
Car/Jeep	Tourist			217	215	26	22	22	0	0	0
	Government			4485	4409	4217	3856	3749	3588	3325	3240
	Corporation			1342	1307	1121	1003	937	867	812	755
	Private			18508	17801	16753	14706	13863	12625	11258	10862
	Commercial			3579	3374	2237	2190	2177	2164	1905	1769
	CD/UN			0	0	0	0	0	0	0	0
	Total	31587		28131	27106	24354	21777	20748	19244	17300	16626
3-Wheeler	Tourist			0	0	0	0	0	0	0	0
	Government			138	138	138	138	138	138	137	137
	Corporation			35	35	35	35	35	35	34	33
	Private			255	254	254	254	254	254	215	199
	Commercial			3438	3425	3417	3417	3417	3417	1800	1485
	CD/UN			0	0	0	0	0	0	0	0
	Total	4003		3866	3852	3844	3844	3844	3844	2186	1854
2-Wheeler	Tourist			0	0	0	0	0	0	0	0
	Government			2994	2960	2780	2622	2487	2290	2205	2126
	Corporation			1225	1208	1093	1004	959	861	802	788
	Private			57395	53771	45392	38037	34328	29089	25400	19445
	Commercial			0	0	0	0	0	0	0	0
	CD/UN			0	0	0	0	0	0	0	0
	Total	74128		61614	57939	49265	41663	37774	32240	28407	22359
Tractor	Tourist			0	0	0	0	0	0	0	0
	Government			47	47	47	47	46	45	43	41
	Corporation			18	18	18	46	18	18	12	3
	Private			448	448	451	406	405	398	369	337
	Commercial			1161	1161	1161	1154	1154	1154	925	775
	CD/UN			0	0	0	0	0	0	0	0
	Total	1672		1674	1674	1677	1653	1623	1615	1349	1156
Other	Tourist			0	0	0	0	0	0	0	0
	Government			0	0	0	0	0	0	0	0
	Corporation			0	0	0	0	0	0	0	0
	Private			0	0	0	0	0	0	0	0
	Commercial			0	0	0	0	0	0	0	0
	CD/UN			3607	3410	3007	2806	2561	2215	0	0
	Total	3278		3607	3410	3007	2806	2561	2215	0	0
Total	Total in Nepal	122812		106351	101260	88684	77608	72037	64103	53704	45871

Table1: Meteorological Information of the Study Areas

Annex-4

Measring Station			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pokhara	Mean Temp.	°C	13.04	15.14	19.91	23.23	24.34	25.16	25.34	25.42	24.3	21.46	17.33	13.92
	Min. Temp.	°C	7.35	8.99	12.76	16.32	18.54	20.68	21.53	21.68	20.53	16.69	11.47	7.94
	Max. Temp.	°C	18.72	21.29	26.03	30.15	30.17	29.64	29.16	29.16	28.38	26.23	23.19	19.89
	Precipitation	mm	24.00	31	54	124	329	659	912	806	616	189	24	22
	Relative Hum.(%)	8:45 am	75.00	67	57	54	64	82	87	87	84	73	71	73
		5:45 pm	60.00	49	43	48	59	75	79	78	80	76	70	65
	Av. Wind Speed	km/hr	2.20	2.9	3.8	4.3	3.5	3.4	2.4	2.4	2.5	2.3	2.3	2.4
	Sunshine Duration	hrs/day	6.60	7.1	7.3	7.4	7	6	4	4.9	5.2	7.4	7.7	6.7
	Rainny days	nos	5	4	4	12	15	21	23	22	18	7	4	7
Kathmandu	Mean Temp.	°C	9.44	11.16	15.53	19.16	21.55	22.95	23.38	23.29	21.95	18.96	14.04	10.22
	Min. Temp.	°C	2.24	3.28	7.43	11.6	15.46	18.74	19.83	19.56	18	13.31	6.88	2.15
	Max. Temp.	°C	16.64	19.04	23.63	26.71	27.64	27.16	26.93	27.03	25.96	24.91	21.21	18.29
	Precipitation	mm	14	16	32	56	103	248	364	299	192	68	7	12
	Relative Hum.(%)	8:45 am	94	88	78	67	70	80	84	85	87	89	90	94
		5:45 pm	64	51	43	44	55	72	80	81	80	75	72	65
	Av. Wind Speed	km/hr	2.1	2.4	2.8	3	2.8	3.1	2.5	2.1	2.2	2.2	1	1.6
	Sunshine Duration	hrs/day	6.9	7.6	8.2	8	8	5.9	4.1	5.1	5	7.1	7.3	6.6
	Rainny days	nos	2	3	2	10	7	15	26	24	10	2	1	4
Biratnagar	Mean Temp.	°C	16.07	16.02	23.13	22.16	27.76	28.64	27.75	27.93	26.98	25.61	20.66	16.32
	Min. Temp.	°C	8.85	10.23	14.92	20.52	22.62	24.92	23.95	23.97	22.95	20.13	12.7	7.72
	Max. Temp.	°C	23.28	25.8	31.35	33.8	32.9	32.37	31.55	31.9	31	31.08	28.62	24.87
	Precipitation	mm	16	12	23	62	112	209	310	134	141	81	8	10
	Relative Hum.(%)	8:45 am	88	82	64	66	77	83	87	85	85	83	81	85
		5:45 pm	62	51	48	46	63	74	77	78	79	76	66	62
	Av. Wind Speed	km/hr	2	3.2	4.7	8.7	6.4	6.8	6.2	4	4.2	3	2	1.7
	Sunshine Duration	hrs/day	7.6	8.4	8.8	9	9.1	6.9	5.1	6.5	5.9	8	8.9	8
	Rainny days	nos	1	1	2	6	10	9	16	17	16	1	0	5

Source: CBS, 1998 (A Compendium on Environment Statics 1998 Nepal)

Annex-5

World Health Organization Guideline for Ambient Air Quality

Pollutant	Guideline values**	
	WHO (1979)	WHO (1987)
Sulfur dioxide	- - - 40-60* (annual)	500 (10 min) 350 (1 hr) 125* (24 hr) 50 (annual)
Suspended particulated matter (SPM) (a) Black smoke (b) Gravimetric SPM	 - 40-60 (annual) - 60-90 (annual)	 125* (24 hr) 50* (annual) 120* (annual) -
Lead	0.5 - 1 (annual)	0.5 - 1 (annual)
Nitrogen dioxide	400 (1 hr) 150 (24 hr)	400 (1 hr) 150 (24 hr)
Carbon dioxide	100 (15 min) 60 (30 min) 30 (1 hr) 10 (8 hr)	101 (15 min) 61 (30 min) 31 (1 hr) 11 (8 hr)

* Effects result from combined exposures of sulfur dioxide and suspended particulate matter.

** Concentrations are in microgrammes per cubic meter of air (for CO only, in milligrammes per cubic meter of air).

Notes:-

1. WHO Guideline (WHO, 1987) are specified for Europe but they are intended to have a wider application for worldwide use.
2. Ninety eight percentile values for 24 hours averages are in a given year: sulfur dioxide, 100-150**; black smoke, 100-150**; gravimetric suspended particulate matter, 150-230** (WHO, 1979)

Source:- (UN, 1994)

Annex-6

The United States National Ambient Air Quality Standards

Pollutant	Primary (health-related)		Secondary (welfare-related)	
	Averaging time	Concentration	Averaging time	Concentration
Particulates	Annual geometric mean 24 hours	75 □g/m3 260 □g/m3	Annual geometric mean 24 hours	60 □g/m3 150 □g/m3
Sulfur dioxide	Annual geometric mean 24 hours	80 □g/m3 365 □g/m3	3 hours	1300 □g/m3
Carbon monoxide	8 hours 1 hour	10 □g/m3 40 □g/m3	same as primary same as primary	same as primary same as primary
Nitrogen dioxide	Annual geometric mean	100 □g/m3	same as primary	same as primary
Ozone	Maximum daily 1 hour	235 □g/m3	same as primary	same as primary
Lead	Maximum quarterly average	1.5 □g/m3	same as primary	same as primary

Source:- UN, 1994

Monitoring Networks and Objectives of Various Polluting Cities in the World

City/Country	Network present	Estimate exposure	Comp -liance	Public information	Fore-casting	Spatial distribution
Alexandria/Egypt	■	■	□	□	□	□
Ankara/Turkey	■	■	■	■	□	□
Belo Horizonte/Brazil	(1)	■	■	□	□	■
Birmingham/UK	■	■	■	■	■	■
Ekaterinburg/Russian Federation	■	■	■	■	■	■
Hong Kong/China	■	■	■	■	(a)	■
Hyderabad/India	■	■	■	■	□	□
Johannesburg/South Africa	■	■	■	■	□	□
Katowice/Poland	■	■	■	■	□	■
Kiev/Ukraine	■	■	■	■	■	■
Lagos/Nigeria	(2)	□	□	□	□	□
Madras/India	■	■	□	■	□	□
Lahore/Pakistan	■	■	■	■	□	□
Nairobi/Kenya	(2)	■	□	□	□	■
Pusan/Republic of Korea	■	■	■	■	■	■
Quito/Ecuador	■	■	■	■	□	□
Santiago/Chile	■	■	■	■	■	■
Singapore/Singapore	■	■	■	■	■	■
St Peterburg/Russian Federation	■	■	■	■	■	■
Taipei/Taiwan	■	■	■	■	■	■

■ Operational monitoring network/objective of monitoring

□ No monitoring network/ Not an objective for monitoring

(1) Currently suspended

(2) Periodic measurements made- no formal network

(a) Forecasting now carried out

Source: UNEP/WHO, 1996

Instrumental Air Monitoring Techniques

Method	Advantages	Disadvantages	Capital cost per sampler
Passive samplers Collect an integrated sample of pollutants by diffusion with collection on a tripping medium which is subsequently analyzed.	Very low cost and simple. Useful for screening and base-line studies.	Unproven for some pollutants. Integrated sample. Laboratory analysis required.	US $ 2-4
Active samplers Collect an integrated sample of pollutant by pumping air through the sampler and trapping the pollutant in a collecting medium which is subsequently analyzed.	Low cost. Easy and reliable to operate. Historical data set in some cities.	Integrated samples. Labour intensive. Laboratory analysis required.	US $ 2,000 – 4,000
Automatic analyzers Use a physical or chemical property of the pollutant to measure the concentration in continuously collected samples. Calibrations are performed using a standard of known concentration for comparison.	Proven high performance. Continuous, on-line measurement. Low direct costs.	Complex and expensive. High skills required to maintain and operate. High recurrent costs.	US $ 10,000 – 20,000
Remote sensors Determine the average concentration of the pollutant over a fixed path spectroscopically.	Provide path or range resolved data. Useful near sources and for vertical measurements.	Difficult to support, operate, calibrate and validate. Not always comparable with fixed point sampling analyzers.	> US $ 200,000

Source: UNEP/WHO, 1996

Continuous Monitoring Instruments in Common Use

Pollutant	Technique
NO	**Chemiluminescence** (reaction with excess O_3 present).
NO_2	**Chemiluminescence** (reduction to NO using a molybdenum converter prior to reaction with O_3; also through reaction of NO_2 with luminol).
SO_2	**Fluorescence**
CO	**Non-dispersive inffra-red** **Coulometry** **Gas filter correlation** **Cross flow correction**
O_3	**Spectrophotometry** (UV absorption). **Chemiluminescence** (gas phase titration with NO).
VOCs	**Ionization.** Collection upon an absorbing solid followed by thermal desorbtion seperation using gas chromatography (GC). Species identification on the basis of retention time compared with known standards and quantification using a flame ionization detector (FID) or electron capture detector•.
Particulate matter	**Tapered Element Oscillating Microbalance** – TEOM. Measures the frequency of oscillation of a resonating piezo-electric electric fitted with a filter cartridge to collect the sample. As particles collect the mass increase which reduces the speed of vibration which is measured and converted into a mass. **Beta attenuation.** Absorption of β–radiation is dependent upon the mass of the sample and almost independent of composition. The attenuation of β–radiation can, therefore, be used as a pseudogravitimetric technique to determine the mass of particles collected at given intervals.

- Strictly speaking this is an active sampling procedure but, since development of the process has now been fully automated to provide 60-minute average concentrations, it can be equally considered a continuous instrument.

Source: UNEP/WHO, 1996

Particulate Matter Monitoring Methodologies

City/Country	Dustfall	Black smoke	TSP	PM_{10}	$PM_{2.5}$
Alexandria/Egypt			HVS		
Ankara/Turkey				□-atten	
Belo Horizonte/Brazil			HVS		
Birmingham/UK		REF	LVS	TEOM	TEOM
Ekaterinburg/Russian Federation			LVS		
Hong Kong/China			HVS	TEOM	
Hyderabad/India			HVS	LVS	
Johannesburg/South Africa			LVS		
Katowice/Poland		REF		TEOM/HVS	
Kiev/Ukraine			HVS		
Lagos/Nigeria			LVS		
Madras/India			HVS	LVS	
Lahore/Pakistan			HVS		
Nairobi/Kenya			LVS		
Pusan/Republic of Korea			□-atten		
Quito/Ecuador		REF	HVS		
Santiago/Chile			HVS	DS/□-atten /TEOM	DS /TEOM
Singapore/Singapore		REF	HVS	□-atten	
St Peterburg/Russian Federation			LVS		
Taipei/Taiwan				□-atten	

Methodology used

Methodology not used

REF	Reflectance
TMS	Transmission
□-atten	□-attenuation
TEOM	Tapered element oscillating micro-balance
LVS	Low volume sampler
HVS	High volume sampler
DS	Dichotomous sampler

Source: UNEP/WHO, 1996

Emissions Limits and Emissions Monitoring

City/Country	Emissions limits and controls				Emissions monitoring		
	Industry	Cars	HGVs	Domestic	Industry	Cars	HGVs
Alexandria/Egypt							
Ankara/Turkey		■	■	■	■	■	■
Belo Horizonte/Brazil	■	■	■				
Birmingham/UK	■	■	■	■	■	■	■
Ekaterinburg/Russian Federation	■	■			■		
Hong Kong/China	■	■	■		■	■	■
Hyderabad/India	■	■	■		■		
Johannesburg/South Africa	■		■	■	■		■
Katowice/Poland	■	■	■		■		
Kiev/Ukraine	■	■	■		■	■	■
Lagos/Nigeria	■	■	■				
Madras/India	■	■	■		■		
Lahore/Pakistan	■	■	■				
Nairobi/Kenya							
Pusan/Republic of Korea	■	■	■		■	■	■
Quito/Ecuador							
Santiago/Chile	■	■	■			■	■
Singapore/Singapore	■	■	■	■	■	■	■
St Peterburg/Russian Federation	■	■			■		
Taipei/Taiwan	■	■	■	■	■	■	■

■ Emission limit set/emissions monitoring conducted.

□ Emission limit not set/no emissions monitoring conducted.

HGVs Heavy Goods Vehicles

Source: UNEP/WHO, 1996

Health Effects of Common Air Pollutants

Pollutant	Acute health effects	Chronic/Toxic health effects
SO_2	Narrowing of the airways, particularly in sensitive individuals, producing symptoms ranging from coughing and wheeze to bronchitis and asthma.	Increased prevalence to chronic bronchitis.
Particulate matter	Increased cardio-respiratory mortality and morbidity – particularly in combination with SO_2.	Increased respiratory mortality and morbidity; no observable threshold.
NO_2	Sensitizes the lungs to other pollutants and allergens.	No definite effects of outdoor exposure but indoor exposure suggests a range of effects upon lung function.
O_3	Powerful oxidant reacting with most biological substances; a lung irritant and sensitizer to other pollutants and allergens; can produce runny eyes and sore throats.	None known for certain but it has recently been suggested 0_3 is a geno-toxic.
CO	Reduce oxygen carrying capacity of the blood by combing with haemoglobin.	None known.
Pb	None known.	Neurotoxin, (suggestion of impairment to cognitive development); affects blood biochemistry and can raise blood pressure.
PAHs	None known.	Benzo-□-pyrene and certain other species are carcinogenic.
Benzene	None known.	Powerful carcinogen linked to leukaemia.

Source: UNEP/WHO, 1996