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On

SCOPE AND CURRENT STATUS OF WIND ENGINEERING - INDIAN SCENARIO

(b) Wind & Environmental Hazards

Submitted

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CURRENT STATUS & SCOPE OF WIND ENGINEERING – INDIAN SCENARIO (b) Wind and Environmental hazards

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ABSTRACT

Acute air pollution is being faced in urban agglomeration due to economic expansion, increase in population, increased industrial activities and exponential growth in automobiles. The air pollution from these sources is imposing threat to urban human health. The morbidity & mortality caused by air pollution result in long term reduction of productivity and finally in overall deterioration of economic condition. A positive approach for designing policies and implementation of monitoring and management system is needed to identify major sources of air pollution & subsequently restore air quality in major urban centers by corrective measures. There is a constant conflict between the industrial progress and economic developments vis- a-vis environmental concerns. Therefore it becomes mandatory to explore the strategies for the sustainable development. The major causes of environmental degradation are the unprecedented growth of population, industries and vehicles. The air quality crisis in cities is often attributed in large measure (40–80%) to vehicular emissions. Asian sub-continent is presently set to be the world's most polluted region in the 21st century. Heavy reliance on coal in power production and a rapidly growing vehicle fleet, usually in combination with outdated technologies and poor maintenance, has led to a concentration of air pollutants far exceeding the limits of national ambient air quality standards.

Air quality modeling plays a very important role in assessing the benefits of projects and providing guidelines for better and more efficient air quality planning. Development of suitable prediction model for obtaining the relationship between the source and the receptor are very vital for reconciling the economic growth and environmental conflicts.

KEY WORD : *Air pollution, design policy, sustainable development, ambient quality standards.*

1. INTRODUCTION

The scientific achievements and technological advancements ushered a new era in the domain of trade and world economy resulting in nations and the people becoming very close to each other, than ever before. However these developmental processes which started some two hundred years ago were mainly dependent on coal as the main energy source in the initial stages and later on oil and gas also got introduced in a big way, giving rise to an enormous increase in the world industrial production capacity. During the last four decades, there has been an unprecedented increase in the industrialization, urbanization, and population explosion. These have necessitated high densities of the motor vehicle traffic and increased power generation to meet the demands of expanding commercial and industrial activities. The monumental amounts of emissions released from these urban centers have given rise to significant degradation in the air quality. Particularly the vehicular pollution poses a significant threat to the urban air quality because unlike other polluting industries they cannot be relocated to the remote areas and thus they remain encompassed within the limits of the city and the city

has to live with them. In fact, air pollution is an ever growing problem and presently is at the forefront of the concern in almost all the countries. Mage et. al., (1996) have reported on the basis of the analysis of the air quality trend, monitored under Global environment monitoring system (GEMS) that in the 20 of the 24 mega cities of the world, having population over 10 million, the pollutants concentrations would be so high as to cause serious health hazards. Therefore, it is imperative to develop relevant relationships between the pollution sources and receptors, which can highlight the strategies to bring about a balance between the economic developments and environmental conflicts. In other words we need to go in for a sustainable development. Figure 1 shows a typical scenario of an environmental management system.

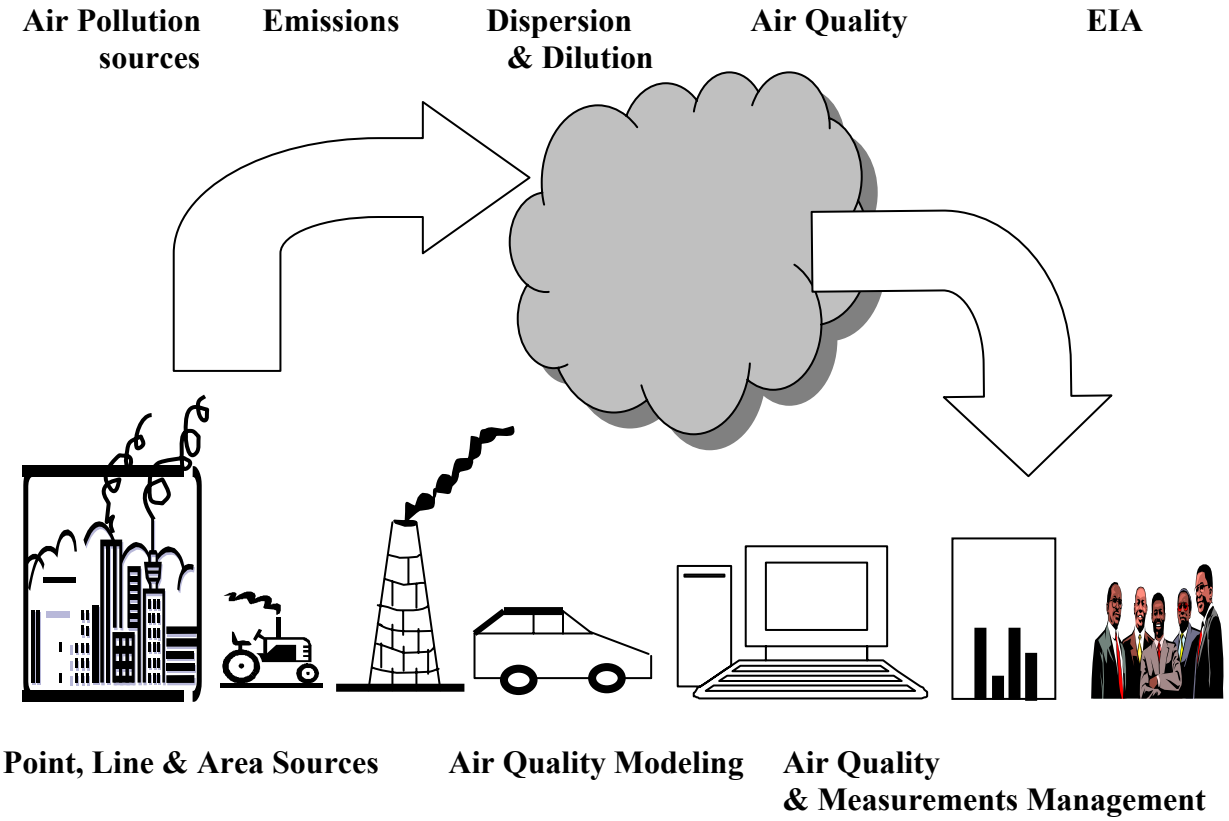

Figure 1 : Environmental Management System

Indian subcontinent is one of the most dynamic regions in the world. It hosts 25% of the world population, consumes 19% of its total energy and produces 21% of its total cereals. Due to population growth and increased fossil fuel consumption, this region is experiencing serious air pollution problems. Presently, in 40 of the Indian cities with population of the order of 1 million, automobile exhausts and industrial emissions have crossed *"Alarm levels"* i.e., these are far beyond the National ambient air quality standards (NAAQS). For example in Calcutta, Suspended particulate matter (SPM) coated with toxic gases can be as high as 12 times the prescribed standards. Recent studies reveal that number of patients with respiratory diseases and allergies have roughly doubled as compared to 1990. If you happen to live in any of Indian mega-cities (in reality the smog cities), you become a passive smoker, as you would be inhaling equivalent of 10-20 cigarettes per day. In fact an envelope containing a frightening mixture of a number of toxic pollutants encloses the biosphere of the mega cities, which

constitutes a situation similar to a *Gas Chamber Effect that is responsible for infusing "Slow Poison"* continuously to the humanity and the eco-system.

It may be noted that the capital city of India, namely Delhi, has the dubious distinction of being fourth most polluted city in the world and has been nick named as the pollution capital of India. This is because of uncontrolled urbanization with respect to population, transport, industrialization, trade and commercialization. Projections made by different researchers reflect that Delhi's present population of 13.8 million will further increase to 19.5 million to 2011 and 22.4 million by 2021. Such unprecedented growth of population, industries and vehicles has negative impact on Delhi's environment. The study reported by Centre for Science and Environment (CSE) (1996) has stated that Capital's air pollution scenario is India's grimmest and consequently stringent pollution management measures are needed in terms of its prevention as well as its control. The highlights of Delhi City, air pollution scenarios are as follows:

- The current vehicle population in Delhi is 4 million and further it is growing at an astonishing rate of 12.5% per annum.
- Delhi leads the other metros in vehicular pollution levels**.** Capital's air is dirtied by daily emissions of approximately 2000 tones of pollutants per day and out of which vehicular pollution alone contributes to a shocking 70% level.
- Delhi city has 12 times the National average of the diseases like, respiratory problems heart disorders, lung cancer, severe headaches, still births, nervous system damage, mental retardation especially in children.
- According to a World Bank estimate the air pollution in Delhi caused 7491 premature deaths in 1991/ 92, which further increased to 9859 in 1995 and in monetary terms it cost 8567 million rupees to the society.

2 SOURCES OF AIR POLLUTION AND ITS MONITORING IN INDIA

The various sources of pollutants are industrial giants like oil refineries, cement, iron and steel and thermal power plants along with vehicles (petrol/ diesel/ gas driven). In addition domestic activities refuse burning and construction activities also add to the pollution load. Urban air quality, which is typically characterized by the conspicuous presence of a dangerous cocktail of pollutants namely Carbon monoxide (CO), Oxides of nitrogen (NO_X), Sulfur dioxides, reactive hydrocarbons, Volatile organic compounds (VOCs), Suspended particulate matter (SPM) and heavy metals like Lead (Pb), Nickel (Ni), Copper (Cu), Zinc (Zn) etc., present a potential threat, to the public health.

Air pollution monitoring in India is carried out under the auspices of National ambient air quality programme (NAMP) consisting of more than 290 monitoring stations operated by CPCB with active participation from State pollution control boards (SPCBs) and NEERI (CPCB, 2000). Various conventional parameters like SO_2, NOx (4 hourly) and SPM, RSPM (8 hourly) are monitored at these sites. Additional monitoring stations are also operated under the GEMS (Global environmental monitoring system) and WHO (World health organization) (30 nos) and World Bank (8 Nos). These air quality monitoring programmes, also involve monitoring of other parameters viz. RSPM, O_3 and Benzene not adequately covered under NAMP. Despite all these number of monitoring stations, their frequency of sampling and extent of ambient air quality monitoring network cannot be described as adequate. Moreover,

most of these monitoring stations still employ high volume sampling and wet analysis methods, which will not be adequate enough to represent the complexities of air pollution problems.

In order to identify the pollution hot spots in the country we need to have much more than 290 monitoring stations for a big country like India. Another serious cause of concern is that many air toxins are not even monitored. They are benzene, ozone, Volatile organic compounds (VOCs) and Polycyclic aromatic hydrocarbons (PAHs).

3 STATUS OF VEHICULAR POLLUTION IN INDIA

Motor vehicles have been closely identified with increasing air pollution levels in most of the urban centers of the world. Besides substantial CO_2 emissions, significant quantities of CO, HC, NOx, SPM and other air toxins are emitted from these motor vehicles in the atmosphere, causing serious environmental and health impacts. Like in many other parts of the world, air pollution from motor vehicles is one of the most serious and rapidly growing problems in most of the urban centers of India (CSE, 1996). Although improvement in air quality with reference to the criteria pollutants (viz. NOx, SO_2, CO and HC) has been reported from some of the cities, the air pollution situation in most of the cities is still far from satisfactory (CPCB, 2000). The problem has further been compounded by the concentration of large number of vehicles and comparatively high motor vehicles to population ratios in these cities. In India, the number of motor vehicles has grown from 0.3 millions in 1951 to approximately 50 millions in 2000, of which, two wheelers (mainly driven by two stroke engines) account for 70% of the total vehicular population. Two wheelers and cars (four wheelers excluding taxis) which mainly constitute personal mode of transportation, account for approximately four fifth of the total vehicular population. Similarly, human population has also increased from 361 millions to more than 1000 millions during this period. The problem has been further compounded by steady increase in urban population (from approximately 17% to 28% during 1951-2001) and larger concentration of vehicles in these urban cities especially in four major metros Delhi, Mumbai, Chennai and Kolkatta. These cities account for more than 15% of the total vehicular population of the whole country, whereas, more than 40 other metropolitan cities (with human population more than 1 million) accounted for 35% of the vehicular population in the country. In India, 25% of the total energy (of which 98% comes from oil) is consumed by road sector only. Although gasoline vehicles dominate (approximately 85%) the vehicular population, the consumption of diesel is six times more than the consumption of gasoline (petrol). A gradual shift in passenger and freight movement from rail to road-based transportation has also lead to marked increase in fuel consumption by the road sector. Vehicles in major metropolitan cities of India are estimated to account for 70% of CO, 50% of HC, 30-40% of NOx, 30%of SPM and 10% of SO_2 of the total pollution load of these cities, of which two third is contributed by two wheelers alone.

We have a large number of old vehicles with very poor pollution emission characteristics. It is very difficult to get rid of them fast. The hard option available to us is to phase them out as soon as possible. Secondly, private vehicle numbers are growing leaps and bounds and there is no restriction imposed by the state governments in restricting these vehicles. Thirdly, no serious investment has been envisaged for strengthening/ improving the public transport system/ mass transit system.

4 VEHICULAR POLLUTION MODELING IN INDIA

In India, various Gaussian based line source models like CALINE 3 and 4, GM and HIWAY 4 are routinely used to predict the impact of vehicular pollution along the roads/highways. Presently, it is mandatory for all new and existing highway/road projects to have prediction estimates of vehicular pollutants along the highways/roads. These are routinely carried out by using

various Gaussian based dispersion models. Based on the modeling exercise, Environmental management plan (EMP) is suggested so that the predicted air pollution levels do not exceed the National ambient air quality standards (NAAQS). Central pollution control board (CPCB), Delhi under the Ministry of Environment and Forests (MoEF) had issued necessary guidelines for air quality modeling, but unfortunately they do not contain any standardized reference/guidelines, with respect to line source models. The experience so far has shown that the values of various input parameters to these models are often adopted from other countries without understanding their applicability in Indian context, resulting in inaccurate and unreliable predictions.

Recently, some efforts have also been made in India to apply statistical models to predict pollutant concentrations from observed meteorological and traffic parameters. However, due to lack of comprehensive, long term and reliable data on pollution, traffic and meteorological parameters, statistical modeling exercise has been carried out for few major metros only, whereas these data, to a certain extent, are available with various government agencies and R&D organizations. Various time series analysis techniques viz. Box-Jenkins (B- J) models such as Auto regression integrated moving average (ARIMA), ARIMA with exogenous inputs (ARMAX), Transfer function noise (TFN) and Intervention analysis model (IAM) have been applied for predicting vehicular pollution estimation at traffic intersection and heavily trafficked roads (Sharma and Khare , 2002)

4.1 *Inadequacies of Vehicular Pollution Modeling*

Various Gaussian based line source models require various input parameters pertaining to meteorology, traffic, and road geometry land use pattern, besides receptor locations. Besides the basic Gaussian dispersion approach, each dispersion model differs with respect to the treatment of modified wind and turbulence due to vehicle wakes resulting in different values of dispersion parameters σ_y and σ_z , near the roads. Adequacies, limitations, reliability and associated uncertainties of these dispersion models have already been discussed by various researchers (Sharma et al., 2004). Various Gaussian based dispersion models, initially developed in West are extensively used in India without properly calibrating them for Indian climatic and traffic conditions. Moreover, various input parameters used in these models are not accurately known leading to incorrect or sometimes even unreliable predictions. Greatest inaccuracy in vehicular pollution modeling exercise in India is due to the improper emission factors used for different categories of vehicles. Unfortunately in India, no serious efforts have been made to accurately determine the emission factors for different categories of in-use vehicles as a function of vehicle speed, engine technology, fuel quality and age of the vehicles. Various researchers had used emission factors, which were obtained from limited experimental data on chassis dynamometer under laboratory conditions, or directly adopting emission factors which are applicable to European vehicles. Thus, with different combinations of vehicles (age wise and technology wise) and fuels of wide ranging quality, finding reliable emission factors for different categories of vehicles under Indian driving and road conditions with limited emission testing facilities is a task which needs to be addressed immediately. Further, with the recent emphasis on replacing old technology vehicles with the latest ones and improvement of fuel quality, the existing facilities need to be upgraded keeping in tune with the latest developments that are taking place in the other parts of the world. Although, recently serious efforts are being made by various research and regulatory agencies including Central pollution control board (CPCB), Society of Indian automobile manufacturers (SIAM), Automotive research association of India (ARAI), VRDE (Vehicle research and development establishment), Indian Institute of Petroleum (IIP), National Environmental Engineering Research Institute (NEERI) and various academic institutions like Indian Institute of Technology (IITs) to estimate emission factors for different categories of in-

use vehicles under field conditions as a function of vehicle speed, age and related variables. Recently, CPCB (CPCB, 2000) has suggested a set of emission factors for different categories of vehicles on the basis of year of manufacture and engine technology. However, it is still a long way before more reliable emission factors that reflect Indian traffic conditions are worked out. Another source of inaccuracy in these models pertain to non- availability of onsite meteorological data. Although onsite meteorological data about wind speed, direction, atmospheric stability conditions and mixing height is recommended to be used but most often modelers in India rely on nearest Indian Meteorological Department (IMD) data which does not reflect actual field conditions and adds to inaccurate prediction estimates. Thus in major urban areas, a network of meteorological stations / observatory posts can be of immense help to understand and explain the dispersion phenomena in the complex urban environments. There is also a need to upgrade and modernize the facilities so that these IMD stations can serve better in understanding and explaining the dispersion phenomena in urban / city conditions. Use of improper monitoring techniques for measurements of air pollutants, traffic volumes and traffic related parameters further lead to unreliable estimates.

The use of recent techniques like ANN and GIS in air pollution related research is at nascent stage in India. GIS has been used quite extensively in transportation related research but only few studies have been carried out in air pollution related research by making use of GIS. Sharma et al. (2004) applied GIS for air pollution profiling for Delhi city from observed hourly air pollution data and demonstrated its usefulness in transport development and traffic management planning. Recently, an environmental wind tunnel has been constructed and made operational at the Indian Institute of Technology (IIT), Delhi (Sharma et al., 2000). The facility at IIT is being used for carrying out different types of dispersion studies in the area of vehicular pollution relevant to the Indian context.

5 AIR POLLUTION RELATED LEGISLATION

India is among the few countries of the world that has made provisions in the constitution to safe guard the environments. Indian constitution empowers the states to take measures in order to protect and improve the quality of environments. Further, a significant component in legal matters in relation to the environments has come through judicial pronouncements (see Table 1). In addition, several laws have been enacted in India with the aim of controlling and minimizing the air pollution. Important among them are:

- The Air (Prevention and Control of Air Pollution Act, 1981(amended in 1987):
  Under this act CPCB has been authorized to take necessary action including enactment of rules and regulations for the preservation, control and abatement of air pollution besides advising central and state governments in environmental related matters. It further empowers the state government to declare any area to be notified as air pollution control area. It also empowers framing rules and regulations related to vehicular pollution. The amendment of 1987 has empowered the pollution control boards to take stiff action against the polluting industries.
- The Environmental Protection Act (1986):
  The Environmental protection act 1986 is an umbrella type of act and has provisions to cover the entire area that constitutes the environment. The benefits that have come from these acts are:
- Monitoring of the quality of the environments
- Dissemination of the information on the quality of environments

- Prescribing the standards to be maintained at discharge/ emission level
- Administrative/legal action against offenders.
  Table 2 shows National ambient air quality standards along with the methods of measurements.
- The Motor Vehicle Act (MVA), 1988 :
  This act contains the various rules and regulations to control and manage vehicular pollution. The norms have been issued by Ministry of Surface Transport (MoST), Govt. of India now Ministry of Road Transport and Highway (MoRTH) after consultation with Ministry of Environment and Forests (MoEF), Government of India.

S. No.	Measure	Time Frame
1.	Phasing out/ban on plying of old commercial/transport vehicles Vehicles more than 20 years old : Vehicles more than 17 years old : Vehicles more than 15 years old :	 02-10-1998 15-11-1998 31-12-1998
2.	Replacement of all pre-1990 autos and taxis with new vehicle using clean fuel :	31-03-2000
3.	Ban on plying of buses more than 8 years old except on clean fuels :	01-04-2000
4.	Entire city bus fleet (DTC and Private) to be converted on single fuel mode on CNG :	31-03-2001
5.	New ISBT to be built at Delhi's North and South-West Borders (to avoid pollution due to entry of inter-state buses) :	31-03-2000
6.	Supply of only pre-mix petrol to 2-stroke engine vehicles	31-12-1998
7.	Elimination of leaded petrol from Delhi	01-09-1998
8.	Strengthening of existing air quality monitoring stations and setting up of new stations for critical pollutants :	01-04-2000

Table 1: Directions Of Hon'ble Supreme Court For Control Of Pollution In Delhi

6 PREVENTION AND CONTROL OF AIR POLLUTION

Several studies have indicated that heavily polluted urban air is very harmful to human health (Sen Gupta et. al., 2001; CPCB, 2002). Therefore it is imperative to identify the pollution hotspots in the country and take suitable measures to reduce the pollution at source (prevention) as well as its control after the release of pollutant in the atmosphere. The main sources of the urban air pollution are; a) motor vehicles, b) industries, particularly their chimney waste and c) fossil fuel (coal) based plants such as thermal power plants. The following are some of the emission control techniques:

- To reduce the emission potential of the fuel by incorporating pre-combustion controls. For example, switching to cleaner fuels with less sulphur or nitrogen content in power plants or burning methanol or ethanol or CNG instead of leaded petrol in the internal combustion engines. Also in the coal-fired power plants, fuel can be physically and chemically treated to remove sulphur or nitrogen before combustion.

- To reduce the emissions by improving the combustion process itself. For example, new type of burners have been designed and developed for power plants, which reduce NOx emissions, and further, new fluidized beds reduce both NO_X as well as SO_X. In addition, we need to phase out old vehicles especially, the two stroke engines and switch to new updated fuel-efficient internal combustion engines conforming to very stringent emission norms.
- To incorporate post-combustion controls to capture emissions after they have been formed but before they are released to the atmosphere. For example, particulate collection devices such as cyclone devices and electrostatic dust precipitators can be employed for particulate removal. Further flue gas de-sulphurisation techniques are employed after the combustion but before the exhaust stack, to removal of SO_X. In automobiles catalytic converters are now most commonly employed in the exhaust pipes to remove CO.

In addition we need to redesign our lifestyle by changing our attitude and value systems by being more eco-friendly so as to protect and regenerate our environments. We can indeed reduce the air pollution by practicing the following in our daily life:

- Use public transport systems more often & use "car-pools" amongst residents of each locality.
- Plant and nurture lots of saplings to full growth as trees and look after them. Further, see that existing trees have enough soil around their roots and thus do not die due to cementing around their trunks.
- Convert vehicles to run on CNG i.e., buses, cars, auto rickshaws etc.
- Do a Pollution check of all vehicles & ensure regular servicing and "tune-up" of vehicles.
- Relocate polluting industries from residential areas to industrial area or out of the city.
- Do not burn the garbage, leaves or other items.
- Do not ever burn plastics as some plastics give off "toxic gases" which can cause death or permanent damage to organs and health.
- Minimize the use of gen-sets and switch over to "inverters".
- Reduce benzene levels drastically in fuels.

7 CURRENT MONITORING NETWORK

As an integral part of the air pollution control programme, CPCB has established a national network of ambient air quality monitoring stations. This nation-wide programme, called the National Ambient Air Quality Monitoring (NAAQM) was launched in 1984 with a network of 28 monitoring stations covering 7 cities. Over the years, the number of stations have increased and presently, the network comprises 290 stations spread over 92 cities/towns distributed over 24 stations and 4 UTs. In addition to the NAAQM programme, operated by CPCB, many State Boards have set up Ambient air quality monitoring stations under their own programme known as Ambient Air Quality Monitoring (AAQM) programme. National Environmental Engineering Research Institute (NEERI) monitors ambient air quality in 30 stations covering 10 major cities. In addition to the monitoring stations, operated by the Central/State Boards and Research Organisations, major industries have set up monitoring stations as part of the compliance of the consent conditions. The location of the monitoring stations established under NAAQM programme are depicted in Figures – 1 & 2.

Fig. 1 National Ambient Air Quality Monitoring Network

Fig. 2 National Ambient Air Quality Monitoring Network of NEERI

The pollutants monitored at NAAQM/AAQM stations are NO_2, SO_2, SPM besides meteorological parameters like wind speed, wind direction, temperature and humidity. In addition to these three conventional parameters, NEERI monitors special parameters like NH_3, H_2S, RSPM, PAH and heavy metals. CPCB has initiated monitoring of particulate lead, PAH, heavy metals, ozone and CO at some of its monitoring stations in Delhi. The objectives of the air quality monitoring programme are :

- to strengthen the existing air monitoring system with the adoption of state-of-the-art methodologies to monitor the air quality;
- to monitor the criteria pollutants depending on the locations;
- to determine present air quality status and trend;
- to provide background air quality data as need for industrial siting and town planning; and
- to control and regulate pollution from industries and other sources to meet the air quality standards.

8 CONCLUDING REMARKS

Currently environmental pollution is posing a serious threat to very existence of lives in the mega cities of India. Studies conducted by both CPCB and CSE on pollution scenario of Delhi city indicates that in spite of the suitable interventions and proposed actions, the situation remains the grimmest possible and air pollution control within ambient air quality standards

remains a distant dream. We have failed miserably in the management of air pollution and consequently in its abatement. This is because, presently there is no national level planning to deal with this problem. Air pollution laws are very weak and there is no punitive action taken on the state governments for not meeting the ambient air quality norms. In US, the federal government can penalize the state governments in case regional air quality standards are not met. In India, air pollution remains unchecked till the courts intervene and by that time significant damage generally takes place.

Presently, no soft options are left. Now there is an urgent necessitity to take bold and progressive type of decisions, in order to evolve the road map for the air pollution improvement in the mega cities of India. We must introduce the latest state of art norms of the fuel quality and emission standards in all the vehicles. Further, the Euro IV fuel and vehicle technology should be made mandatory in the pollution hotspots of the country. Secondly, air quality surveillance in the country need to be strengthened by setting up a large number of air quality monitoring stations. These stations should be equipped with smog alert systems along with air pollution emergency measures in case of any immediate local impact-taking place at any time. Thirdly, some fiscal measures have to be introduced to encourage fast replacement of old vehicles not conforming to the latest emission norms. Lastly, there is an urgent need to develop a comprehensive transportation plan which should discourage ownership and usage of private vehicles and promote public transport / mass transit system.

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