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Acid Rain & Atmospheric Pollution

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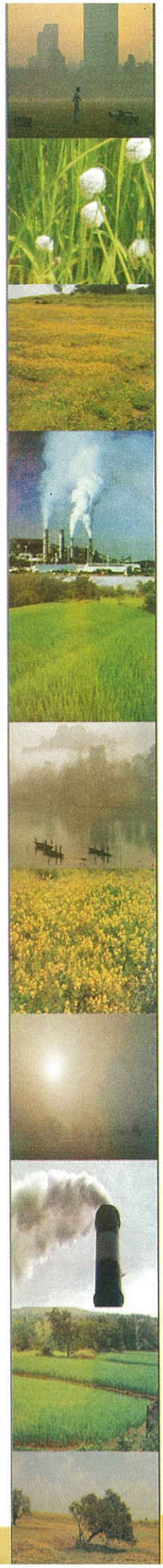
Editorial

There was a flurry of activities going on during the past couple of months, towards the successful launching of the SAFAR system. The first Air quality forecasting system was dedicated to the nation on 22nd September 2010 during CWG-2010. The previous issues covered the topics related to the development of the SAFAR system. However, the topic will remain incomplete if the details regarding emission inventory and data generation are left unattended. In this context, the present issue covers the topic related with the development of emission inventory and other related details therein.

We thank to all who contributed with their valuable suggestions for our newsletters, it would be highly appreciated if you could keep up for our future improvement.



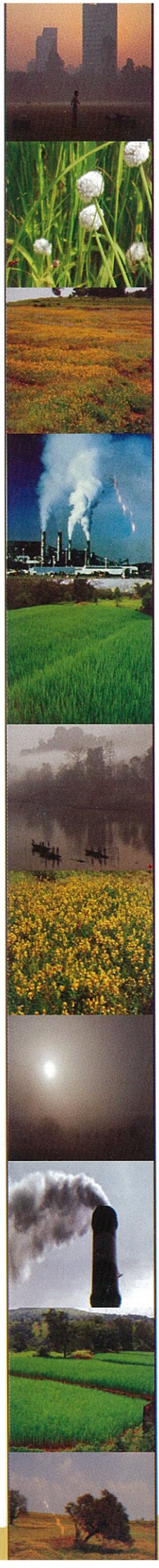
Executive Summary

Development of High Resolution Emission Inventory of Major Air Pollutants Over NCR-Delhi for the Commonwealth Games-2010

Clean air is a basic necessity for Human health and well-being. When the local concentrations of air pollutants exceed certain threshold limit, it can have adverse effect on Human health, plants, animals, aviation activities. Most of the mega cities all over the world are experiencing the deterioration of air quality problem including National Capital Territory of Delhi. The pollutants are emitted to the environment through various natural as well as anthropogenic sources. The anthropogenic emission (emerging from industrial process, auto exhaust, power plants, open fires, cooking, residential burning, heating and domestic sources, etc.) is on the rise due to Human intervention and mainly responsible for deteriorating air quality in recent time. **Emission Inventory** is a comprehensive listing by sources of air pollutant emissions and amount of air pollutants released into air as a result of a specific process in a particular geographic region during a specific time period. This is one of the most critical factor required for 3-D atmospheric chemistry transport models along with meteorological input to forecasting the air quality for mitigation. Quality of forecasting depends on accuracy and reliability of emission estimation. Emission inventories could also be used for air quality management and formulating environmental policy.

Scientific Expertise

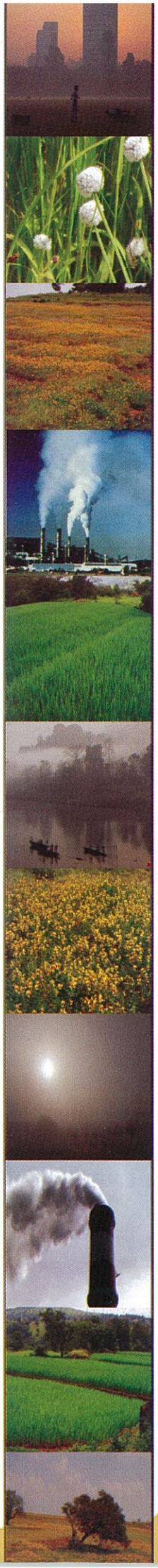
Development of emission inventory is a complex process due to numerous, diverse and widely dispersed emission sources in city like Delhi and its adjacent region and requires huge amount of high resolution activity data, emission factors along with knowledge of fundamental scientific processes. Scientists of MoES are involved



in this area of research for more than a decade at IITM, Pune and published first ever inventory of several pollutants for our country India in international journals (*Sahu et al., GRL, 2008; Beig and Brasseur, GRL, 2006*, etc). Since, MoES has taken up the mission mod project called ***SAFAR (System of Air Quality Forecasting and Research)*** to forecast the air quality of NCR Delhi for the first time in our country on the occasion of Commonwealth games-2010, a comprehensive study based on the scientific knowledge has been made to develop the high resolution (1.67 km x 1.67 km) emission inventory of all major air pollutants for a domain of ~65 km×70 km (~4500 km^2 area) covering Delhi and its adjacent region to facilitate accurate air quality forecasting. Emission inventories have been developed for 8 air pollutants namely, *Oxides of Nitrogen (NO_X); Carbon Monoxide (CO); Black Carbon (BC); Organic Carbon (OC); Particulate Matter <2.5 micron ($PM_{2.5}$); Particulate Matter <10 micron (PM_{10}); Sulfur Dioxide (SO_2) and Volatile Organic Compounds (VOCs).*

Methodology Development and Data Generation

For the development of emission inventory, a bottom up approach has been used for which a GIS (Geographical Information System) based statistical model has been developed by our scientists at IITM to prepare high resolution gridded emission inventory. The emissions have been estimated for the individual sources and for that purpose, an extensive scientific field campaign has been carried out in NCR region during the past several months by involving more than 250 students from different colleges and university in Delhi and Pune by which a noble cause to inculcate the feeling of scientific temperaments in young mind is also achieved. The main focus of the campaign was to generate missing primary data, validate some uncertain secondary data and to collect the available secondary data. During the campaign, information related to



following major activities are either generated or collected from relevant institutions regarding the quantity of fuel used, their type and daily usage:

(1) Power (Coal used in all Thermal Power Plants

(2) Transport Sector (CNG véhicule, diesel, petrol driven véhicules, etc)

(3) Industrial (fuel used in cement, steel, bakery, chemical, metal industries, etc)

(4) Slum Cooking (use and type of kerosene, wood, coal etc)

(5) Commercial Cooking (in hotels, restaurants)

(6) Street vendor fuel usage survey

(7) Paved /Unpaved Road (dust release)

(8) Industrial /shop Generator sets (Diesel used) and

(9) Bio-fuel Burning (dung, crop-residue, wood, bio-mass burning, etc).

To know the traffic volume on different major and minor roads and traffic junction in NCR region, vehicle number density have been counted using click counter at various traffic junction and busy locations in NCR region by students. Delhi has a major road network of nearly 2150 km as compared to minor road network of around 30000 km and it is found that 67% of vehicular density runs on major road. Major traffic junctions contributing to high emission are identified. The sources of emissions are categorized in 4 major sectors namely,

(1) Power

(2) Industrial

(3) Transport

(4) Residential

Industrial and power sector includes emissions from fossil fuel burning; residential sector involves major sources such as fuel (bio-fuel, fossil fuel) burning in slums, hotels, street vendors etc. while transport sector involves emissions from different types of vehicles according to their age, fuel used and present engine technology.

Results and Findings

The brief summary of estimated emission for 2009-2010 as

obtained in this study has been given in Table-1.

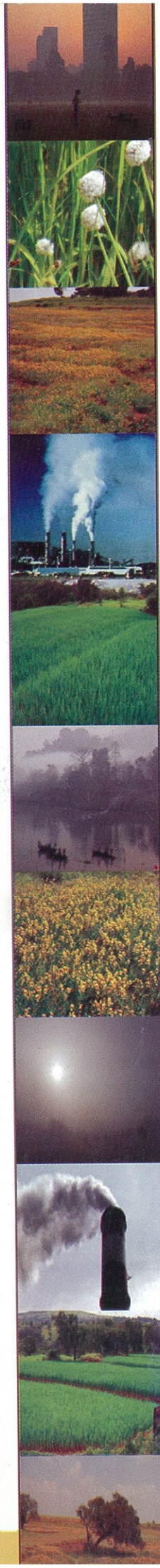
SECTORS	CO	NO_x	VOC_s	$PM_{2.5}$	PM_{10}	BC	OC	SO_2
Power	0.29	6.9	0.10	2.87	11.02	0.29	0.04	57.65
Industry	10.92	79.84	34.76	16.29	16.49	20.27	12.60	209.70
Transport	427.55	162.28	419.16	30.25	30.29	02.87	3.20	47.30
Residential	329.95	36.21	67.00	18.65	36.07	3.11	21.81	27.68
TOTAL	768.71	285.23	521.02	68.06	93.87	26.54	37.65	342.33

Table-1: *Emissions (in Gg/yr) of various air pollutants by different sectors as developed in the present work for the year 2009-2010 in the area of approx.65 km x 70 km covering major parts of National capital region of Delhi as shown in the map.*

The detailed methodology and scientific basis and inter-s pretation of the newly developed emission inventory are available in the technical report released by our ministry as IITM Research report. However, in this summary, a brief discussion on one of the pollutants $PM_{2.5}$ (which can enter in the Human respiratory system through inhalation and pose health hazards) provided as a case result to demonstrate the quantum of detailed work carried out in this study. The spatial distribution of emission from all sources over Delhi and its adjacent NCR region for the year 2009-2010 is depicted in Figure 1. The estimated total emission of $PM_{2.5}$ for Delhi is calculated to be around 68.06 Gg/yr in 2010. The trend of high emission of the order of 50-400 ton/yr is found over the Rajiv Chowk, Sansad Bhawan, India gate, Indira Gandhi international airport, Okhala Industrial Area, Pragati Maidan, IP-estate, Janakpuri, Meharoli, Lakshmi-nagar, etc. Large Point Sources like thermal power stations and other major industrial zones are the major contributors of $PM_{2.5}$ with an order of 500-9000 ton/yr. The percent contribution of different sectors to the total $PM_{2.5}$ emission is more or less similar. The relative contribution

of $PM_{2.5}$ emissions from industrial, power, transport and residential sector are found to be 16.29 Gg/yr, 2.87 Gg/yr, 30.25 Gg/yr and 18.65Gg/yr respectively. However, $PM_{2.5}$ emission for street vendors followed by slum cooking contributes maximum to the total emission from residential sector where coal, kerosene and LPG is used at very low combustion and much scattered over the dense population. Emissions from transport and industrial sectors are almost similar. There is a reduction in $PM_{2.5}$ from transport sector after implementation of emission norms in Delhi in 2000 by bringing in CNG, improvement in fuel quality and defining Bharat stage-2, 3 etc.

In conclusion, this maiden study reveals that the transport and residential sectors are two dominant sectors responsible for majority of pollutant emissions in Delhi followed by industrial and power sectors. NOx emissions are on the rise whereas Black Carbon emissions are quite low. The unpaved roads have high potential of enhancing the emissions of fine particulate matters which were greatly curbed due to induction of CNG. Hence while formulating and implementing the mitigation strategies, above statistics should be kept in mind. The current work also reveals several interesting features and hot spots which may not deteriorate the air quality for that particular spot due to dynamical meteorology but it will impact the other regions through long range transport of pollutants. The development of emission inventory is still in evolving stage even at international level and hence present results are not free from some amount of uncertainty but we feel that within the constraint, the emission estimates provided for NCR region Delhi are highly robust on such a finer resolution. These results will go long way in helping the air quality management system, environmental policy makers and improving the accuracy of air quality forecasting.



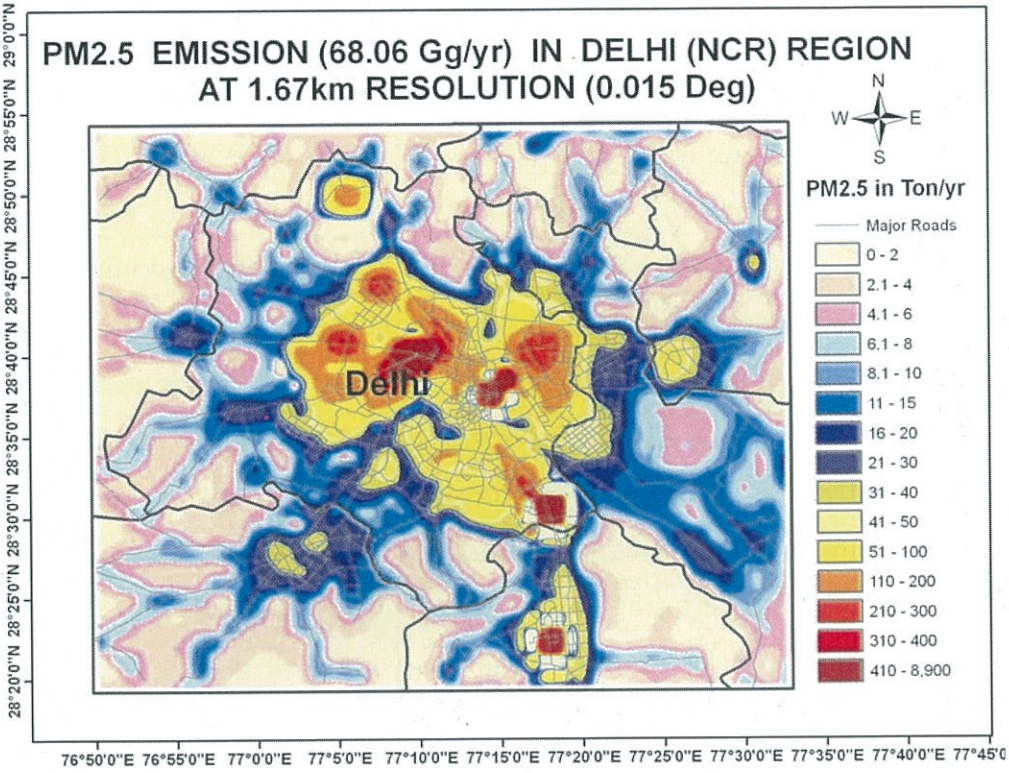


Figure 1: *Spatial distribution of $PM_{2.5}$ Emission over NCR-Delhi*

Some Related Links:

1. http://commonwealthgames-2010india.blogspot.com/2010/12/pollution-levels-moderate-during-cwg.html
2. http://www.expressindia.com/latest-news/air-pollution-prediction-system-gets-un-praise/617668/
3. http://timesofindia.indiatimes.com/topic/article/0btH1nycBG3pW?q=New+Delhi
4. http://indiacurrentaffairs.org/first-ever-system-of-air-quality-forecasting-and-research-a-success-kalpana-palkhiwala/

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