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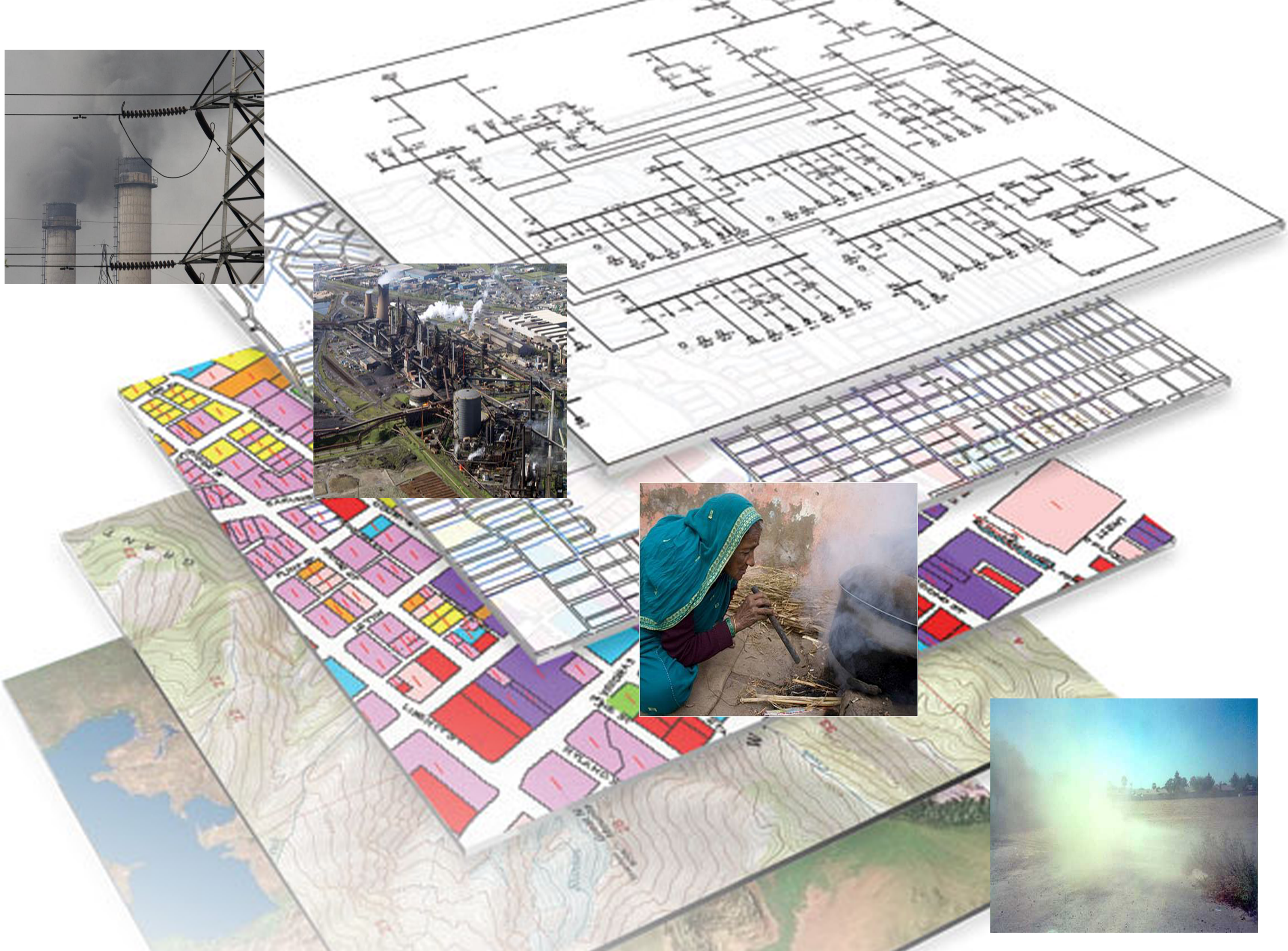

Emission Inventories and Geographical Information System

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Editorial

*ENVIS-IITM centre deals with the very important and sensitive component of the environment **"The Air we breathe"** and related challenges. In our last series of newsletters under the heading "Air Pollution Chemistry" we have taken a brief knowledge of Earth system, interdependence of different components of environment, the atmosphere, air pollution, criteria air pollutants etc. Alteration in the natural composition of the air can harm not only the health of human being but also it affects the health of environment which will eventually end up with the imbalance in the functioning of Earth System. Hence it becomes necessity to keep account of each of the natural as well as human activity which has potential to change the composition of the air over time. Emission of various air pollutants as a consequence of burning of fossil fuel and bio-fuel in our day to day life for industrial activity, transportation, cooking activity, power generation, agricultural production, waste disposal and so on is important phenomenon which alters the normal composition of air. In any urban settlement these are the most potential air pollution sources but their contribution and intensity varies with geographical and social factors. To identify the major air pollution sources in the region and their region specific spatial distribution, scientific approach has to be adopted. **Emissions Inventory** is the most effective scientific tool for the same. Moreover, emission Inventory is the most critical input to the 3-D atmospheric chemistry transport modeling along with meteorological input to forecast the air quality which will help to implement effective air quality management program and formulate environmental policy.*

Present issue gives you information about emission inventories. We hope our attempt to convey complicated scientific information in simple language will help to create awareness amongst the common public which is the first step towards safeguarding our environment

Emission Inventory

– Concept & Need

In order to understand the chemistry of tropospheric ozone, air quality, accurate calculation of radiative forcing driving global warming and corresponding climatic impact, an accurate calculation of rate of anthropogenic emission of GHGs and other atmospheric pollutants is of great significance. Air pollutants that are emitted into the atmosphere as a result of variety of individual sources and processes have a large spatial and temporal variability. The rate of emission depends entirely on the socio-economic factor and rate of urbanization in the region and makes the process of identification of the problem more complex. To know the exact impact of emissions of air pollutants into the atmosphere, information is needed on why, where and when air pollutants are being emitted. So practically, it is impossible to measure each emission source individually. Therefore, an assessment has to be made of the quantity of certain compounds that are emitted at a certain geographical location at a certain time caused by a specific activity.

In such adverse circumstances, emission inventory is the best possible tool to tackle the problem. Emission inventory (EI) is a comprehensive listing by sources of air pollutant emissions and amount of air pollutants released into air as a result of a specific anthropogenic or natural process in a particular geographic region during a specific time period. Emission inventories could be used for either scientific purposes or for making environmental policy.

To improve the air quality in any area/ city one should have detailed information of air pollution sources along with the local meteorological condition and topographical factors. For the purpose the effective science based air quality management is a need of the hour, which can be achieved through comprehensive approach build upon four key areas, viz. (i) Air quality monitoring (ii) development of emissions inventories (iii) atmospheric chemistry-transport modeling and (iv) development of control strategies.

For scientific purposes, emission inventories can be used as an input to 3D atmospheric chemical transport models that are aimed at understanding the chemical and physical processes and the behavior of air pollutants in the atmosphere. To quantify the current development of emission inventories and assess possible future scenarios, it is essential to understand the past anthropogenic changes also. Estimation of the large scale emissions, in most of the cases, is based on the calculation of emissions using an emission factor approach. This approach aggregates information of sources in both time and space, which will lead to an inaccurate representation of the real emission with uncertainty. The usefulness of any developed emission inventory depends on its accuracy and reliability. An emission inventory, therefore, becomes one of the important fundamental components used in air quality model application and also for air quality management plans to measure progress/changes over time to achieve cleaner air. Present and future year inventories are critical components of air quality planning and modeling. Emission inventories are the basis for numerous efforts including trends analysis, regional and local scale air quality modeling, regulatory impact assessments, and human exposure modeling.

Emission inventories helps to identify the emission sources in the region and contribution of each source to the total emission which will eventually guide us to set priorities for the action plan for different sources, evaluating the various options available to reduce the emissions from identified potential sources and formulate and implement the appropriate action plan. Thus, an inventory provides basic information of sources and sink of different gases along with information like what gases to mitigate, how to mitigate, when to mitigate and where the mitigation action should be allocated.

Status of emission inventory development for India

The initial efforts to prepare the emission inventory for India was made by Kato and Akimoto (1992) and Akimoto and Narita (1994) for the SO_2 and NO_x emissions for the base years 1975, 1980 and 1985-1987. Later, there were a few global researchers who developed the inventory over the Indian geographical region like Zhange et al., (2009); Ohara et al., (2007); Garg et al., (2006); Dalvi et al., (2006);

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Parashar et al., (2005); Venkataraman et al., (2005); Bond et al., (2004); Gadi et al., (2003); Reddy et al, (2002a,b); Garg et al., (2001); Streets et al., (2001); Street et al., (2003); Aardenne et al., (1999); Cooke et al.,(1999) and Zhange et al., (1999) etc). In most of the cases, the emission is estimated on country level without including the more detailed micro-level activity data. The estimation is made as per the emission factor approach where the activity levels multiplied by compound specific emission factors at a very broader level (state level). Except few inventories, most of the emission inventories are developed for the base years as mentioned above and in 1990s.

Some Earlier Studies

Emission Inventories for Methane: A potent Green House Gas

The global methane emissions are estimsted at 375 MT in 1990, with top emitters being China (29 MT), the US (27MT), India (17MT) and Brazil (9.9MT). Rice paddy fields are considered as one of the most important source of methane. As per the IPCC (1992) estimates, the global emission rate from paddy field is 60 Tg/yr, with a range of 20 to 100 Tg/yr.

So far India is concern, studies carried out in the year 1990 and 1995 show that Uttar Pradesh, Madhya Pradesh, Bihar, Maharashtra, West Bengal and Orissa are the six largest methane emitting states in India. UNFCCC Data Interface provides information that in the year 1994 the annual methane emission from different sectors over India is as follows –a) agriculture sector - 78.39%, b) energy sector -16.02% and c) waste sector - 5.54%.

Inventory assessment of three GHGs, namely CO_2, CH_4 and NO_2 done by Amit Garge and P.R. Shukla for the year 1990 and 1995 showed that next to the CO_2, methane is the important GHG contributing almost 30% to India's CO_2 equivalent GHG emissions. Agriculture sector has contributed more than 80% of all Indian methane emissions in 1995 including 42% from livestock related activities (which includes 90% emissions from enteric fermentation and 10% from manure management), 23% from rice cultivation and 16% from biomass consumption.

The projections of emission inventory of the year 1995 shows that methane emissions grow along agriculture sector rate.

In India, methane emissions from disposal and treatment of municipal waste are a prominent source in the larger urban centers and it contributes 10% to the total methane emissions from different sectors, in addition to this, oil and gas transport contributed 10% to the total methane emission over India, in 1990 and 1995. Besides above, Bhattacharya et al (2006), Sharma et al (2002), Bhatia et al (2004), Singhal et al (2005) have made noteworthy inventory studies regarding these GHGs, i.e. methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O), from agriculture, livestock, waste sectors of different states, in order to study their impacts on global warming.

Emission Inventories for Particulate Matter

In India existing emission inventories focus on a particular emission source such as biomass combustion, fossil fuel combustion etc. or a particular problem e.g. greenhouse gases. It has been observed that most of the emission inventories are developed to estimate the emissions of individual PM components such as BC, OC, sulphate aerosols etc.

Earlier study carried out by M. S. Reddy and C. Venkataraman for the year 1996–1997 on aerosol emissions from biofuels and fossil fuel combustion in India shows that emissions from biomass combustion are area sources spread all over the India while emissions from fossil fuel combustion are localized to large point sources and major cities. According to their estimates the biomass combustion in India resulted in 2.04 Tg/year of PM2.5 emissions with higher emissions rates from east-coast and north India.

While coal burning in power plants and industrial sector results in the emission of 0.49 Tg/year and 2.0 Tg/ year for the 100% and the 50% control scenario, respectively. Another resent study carried out by T. V. Ramchandra and Shwetmala on India's transport sector shows that average state-wise emission of PM is 4.37Gg. Their result shows that Gujarat, Maharashtra and Tamil Nadu have higher proportion of PM emission from transport sector. It has been observed that very few estimates are available for state level PM emission over India. They are available mostly for large cities such as Delhi, [Gurjar et al (2004) and Goyel et al], Mumbai [Bhanarkar et al (2005)], Pune [USEPA-MoEF project (2002)] and the state of

Andhra Pradesh [Integrated Environmental Strategies (EIS)-India project (2003)].

According to the study conducted by NEERI in 1994, the particulate emission from air polluting industries in Delhi had been estimated to be 6800 kg/hr. Study conducted by Gurjar et al (2004) reveals that the TSP emissions in Delhi increased from 131 Gg in 1990 to 150 Gg in 2000. Their results show that thermal power plants is the major source of TSP in Delhi contributing about 80% to the total TSP emissions while transport sector contributed about 19% by the year 2000. Within the transport sector about 39% of TSP is emitted by two wheelers, which contribute about 65% of Delhi's total vehicle population. P. Goyal and N. Jaiswal assessed the impact of fuel changes and implementation of different emission norms on PM emissions. Their results show that PM emissions from transport sector decreased by 48% during the year 1996 and again 48% in 2005 due to the implementation of stricter emission norms and improvement in fuel quality.

Geographical Information System (GIS)

A Geographic Information System (GIS) database consists of a spatially registered set of data planes or themes of objects (e.g. assets) that can be mapped. A GIS represents the data graphically and provides additional tools for analyzing spatially referenced data. Therefore, a GIS is sometimes also called as a Spatial Database Management System (SDMS). By representing the data appropriately in a GIS and by applying the concepts of spatial relations on the geographical maps we can produce more informative maps which ultimately improve our ability to make good decisions. The application of Geographical Information System (GIS) tools towards the development of inventory remained limited until recently. Emission in gridded form is always required as input to exercise the atmospheric models. GIS has adequate means to store and process the spatial and temporal emission information and provides it in appropriate format required in the model, which is often not available, in particular, for the Indian geographical region.

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Earlier, Dalvi et al. (2006) have used the GIS based methodology to develop gridded emission inventory of carbon monoxide. Streets et al. (2003), Bond et al. (2004) and Cao et al. (2006) have used GIS for gridding emissions for several gases and pollutants including BC. Recently Sahu et al. (2008) also reported the BC emission for the 1990s over the Indian region. For the scientific purpose, among the global inventories, Emission Database for Global Atmospheric Research (EDGAR), Regional Air pollution Information and Simulation (RAINS-Asia) initiated by International Institute for Applied System Analysis (IIASA), Transport and Chemical Evolution over the Pacific (TRACE-P) and Global Emission Inventory Activity (GEIA) are the two most widely used emission inventories that are utilized as input into atmospheric chemical transport models, which aims at understanding the chemical and physical processes and the behavior of atmospheric species by global modeling communities.

High Resolution Gridded Emission Inventory

Scientist of IITM have published the first ever inventory of several pollutants

During commonwealth Games-2010, a very high resolution Emission Inventory (1.67km×1.67km) for a domain of 70km×65km covering Delhi and its adjacent region was developed for gaseous pollutants; viz. CO, NOx, SO2 and VOC and particulate matters including PM10, PM2.5, BC and OC, by Indian Institute of Tropical Meteorology (IITM), Pune, under the Ministry of Earth Sciences (MoES) project, "System of Air Quality Forecasting and Research (SAFAR)", to forecast the air quality during Commonwealth Games 2010 (CWG-2010). The project got lot of success and helped in preparing event based air quality model, which was used to reduce the emissions during the international event of CWG-2010 and prevented the deterioration of air quality and its further impacts. Recently under the project SAFAR-Pune, Emission Inventory (1.67km ×1.67km) for a domain of 60km×60km has been prepared for Pune Metropolitan Region (PMR) –Pune.

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