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ENVIS NEWS LETTER

Acid Rain and Atmospheric Pollutant Modeling

(A Project of the Ministry of Environment and Forests, Govt. of India)

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Indian Institute of Tropical Meteorology PUNE

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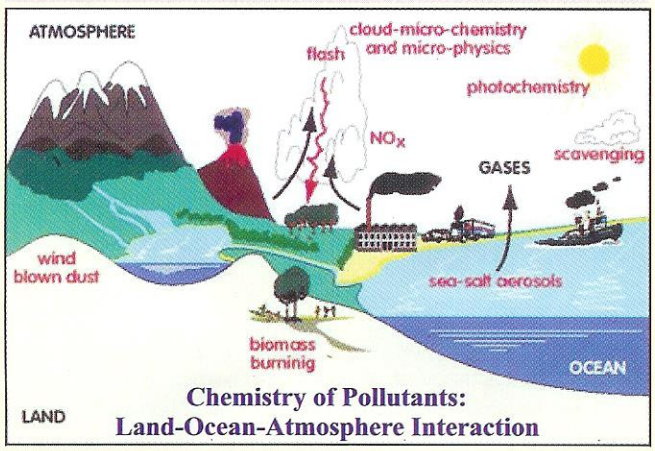


Chemistry of Pollutants: Land-Ocean-Atmosphere Interaction

Editors's Foreword

The importance of issues related to environment and related information has long been recognized by the Government of India, which established an Environmental Information System (ENVIS) as a plan programme in December, 1982 itself. The launching of an ENVIS node "Acid Rain and Atmospheric Pollutant Modeling" marks a new and major multi-faceted initiative. The acid rain and pollution problems has a concern to our daily life but that is not visible to the general public, either because it is hidden by concealed interests or because it has such slow effects that even their additive results are difficult to perceive. The subtle effects of the growth of secondary pollutants like NOx, CO, Hydrocarbons and even ozone at surface cannot be easily perceived by a common public because they are not instantaneous, and unless an event of great proportions occupies for a few days the first page of our newspaper it goes into oblivion. Are we aware that the air pollution is responsible for about 35% of the toxic contaminants that end up in oceans and coastal water. The thermal power plants generates about 30-40 million tonnes of fly ash annually in India but only 2-3 percent of it is productively utilized and remaining add up to pollution. Although pollution levels in metro cities are showing a downward trend, still the situation is far from satisfactory as the vehicle population is alarmingly increasing. In this context, there has been a long-felt need to provide an effective medium of communication for the dissemination of information as well as interaction between the research groups, relevant to the air pollution and acid rain. The present ENVIS newsletter on the above subject area, the inaugural issue of which is in your hands now, is mean to fulfill this need. Everything is small in the beginning; this issue is no exception. We have made a serious attempt to put together some of the available basic information, but hope to improve and expand the Bulletin in due course of time. The co-operation, suggestions and input material from all the related researchers and associated groups both in India and abroad are most essential to make the Bulletin a truly effective forum for all pollution related issues of the country. We hope this ENVIS newsletter will succeed in living up to its expectations. We welcome all constructive criticism on the contents as well as on presentation from the readers.

G. Beig G.B. Pant

Editors

About Indian institute of Tropical Meterology, Pune

The ENVIS node on "Acid Rain and Atmospheric Pollutant Modeling" exists at the Indian Institute of Tropical Meteorology, Pune which is an autonomous institute under the Department of Science and Technology, Government of India. The Institute was formally established under the UNDP's (United Nations Development Programme) Special Fund Project as the Institute of Tropical Meteorology (ITM) at Pune on November 17, 1962 as a distinct part of the India Meteorological Department (IMD). On April 1, 1971, the Government of India gave it an autonomous status with a new name as the Indian Institute of Tropical Meteorology.

The Atmospheric Science has been recognized as an important area of research due to its impact on various human activities, specially agriculture and earth's environment. Hence, the objectives of the Institute are set forth to undertake and encourage research aimed at advancing the present knowledge in Atmospheric Sciences by identifying, planning, collaborating and conducting research programmes on problems of national and international importance. The Institute has built up expertise for application of knowledge as a national resource in terms of weather, climate and related atmospheric processes. Its primary functions are to promote, guide and conduct research in the field of meteorology in all its aspects. The IITM also functions as a national centre for basic and applied research in monsoon meteorology of the tropics in general with special reference to monsoon meteorology of India and neighborhoods. It has made significant contributions in the challenging areas of the Meteorology and Atmospheric Sciences like Weather Forecasting, Climatology and Global Change, Hydrometeorology, Monsoon, Climate Modeling, Cloud Physics, Weather Modification, Atmospheric Chemistry, Atmospheric Electricity, Instrumentation for the observational studies, and studies relating to Land-Surface Processes.

The Institute has kept a good mix of fundamental and applied research in its programmes. Its research findings have received attention of the national and inter-national participating in several International scientific community. The IITM is recognized by several universities as a Centre of Advanced Research for carrying out work leading to the award of M.Sc. and Ph.D. Degrees in Atmospheric Sciences. It also provides teaching and research support to the universities in their M.Sc. and M.Tech. courses in Atmospheric Physics / Sciences. The Institute has been pursuing its field experimental programmes and also participating in several International Bilateral Programmes in the field of Atmospheric Sciences. Considering the increased concern among Government and general public about a variety of environmental issues, the Institute plans it's research programmes to meet the critical national needs for providing information relating to various aspects of the atmosphere. For more information on IITM please log onto our website at **http://www.tropmet.res.in**

About ENVIS

Realizing the importance of Environmental information, the Government of India, in December, 1982, established an environmental information system (ENVIS). ENVIS has started implementing the world bank assisted environment management capacity building technical assistance project (EMCBTAP) since January, 2002 which aims at structuring the ENVIS scheme by extending its reach through involvement of institutions/organizations in state governments, academia sector, corporate sector, NGO sector, etc. ENVIS is a decentralized system with a network of distributed subject oriented centers ensuring integration of national efforts in environmental information collection, collation, storage, retrieval and dissemination to all concerned. ENVIS centers have been set up in the areas of pollution control, toxic chemicals, central and offshore ecology, environmentally sound and appropriate technology, bio-degradation of wastes and environment management, etc. ENVIS India has already established 81 partner nodes which include 30 government departments, 36 institutions and 15 NGOs. These nodes are supposed to create Websites and disseminate related information with defined goals on specific environment related subject areas. For more information on this please log on to their website: *http://www. envis. nic. in*. An ENVIS node "**Acid rain and Atmospheric Pollutant Modeling**" which falls under the broad subject area "Chemicals, Waste and Toxicology" has recently been set-up at the Indian Institute of Tropical Meteorology, Pune. Details about the homepage of this node is presented in the last page.

Atmospheric Pollutants and Their Effects

Some of the major air pollutants are;

Domestic Smoke;
The Greenhouse Gases;
Radionuclide;
Nitrogen dioxide;
Toxic Air Pollutants
Smog
Particulates
Carbon monoxide
Lead

Domestic Smoke

About 37 percent of the smoke in our atmosphere is generated in people's homes, and most of this is from coal fires. These produce much more tar and hydrocarbons than an equivalent-sized industrial furnace, and used to be a major contributor to smog.

Smog

Smog looks like a mixture of smoke and fog, which is why it is called smog. It is made up of particulates, which are formed by a complex reaction between various oxides of nitrogen and a

wide range of hydrocarbons, which is triggered by sunlight. This means that smog tends to form in urban areas where there are lots of automobiles, and especially where the ambient air is stagnant, so the smog is not dispersed naturally in the medium.

The Greenhouse gases

Over the millennium before the Industrial Era, the atmospheric concentrations of greenhouse gases remained relatively constant. Since then, however, the concentrations of many greenhouse gases have increased directly or indirectly because of human activities. Hence, one of the major human-induced mechanisms responsible for climate changes on decade to century timescales is provided by the increasing emissions of radiatively active gases including carbon dioxide, methane, nitrous oxide, and halocarbons. Changes in the ozone concentration in the upper troposphere and lower stratosphere lead to additional climate forcing. By trapping infrared radiation emitted by the surface-atmosphere system, these gases tend to warm the planet and, as a consequence, to generate substantial changes in the weather patterns and in the hydrological cycle. Increasing aerosol loading caused by human activities also modifies the radiation budget of the atmosphere with consequences on the climate system. Depending on their size and physical/chemical nature, these particles can scatter solar radiation back to space (producing a cooling of the Earth's surface) or absorb the terrestrial radiation (contributing to the warming of the planet). Aerosols also affect cloud properties with an indirect effect on atmospheric radiative transfer. Carbon dioxide is the most important greenhouse gas, and it comes from the burning of fossil fuels in automobiles, power plants, houses, and industry. Methane is released during the processing of fossil fuels, and also comes from natural sources like cows and rice paddies. Nitrous oxide comes from industrial sources and decaying plants. The greenhouse effect can lead to changes in the climate of the planet. Some of these changes might include more temperature extremes, higher sea levels, changes in forest composition, and damage to land near the coast. Human health might be affected by diseases that are related to temperature or by damage to land and water.

Particulates

Particulates is a general term used to describe tiny bits of matter (technically between 0.1 and 25 thousandths of a millimeter) floating around in the atmosphere, such as certain types of smoke, fine ash and dust. Larger particles are caught by the hairs in our nose and breathing tubes, but smaller particles (less than 2.5 thousandths of a millimeter) can get past these defenses and cause lots of trouble. In urban areas, 5 to 20 percent of particulates are various sulphates, which are believed to be responsible for increased asthma attacks, aggravation of any existing heart and lung disease, and a lowered resistance to breathing problems in children. These particulates also damage plants by covering their leaves, thus reducing how much sunlight they get, and particulate sulphur dioxide can corrode some buildings.

Radionuclide

Radionuclides are materials which produce ionizing radiation such as X-rays, gamma rays, alpha particles and beta particles. These forms of radiation transfer lots of energy to any matter they pass through, i.e. ionizing it. Living tissue is very sensitive to changes, and this ionization can damage it. The extent of the damage depends on what sort of radiation is doing the ionizing, what sort of tissue it hits, and how much radiation the tissue is exposed to. Low doses of radiation over a long time can cause various types of cancer (thyroid, lung, breast and leukaemia) and tumours, and can mutate DNA, causing similar problems to be passed on to the next generation. We are exposed to about three times as much ionising radiation from natural sources as from all the man-made souces put together. This natural radiation comes from mainly the sun and rocks containing radium. Most man-made radionuclide come from medical uses, like X-rays, with nuclear explosions close behind.

Carbon monoxide

It is a gas that comes from the burning of fossil fuels, mostly in automobiles. It cannot be seen or smelled. Carbon monoxide is released when engines burn fossil fuels. Emissions are higher when engines are not tuned properly, and when fuel is not completely burned. These emit a lot of carbon monoxide found outdoors. Furnaces and heaters in the home can emit high concentrations of carbon monoxide, too, if they are not properly maintained. Carbon monoxide makes it hard for body parts to get the oxygen they need to run correctly. Exposure to carbon monoxide makes people feel dizzy and tired and gives them headaches. Elderly people with heart disease are hospitalized more often when they are exposed to higher amounts of carbon monoxide.

Nitrogen dioxide

A reddish-brown gas that comes from the burning of fossil fuels. It has a strong smell at high levels. Nitrogen dioxide mostly comes from power plants and automobiles. Nitrogen dioxide is formed in two wayswhen nitrogen in the fuel is burned, or when nitrogen in the air reacts with oxygen at very high temperatures. Nitrogen dioxide can also react in the atmosphere to form ozone, acid rain, and particles. High levels of nitrogen dioxide exposure can give people coughs and can make them feel short of breath. People who are exposed to nitrogen dioxide for a long time have a higher chance of getting respiratory infections. Acid rain can hurt plants and animals and can make lakes dangerous to swim or fish in.

Lead

A blue-gray metal that is very toxic and is found in a number of forms and locations. Outside, lead comes from automobiles in areas where unleaded gasoline is not used. Lead can also come from power plants and other industrial sources. Inside, paint is an important source of lead, especially in houses where paint is peeling. Lead in old pipes can also be a source of lead in drinking water. High amounts of lead can be dangerous for small children and can lead to lower IQs and kidney problems. For adults, exposure to lead can increase the chance of having heart attacks or strokes.

Toxic air pollutants

Some important pollutants in this category include arsenic, asbestos, benzene, and dioxin. Each toxic air pollutant comes from a slightly different source, but many are created in chemical plants or are emitted when fossil fuels are burned. Some toxic air pollutants, like asbestos and formaldehyde, can be found in building materials and can lead to indoor air problems. Many toxic air pollutants can also enter the food and

water supply, and people can be exposed when they eat or drink. Toxic air pollutants can cause cancer. Some toxic air pollutants can also cause birth defects. Other effects depend on the pollutant, but can include skin and eye irritation and breathing problems.

Ozone Pollution

Ozone is a molecule of three oxygen atoms bound together (O_3). It is unstable and highly reactive. Ozone is used as a bleach, a deodorizing agent, and a sterilization agent for air and drinking water. At low concentrations, it is toxic.

Ozone which is found in the troposphere (surface to about 15 km), the lowest layer of the atmosphere) is man-made, a result of air pollution from internal combustion engines and power plants and often termed "bad" ozone. Automobile exhaust and industrial emissions release a family of nitrogen oxide gases (NOx) and volatile organic compounds (VOC), by-products of burning gasoline and coal. NOx and VOC combine chemically with oxygen to form ozone during sunny, high-temperature conditions of late spring, summer and early fall. High levels of ozone are usually formed in the heat of the afternoon and early evening, dissipating during the cooler nights. Although ozone pollution is formed mainly in urban and suburban areas, it ends up in rural areas as well, carried by prevailing winds. Significant levels of ozone pollution can be detected in rural areas as far as 250 miles (150 km) downwind from urban industrial zones.

The global average radiative forcing due to increases in surface and tropospheric ozone since pre-industrial times is estimated to have enhanced the anthropogenic greenhouse gas forcing by 0.35 ± 0.2 Wm^{-2}. This makes tropospheric ozone the third most important greenhouse gas after CO_2 and CH_4. Ozone is formed by photochemical reactions and its future change will be determined by, among other things, emissions of methane and pollutants. Ozone concentrations respond relatively quickly to changes in the emissions of pollutants. On the basis of limited observations and several modeling studies, tropospheric ozone is estimated to have increased by about 35% since the Pre-industrial Era, with some regions experiencing larger and some with smaller increases. Some Asian stations indicate a possible rise in tropospheric ozone, which could be related to the increase in East Asian emissions.

Reducing Ozone Pollution

There are several ways to help decrease ozone pollution:

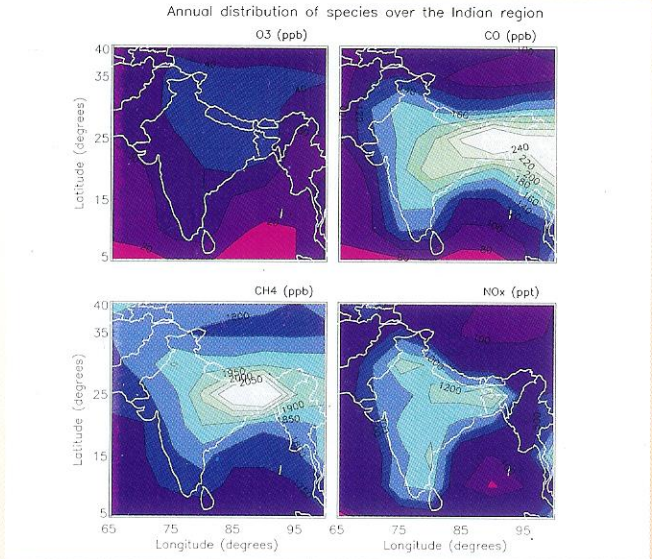
- Limit using automobile during afternoon and early evening hours in the late spring, summer and early fall.
- Do not fuel your vehicle during these times.
- Do not light fires or outdoor grills during these times.
- Keep the engine of your vehicle tuned.
- Make sure that your tires are properly inflated.
- Use environmentally safe paints, cleaning and office products (some of these chemicals are sources of VOC).
- Conserve energy.

Recent efforts on setting cleaner air standards and their compliance by industries, manufacturers and state and local governments has significantly reduced the levels of many common air pollutants with continued reduction and conservation practices, adherence to ozone-pollution warnings, research regulation, ozone-pollution levels should continue to fall, so perhaps future generations will not be threatened by this environmental pollutant.

Distribution of Ozone and Secondary Pollutants over India

One of the important thrust areas of present time is to study the chemical climate of the atmosphere. There has been much concern that increasing concentrations of some source gases resulting from human activities will significantly modify the chemical composition of the atmosphere and consequently the radiative balance of the earth. The above mentioned aspect along with several key issues is being studied word over. In India, a major research programme is initiated at IITM, Pune to study of tropospheric ozone and its precursors namely NOx, CO, CH_4 and hydrocarbons volatile organic compounds (VOC) using both experimental and theoretical modeling approach.

The annually averaged surface distribution of ozone and its precursor gases CO, NO_x and methane over the Indian subcontinent as simulated using a three dimensional chemical transport model operational at IITM, Pune which is shown in the next page. The modeled distribution of ozone which maximizes over the northern part of India (~ 40 ppb) can be explained very well with reference to the simulated distribution of its precursors gases like CO, NO_x and methane. The concentrations of CO over the Indian region are seen to maximize over the eastern Indian region (~240 ppb) and decreases gradually towards the Oceanic region and over the Himalayan region. The emissions of CO over the Indian subcontinent are mostly due to biomass burning and fossil fuel combustion processes. Similar distribution is seen to occur for methane also. Over the Indian region the NO_x distribution is found to maximize (1200 ppt) over the central Indian region and decreases towards the Arabian Sea, Bay of Bengal and the Indian Ocean. A very important aspect of ozone formation and its relation to NO_x can be inferred from the figures shown. Although the concentrations of NO_x is highest over central India and concentrations of pollutants like CO and methane are found to be largest towards eastern India, the ozone concentrations is found to be maximum towards the northern region. This is due to the non-linear relationship of ozone with NO_x. Ozone do not follow NOx pattern after NO_x mixing ratios reach beyond a critical limit. Over the marine region where the NO_x values are very low, ozone concentrations are also found to be very low. The effect of transport of pollutants from the plain regions to hilly regions has also been investigated by this research group. This research work at IITM, Pune is being carried out by a team of scientists led by Dr. Gufran Beig who can be contacted for further details (beig@tropmet.res.in).



Acid Rain

Acid rain is nothing but rain, snow or fog that is polluted by acid in the atmosphere and damages our environment. Some of the common air pollutants that acidify rain are sulphur dioxide (SO_2) and nitrous oxide (N_2O), Nitrogen oxides (NOx), Carbon dioxide (CO_2) and Methane (CH_4) . NOx and SO_2 are significant local pollutant that generate health impacts, ecological damage and also causes acid rain. Sulfur dioxide is a colourless, prudent gas released as a by-product of combusted fossil fuels containing sulfur. A variety of industrial processes, such as the production of iron and steel, utility factories, and crude oil processing produce this gas. Sulfur dioxide can also be emitted into the atmosphere by natural disasters or means. This ten percent of all sulfur dioxide emission comes from volcanoes, sea spray, plankton, and rotting vegetation. Overall, 69.4 percent of sulfur dioxide is produced by industrial combustion. Only 3.7 percent is caused by transportation. The other chemical that is also chiefly responsible for the make-up of acid rain is nitrogen oxide. Oxides of nitrogen are a term used to describe any compound of nitrogen with any amount of oxygen atoms. Nitrogen monoxide and nitrogen dioxide are all oxides of nitrogen. Such gases are by-products of firing processes of extreme high temperatures (automobiles, utility plants), and in chemical industries (fertilizer production). Natural processes such as bacterial action in soil, forest fires, volcanic action, and lightning make up five percent of nitrogen oxide emission. Transportation makes up 43 percent, and 32 percent belongs to industrial combustion. The formation of sulfur dioxide in the atmosphere can be shown as:

$SO_2(g)+O_2(g) ? SO_3(g)$; $SO_3(g)+H_2O(l) ? H_2SO_4(aq)$

Another common reaction for sulfur dioxide to become sulfuric acid is by oxidation by ozone.

In addition, nitrogen oxides rise into the atmosphere mainly from automobile exhaust. In the atmosphere it reacts with water to form nitric or nitrous acid.

$NO_2(g) + H_2O(l) ? HNO_3(aq)+HNO_2(aq)$

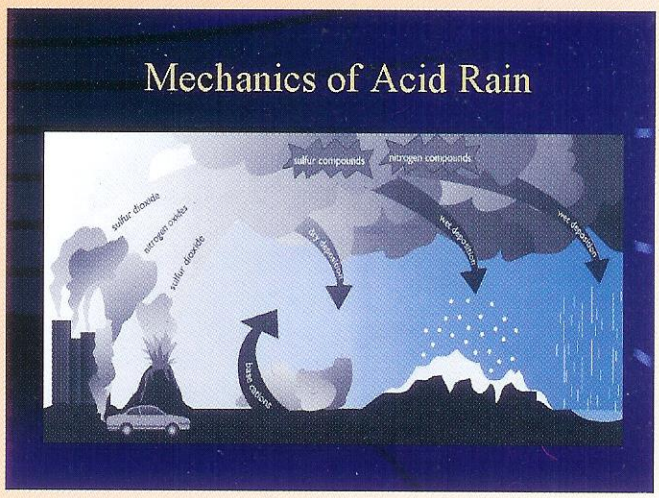
Since most nitrogen oxide emissions are from automobiles, catalytic converters must be installed on these to reduce this emission. Another way to reduce sulfur dioxide before combustion is by burning coal with low sulfur content.

What can we do about acid rain?

What humans can do, as citizens, to reduce sulfur and nitrogen dioxide emission is to reduce the use of fossil fuels. Automobiles pools, public transportation, or walking can reduce tons of nitrogen oxide emissions. Using less energy benefits the environment because the energy used comes from fossil fuels which can lead to acid rain. For example, turning off lights not being used, and reduce air conditioning and heat usage. Replacing old appliances and electronics with newer energy efficient products is also an excellent idea. Sulfur dioxide emission can be reduced by adding scrubbers to utility plants. An alternative power source can also be used in power plants to reduce emissions. These alternatives are: geothermal energy, solar power energy, wind energy, and water energy.

Effects

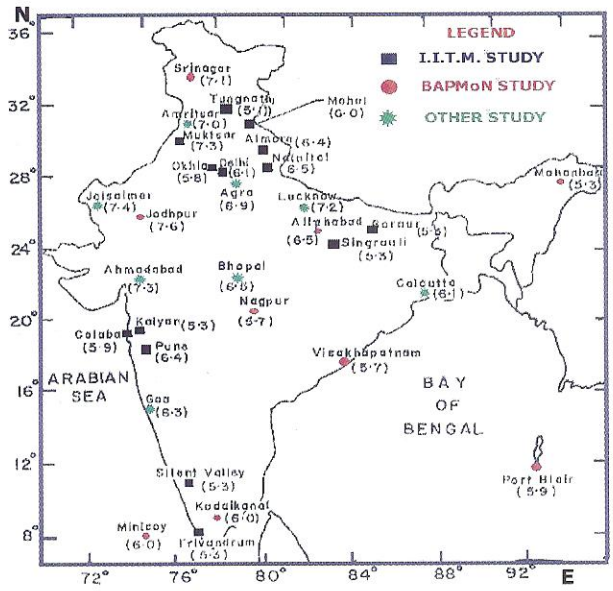
Acid rain does not only effect organisms on land, but also effect organisms in aquatic biomes. Acid rain does not only damage the natural ecosystems, but also man-made materials and structures. Marble, limestone, and sandstone can easily be dissolved by acid rain. Metals, paints, textiles, and ceramic can effortlessly be corroded. Acid rain can downgrade leather and rubber. Acid rain causes carvings and monuments in stones to lose their features. Most importantly, acid rain can affect health of a human being. It can harm us through the atmosphere or through the soil from which our food is grown and eaten from. Acid rain causes toxic metals to break loose from their natural chemical compounds. One of the serious side effects of acid rain on human is respiratory problems. The sulfur dioxide and nitrogen oxide emission gives risk to respiratory problems such as dry coughs, asthma, headaches, eye, nose, and throat irritation.



Acid Rain Study in India

Acid Rain studies are being carried out by IITM since last three decades. In order to study spread of acid rain over India, the pH values of rain water studied by IITM, BAPMoN (Background Air Pollution Monitoring Network) & others at different locations having different environments are shown in the figure. The pH values are higher (pH>7.0) in northy & north-west parts of India. They are slightly lower (6.0 = pH =7.0) in northeastern & southern parts of India. The higher pH is due to neutralisation of acidic ions (SO4 & NO3) by soil originated cations (Ca, K & Mg) as well as by NH4. However,

the pH values are acidic (pH =5.56) at some industrial, rural & remote locations which could be either due to anthropogenic emissions (Kalyan & Singrauli), acidic soil (Goraur & Mohanbari) or due to thick cover of vegetation that prevents soil erosion (Trivandrum, Silent Valley & Tungnath). This work is being carried out at IITM, Pune by a team of scientist led by Dr. P.S.P. Rao.



Bio-mass Burning

Biomass is the name given to any recent organic matter that has been derived from plants as a result of the photosynthetic conversion process. Biomass energy is derived from plant and animal material, such as wood from forests, residues from agricultural and forestry processes, and industrial, human or animal wastes. The energy value of biomass from plant matter originally comes from solar energy through the process known as photosynthesis The chemical energy that is stored in plants and animals (that eat plants or other animals), or in the wastes that they produce, is called bio-energy. During conversion processes such as combustion (burning), biomass releases its energy, often in the form of heat, and the carbon is deoxidized to carbon dioxide to replace that which was absorbed while the plant was growing. Essentially, the use of biomass for energy is the reversal of photosynthesis. Equation for photosynthesis is

$$CO_2 + 2H_2O \xleftarrow[\text{heat}]{\text{light}} ([CH_2O] + H_2O) + O_2$$

In nature, all biomass ultimately decomposes to its elementary molecules with the release of heat. Therefore, the release of energy from the conversion of biomass into useful energy imitates natural processes but at a faster rate. Therefore, the energy obtained from biomass is a form of renewable energy. Utilising this energy recycles the carbon and does not add carbon dioxide to the environment, in contrast to fossil fuels Biomass can be used directly (eg burning wood for heating and cooking) or indirectly by converting it into a liquid or gaseous fuel (eg ethanol from sugar crops or biogas from animal waste).

Biomass resources

Biomass can be used for energy production cover a wide range of materials. Plants are the most common source of biomass. They have been used in the form of wood, peat and straw for thousands of years. Industrial waste that contains biomass may be used to produce energy. For example the sludge left after alcohol is made., waste from food processing and fluff from the cotton and textiles industry. Agricultural waste is a potentially huge source of biomass. like the portions of crop plants discarded (including forestry waste), weather damaged or surplus supplies, and animal dung.

Biomass conversion technologies

These are as follows: Direct Combustion & cogeneration, Anaerobic Digestion, Briquetting & Pelletising, Pyrolysis, Gasification etc.

Biomass Applications

Biofuels-The production of biofuels (ethanol and biodiesel) has the potential to replace significant quantities of fossil fuels in many transport applications

Electicity Generation-Electricity can be generated from a number of biomass sources.

Heat & Steam-The combustion of biomass or biogas can be used to generate heat and steam, for home heating and cooking, to drive steam turbines etc.

Combustible Gas-The biogas produced from anaerobic digestion or pyrolysis can be used in internal combustion engines to drive turbines for electricity generation, to produce heat for commercial and domestic needs etc.

Future of Biomass

In the future, biomass has the potential to provide a cost-effective and sustainable supply of energy, while at the same time aiding countries to meet their greenhouse gas reduction targets. In both developing and industrialized countries, the main biomass processes utilized in the future are expected to be the direct combustion of residues and wastes for electricity generation, bio-ethanol and bio-diesel as liquid fuels, and combined heat and power production from energy crops. In the short to medium term, biomass waste and residues are expected to dominate biomass supply. The future of biomass electricity generation lies in biomass integrated gasification/gas turbine technology, which offers high energy conversion efficiencies. Biomass fuels used in India account for about one third of the total fuel used in the country, being the most important fuel used in over 90% of the rural households and about 15% of the urban households.

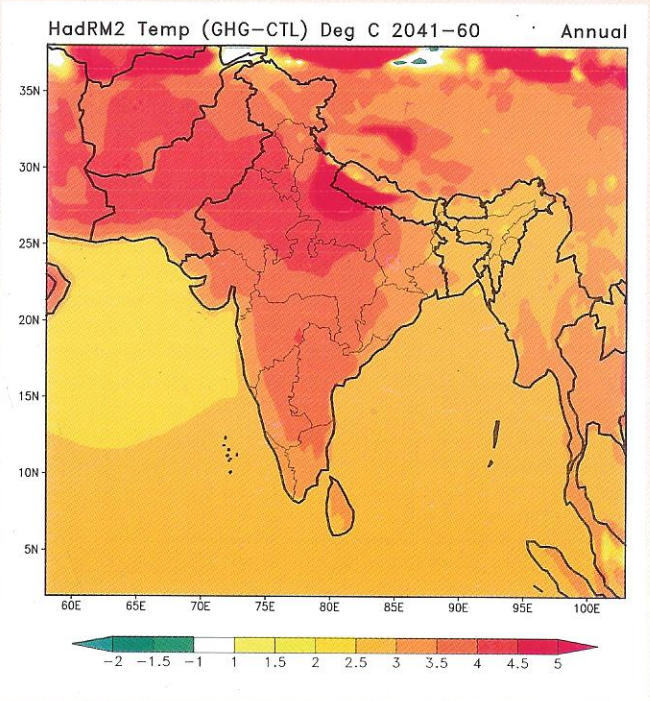
Potential Impact of Anthropogenic Climate Change over India

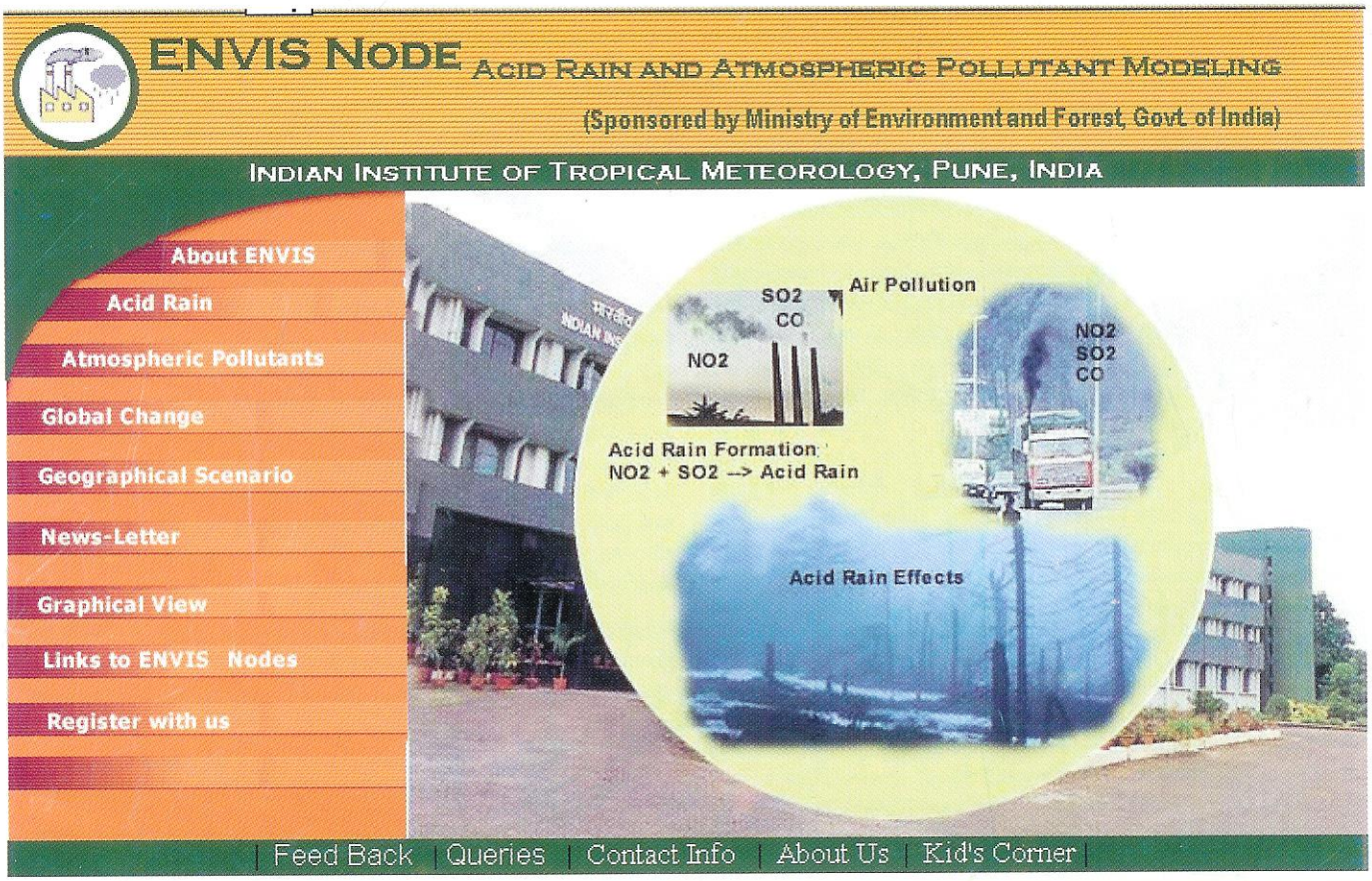
Human activities since the beginning of the industrial revolution have resulted in dramatic changes in the chemical composition of the earth's atmosphere. Such changes have the potential to influence earth's climate; however, the characteristics of climate change associated with natural and anthropogenic forcings are not exactly known because of the complex interactions within the earth's climate system. Although meteorological data compiled over the past century suggest that the earth is warming, there are significant variations at regional levels. There is a strong need for understanding the nature of climate change at global and regional levels to deal with, and plan action for, possible impacts. The so-called 'climate scenario', which has become a buzzword in the parlance of climate change programmes the world over, denotes a plausible representation of future climate that is constructed for explicit use in investigating the potential impacts of anthropogenic climate change.

To address several related issues on a regional scale, IITM, Pune has taken up an exciting task under the Joint Indo-UK collaborative programme on the development of climate change scenarios in India for impact assessment. This project deploys the state-of-art regional climate model (HadRM3H/PRECIS) developed by the Hadley Centre for Climate Prediction and Research of the UK Meteorological Office (UKMO), to simulate the climate over the Indian region. This programme is a coordinated effort to build scientifically sound high-resolution climate change scenarios for India and use them to assess the associated impacts in various sectors. This programme is funded by the Department of the Environment, Food and Rural Affairs (DEFRA), Government of UK, and is coordinated by the Ministry of Environment and Forests (MOEF), Government of India. Messrs. Environmental Resources Management India Ltd. has been acting as the facilitating agency. Other leading partners in this programme are: The Tata Energy and Resources Institute (TERI), Indian Institute of Management, Ahmedabad (IIMA), Indian Institute of Science (IISc), National Physical Laboratory (NPL), National Institute of Oceanography (NIO), and Indian Agricultural Research Institute (IARI). One such coordinated programme was successfully completed in the UK recently, generating a great deal of useful information for policy making. In this project so far, some of the important issues are addressed including the first glimpse of the type of climate change scenario products that are expected to be developed in future. A few climatic projections for the Indian region, based on the transient climate change experiments, and the preliminary climate change scenarios developed as part of the present project, using the Hadley Centre regional climate model HadRM2 have been developed. These scenarios are being used to assess the impact on water resources (IITM), agriculture (IARI), forests (IISc), industry, energy and transport (IIMA), sea-level variability (NIO) and human health (NPL).

In India, agriculture forms a critical component of the national economy, which is mainly dependent on the monsoon rainfall. The regional climatic variations play a dominant role even in other economic sectors like industry, services, transport, forestry, human health, etc. However, due partly to our limited understanding of the climate variability and large uncertainties in their prediction, the climatic anomalies have traditionally come to be viewed as inevitable, giving rise to a variety of adaptive practices based on experience rather than scientific insight. Indeed, very little modern climatic information has so far found direct practical applications in the socio-economic sector in the country. However, with the recent global attention on climate change issues and the particular focus on a regional approach, it is imperative that we make a synthesis of all the climatic information available, to provide a comprehensive description of the regional climate in the context of global change. Such an exercise is expected to help assessment of our vulnerability and to optimize the required adaptive and mitigatory strategies. In particular, if we are able to accurately isolate the anthropogenic impacts on climate, it would be easier to find avenues for intervention policies to avert possible adverse consequences.

Results so far out of this project indicate that, under increasing atmospheric CO_2 concentrations, the mean surface temperatures increase everywhere over India, in all the seasons. The warming is more pronounced over land areas, with the maximum increase over north India. The warming is also relatively greater in winter and post-monsoon seasons. Summer monsoon season is marked by relatively less magnitude of warming. In terms of summer monsoon precipitation response, large decreases are seen over the the western part of the region, mainly over the oceanic areas, and increases over the north-eastern parts of the country. The work here at IITM, on the application of regional climate models to develop high - resolution climate change scenarios for India, is being carried out by a team of scientists led by Dr. K. Rupa Kumar who can be contacted (kolli@tropmet.res.in).





An ENVIS node "**Acid rain and Atmospheric Pollutant Modeling**" which falls under the broad subject area "Chemicals, Waste and Toxicology" has recently been set-up at the Indian Institute of Tropical Meteorology, Pune. The node will help in gradually building up an inventory of information material on the above subject area, disseminate information / data electronically and provide interactive web page for it. A Web site has also been maintained by us for this ENVIS node (**URL:** ***http://envis.tropmet.res.in***) at the IITM, Pune. An actual front page picture for this site is depicted above. The content of the WEB site includes the details as per the following headings: **About ENVIS-** provides brief general introduction to the environmental information system; **Acid rain-** provides information on the subject matter, causes and impacts of acid rain around the globe, in particular over India and discusses other relevant topics on acid rain; **Atmospheric Pollutants-** brief details about pollutants like acid rain, smog, particulates, green-house gases, radionuclides, carbon monoxide, sulphur dioxide, lead etc and their impacts on the environment; **Global change in Atmosphere-** causes of the climatic change and the geographical scenario), **Newletters** and **Links** to some of the other related sites, books/journals etc , **Graphical view** of some of the species (NOx, CO, O_3, CH_4 etc), their contents, emission rates in the atmosphere at different duration (hourly, daily, monthly, etc).

Vatavaran-2003

India's Exclusive National Environment and Wildlife Film Festival, organized by the Centre for Media Studies(CMS) with support of Ministry of Environment & Forests, Govt of India, is all set to roll from 18th - 20th November 2003 at New Delhi. Starting July 2003, a chain of pre festival events like seminars, film screenings, exhibitions & talks will be organized to culminate with the film festival in November 2003. "Vatavaran 2003" festival will also be taken to cities like Ahmedabad, Mumbai, Bangalore, Hyderabad, Kolkata. Eight National Awards with total prize money of Rs 6,50,000/- will be awarded to outstanding documentary films. For more information log on to *www.cmsindia.org/vatavaran2003* or write to "Vatavaran 2003" Centre for Media Studies, Research House Community Centre, Saket, New Delhi-110017, **Tel:** 91-11-24992597, 2686 4020/ 2685 1660; **Fax:** 91-11-2696 8282; **Email:** vatavaran2003@cmsindia.org.

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