

RCAES 2014 DECEMBER 27 -30

TE@IP



सत्यमेव जयते  
Department of Science and Technology  
Ministry of Science and Technology  
Government of India



सत्यमेव जयते  
Ministry of Earth Sciences  
Government of India

**FOUR DAYS WORKSHOP**  
**27<sup>th</sup>Dec to 30<sup>th</sup>Dec 2014**  
On

## **RECENT CHALLENGES IN ATMOSPHERIC AND EARTH SCIENCES**



*Coordinators*

**Dr. Raj Mohan B.**

**Dr. P.E.JagadeeshBabu**

**Dr. Keyur Raval**

**Dr. T.K. Jagannathan**

*Sponsored by*

**NITK/TEQIP/MoES/DST**



*Organized by*  
**Department of Chemical Engineering**  
**National Institute of Technology Karnataka,**  
**Surathkal, Mangalore-575025 Karnataka, India**  
(website: [www.nitk.ac.in](http://www.nitk.ac.in))

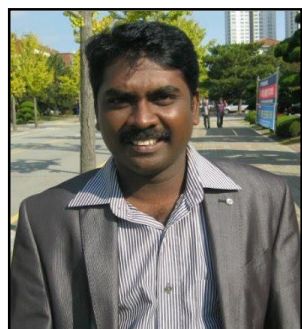


## **ABOUT THE INSTITUTE AND THE DEPARTMENT**

National Institute of Technology Karnataka (NITK), Surathkal (formerly KREC), is one of the Institute of National importance in our country funded by MHRD, Government of India. Since its inception in 1960 as the Karnataka Regional Engineering College, the Institute has established itself as a premier center engaged in imparting quality technological education and providing support to research and development activities. The Institute has a long tradition of research for several decades in both traditional and modern areas of Engineering and Sciences in all Departments.

The Department of Chemical Engineering at National Institute of Technology Karnataka is one of the oldest in this leading Engineering Institute established in the year 1965 with the assistance of MHRD, Government of India and the Government of Karnataka and ranked one of the top Chemical Engineering Departments in India by National Board of Accreditation. This Department offers three M.Tech programmes viz., Chemical Plant Design, Industrial Pollution control and Industrial Biotechnology and one B.Tech course in Chemical Engineering along with Doctoral programs in the advanced areas of Chemical Engineering. The Department has well equipped state-of-art laboratories viz., momentum transfer, mass transfer, heat transfer, control lab, advanced instrumentation lab, industrial pollution control lab, biotechnology lab and testing & consultancy lab to compliment the theoretical coursework. The Department of Chemical Engineering at National Institute of Technology Karnataka, Surathkal, is in existence for the last forty five years. The department consists of a rich blend of people with prolific academic background and invaluable industrial experience.

## MESSAGE FROM THE ORGANISING COMMITTEE



**Dr. Raj Mohan B**  
Associate Professor



**Dr. P.E.JagadeeshBabu**  
Assistant Professor



**Dr. Keyur Raval**  
Assistant Professor



**Dr. T.K.Jagannathan**  
Assistant Professor

The inevitable and valuable yet often forgotten existence of Mother Nature could be marked as the most undesirable after effects of the present way and quality of living. Lack of proper understanding of the complexity of nature its beauty and evolution has led mankind to habitually complicate their own niche. It is however interesting to note that India being one of the largest developing countries in the world with thickly populated cities and fast growing industrial sectors stands as world's fourth largest economy and fifth largest greenhouse gas (GHG) emitter, accounting for about 5% of global emissions. Nearly 700 million people out of over one billion populations live in rural areas and their livelihood directly depend on climate sensitive sectors like agriculture, forests, and fisheries and many other natural resources such as water, biodiversity, mangroves, coastal zones, grasslands for their subsistence and livelihoods. Major public health problems occur under direct and indirect influence of change in the atmospheric composition and change in the local weather. In order to protect our health, vegetation and ecosystems it is necessary to monitor, assess and manage ambient air quality of our environment. Another important challenge faced in the earth sciences sector is the variation in the land use pattern and the associated geological after effects. Appropriate land-use change and emission scenarios calculated with alternative models with consistent socio-economic driving- force assumptions have been adopted for the corresponding scenarios based on the judgment of the individual modeling teams that developed the respective marker scenarios.

The thrust areas under consideration was hydrological aspects due to climate Change, atmospheric aerosols and climate change, land use patterns a changing scenario in Indian context, climatic models for regional adaptation, reduction, loss and extinction in terrestrial biodiversity, geo-scientific techniques to measure inundation vulnerability in coastal regions, disaster management techniques and practices, insights into “The Global Carbon Cycle”. The primary aim of the four days’ workshop was to familiarize the participants with a wide knowledge about the challenges in atmospheric and earth science and the need for the new methods to monitor and control them from pollutions in a way that is accessible to the researchers and teachers with diverse background in chemical, and other allied areas. Further, to create awareness among academic and industrial community about the prognostic measures and methods related to atmospheric and earth science. The proposed course aimed to provide a good overall knowledge about the present challenges in atmospheric and earth science and expose the diagnostic and prognostic measures and method related to them.

The objective of the workshop was to create a platform for interaction between academia, industry and government officials working in similar area, thereby, provide opportunity to enhance the research in the field of atmospheric and earth sciences in India, to provide opportunity for students to gain knowledge on contemporary issues related to atmospheric & earth sciences; thereby, motivating them towards research, to motivate academia and industry to pursue collaborative research in the area of sustainable development and conceptualize the idea of sustainable development with the help of invited talks based on facts.

We hope RCAES 2015 will achieve this objective and contribute to the further development of this vision in the future

For the RCAES 2015 Organizing Committee

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Overall Conclusion of the Workshop

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## Workshop on Recent Challenges in Atmosphere and Earth Science (WRCAES 2014)

December 27 -30 2014 at NITK,  
Surathkal, India

### Day 1: Inaugural session: Saturday, December 27, 2014

<b>09:30 -10:30</b>	<b>Inaugural function</b>		
<b>10:30 -10:45</b>	<b>High Tea</b>		
<b>10:45-13:00</b>	<b>Technical Session I</b>		
10:45 – 11:15	Disaster Risk Management for Industries and Residential Areas		<b>Shri. H S Varadarajan</b> Chief Fire Officer Mangalore District
11: 15 – 12:15 p.m	Key Note Speech: Landslide in fragile slope		<b>Dr. T N Singh</b> IITB Indian Institute of Technology Bombay, Mumbai
12:15 – 13:00	Guidelines and preparedness for Industries to during Emergency / Disastrous Event		<b>Mr. K G Najanppa</b> Deputy Director Inspector of Factories, Mangalore
<b>13:00 -14:00</b>	<b>Lunch Break</b>		





<b>14:00 -17:15</b>		<b>Technical Session II</b>	
14:00 – 15:00	Understanding the sources, transport and fate of pollutants through riverine geochemistry		<b>Dr. Balakrishna</b> Associate Professor Dept. of Civil Engineering MIT Manipal
15:00 – 16:00	Air Pollution by Industrial Sources		<b>Dr. B C Meikap</b> Professor Dept. of Chemical Engineering IIT Kharagpur
<b>16:00-16:15</b>		<b>Tea Break</b>	
16:15 – 17:15	Behaviour and interactions of “Particulate Matter” in the Atmosphere		<b>Dr. Raj Mohan B</b> NITK Associate Professor Dept. of Chemical Engineering NITK

## Workshop on Recent Challenges in Atmosphere and Earth Science (WRCAES 2014)

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Surathkal, India

### Day 2: Sunday, December 28, 2014

09:00 -12:30	<b>Technical Session III</b>		
09:00 -10:00	Changing Patterns of Surface Hydrology in South India		<b>Dr. Lakshman Nandagiri</b> NITK Professor Dept. of. Applied Mechanics and Hydraulics NITK
10:00 – 11:00	Land use Patterns a Changing Scenario across the world		<b>Dr. G. Srinikethan</b> NITK Professor Dept. of. Chemical Engineering NITK
<b>11:00 -11:30</b>	<b>Tea Break</b>		
11:30 – 12: 30	Structural Dynamics & Disaster Risk Mitigation		<b>Dr. Katta Venkatramana</b> NITK Professor Dept. of.Civil Engineering NITK
<b>12:30- 13:30</b>	<b>Lunch Break</b>		






<b>13:30 -18:00</b>	<b>Technical Session IV</b>		
13:30 – 14:30	Aboveground biomass stockpile & carbon sequestration potential of <i>Albizia saman</i> in Chennai metropolitan city		<b>Dr. Sekar</b> Associate Professor Dept. of.Botany Pachaiyappa College
14:30 – 15:30	Receptor Modeling in Atmospheric Pollution		<b>Dr. N. Selvaraju</b> NITC Assistant Professor Dept.of.Chemical Engineering NIT Calicut
<b>15:30-16:00</b>	<b>Tea Break</b>		
16:00 – 17:00	Global Carbon Cycle		<b>Dr. Jagannathan T K, NITK</b> Assistant Professor Dept. of. Chemical Engineering NITK
17:00 – 18:00	Application of Nano Technology in Atmospheric Pollution		<b>Dr.P E JagadeeshBabu</b> NITK Assistant Professor Dept. of. Chemical Engineering NITK




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**Day 3: Monday, December, 29, 2014**

<b>09:00 -13:15</b>	<b>Technical Session V</b>		
09:00 – 10:00	Molecular Cluster Diagnostics for Air Pollution Source Apportionment		<b>Dr.R J Krupadam</b> NEERI Sr.Scientist Environmental Impact & Risk Assessment Division NEERI Nagpur
10:00 - 11:00	Changing Land Use Patterns in Mining Areas in India		<b>Dr. V. R. Sastry</b> NITK Professor Dept.of Mining Engineering NITK
<b>11:00 - 11:15</b>	<b>Tea break</b>		
11:15 - 12:15	Weather Prediction and Modeling of Water Cycle		<b>Dr. Sarath Chandra Kar</b> Scientist – G NCMRWF, MoES, Noida, India

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12:15 - 13:15	Landslides, Debris, Floods, Earthquakes and Tsunamis Emergency Preparedness Plan - A Typical Analysis		<b>Dr. D Venkat Reddy</b> Professor Dept of Civil Engineering NITK
<b>13:15 – 14:00</b>	<b>Lunch</b>		
14:00 – 15:00	Principals of remote Sensing, GIS and GPS		<b>Dr. Dwarakish G S</b> Professor Dept.of.Applied Mechanics and Hydraulics NITK
15:00 – 16:00	Coastal Erosion and its Mitigation along Dakshina Kannada Coast		<b>Dr. Dwarakish G S</b> Professor Dept.of.Applied Mechanics and Hydraulics NITK
<b>16:00 – 16:15</b>	<b>High Tea</b>		
<b>16:15 – 18:00</b>	<b>Practical Training and Demonstration on Fire Disaster Management By Divisional Fire Service, Mangalore at NITK School Ground</b>		

## Workshop on Recent Challenges in Atmosphere and Earth Science (WRCAES 2014)

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### Day 4: Tuesday, December 30, 2014

<b>09:00 – 13:30</b>	<b>Field Trip – Coastal Vulnerability (Ullal, Panambur, Shashithulu)</b>
<b>13:30 – 14:00</b>	<b>Lunch</b>
<b>14:00 – 16:00</b>	<b>Valedictory Function</b>

## Profile of the Resource Persons

### 1. Dr. T N Singh

Professor, Department of Earth Sciences, IITB, is the recipient of National Mineral Award, 2006. Dr. T. N. Singh has made innovative and substantial contribution in several fields of Geosciences. He is well-known in the area of Engineering Geology, Rock mechanics on account of his pioneer work in Rock-Mechanics, establishment of Rock Indices, Triaxial and Post Failure Behaviour of Rocks, Dynamic and Static Properties of Rocks, etc. Dr. Singh's noteworthy contribution in the area of ground vibration due to blasting and slope stability has earned him recognition between the earth scientists and engineers. He has made prominent contribution to the design of blast for improved fragmentation. He has established Equivalent Material Modeling technique for simulating various Geo-mining problems. His major research areas are Slope Stability, Rock – Blasting, Rock Behaviour, Applied Geology, Waste dump and Rock Environment and Ground Control.

### 2. Mr. K G Nanjappa

Mr. K.G.Nanjappa is the Deputy Director Department of Factories and Fire & Safety, Mangalore. Has been spearheading various initiatives to ensure the safety of industries in and around Mangalore. Initiated a major role in building safety guidelines for MRPL.

### 3. Dr. Balakrishna

Associate Professor- Senior Scale & Dr TMA Pai Endowment Chair in Earth Sciences, Department of Civil Engineering, Manipal Institute of Technology, Manipal University, Manipal.

4. Dr. B C Meikap

Professor, Department of Chemical Engineering, IIT Kharagpur has been an active researcher and contributor in the field of atmospheric sciences. His major research areas are Industrial Environmental Pollution Monitoring & Control, Coal Beneficiation, CO<sub>2</sub> Capturing and Fluidization. He is the recipient of various laurels like IChE Award for ARTEMIS-Bio-Tech Best Master's Thesis from Indian Institute of Chemical Engineers (2004), INAE Innovation Potential Project Award (2002), Dr. A. V.Rao Foundation Best Research Award on Chemical Engineering/Technology (2002), J. W. Nelson Best Researchers Award of UKZN (2010) etc. Has more than 100 publications in reputed journals to add to his credentials in the field of air pollution monitoring and control.

5. Dr. Lakshman Nandagiri

Professor, Department of Applied Mechanics and Hydraulics, NITK, is actively involved in research in various fields of hydrology such as, Catchment/Watershed Hydrology, Vadose Zone Processes/Properties, Soil Moisture Measurement/Modelling, Evapotranspiration, Irrigation Scheduling, Remote Sensing/GIS applications in Hydrology, Multivariate Statistics, Artificial Neural Network Applications, Land-Atmosphere Interactions, Hydrological Impacts of Climate Change etc.

6. Dr. G. Srinikethan

Dr. G. Srinikethan has been an active part of NITK teaching and research for the past 31 years. His major research interests include Transfer Operations, Industrial Pollution Control, Hydrodynamics and Environmental Biotechnology. Served as Chairman State Environmental



Impact Assessment Authority From June 2007 and has stewarded several environmental monitoring projects and has numerous publications to his credentials.

7. Dr. Katta Venkatramana

Dr. Katta Venkatramana, has 33 years of teaching experience in structural Engineering, Structural Dynamics & Earthquake Engineering, Offshore Structures and Disaster Risk Mitigation. Initiated significant research projects like Collaborative research in the area of structural engineering (under the MoU between NITK and BARC) and L&T Sponsored MTech(CTM) Programme Project (under the MoU between NITK and L&T).

8. Dr. T. Sekar

Dr. T. Sekar is Associate Professor in Department of Botany, Pachaiyappa's College, Chennai. Major research areas are Eathenobotany, Eathano VeternaryBiodiversity and Conservation of Medicinal Plants. Guided several research fellows and has been an active part of biodiversity studies in and around South India.

9. Dr. N. Selvaraju

Dr. N. Selvaraju is Associate Professor, NIT Calicut. Major research areas include Microfluidics and Micro Reactors, Adsorption in wastewater treatment, Air and Water Quality model, Biodisel and Computational Fluid Flow and Heat transfer. Currently working on receptor modeling for Air pollution. Has been conferred with Young Scientist award and several other recognitions.

10. Dr. Sarat Chandra Kar

Serves as Scientist –G, Ministry of Earth Sciences, Noida. Major research interest include Weather Prediction and Modeling of Water Cycle, characterizing the scales of variability and inter-relations of atmospheric water budget terms and the underlying processes.

11. Dr. R.J.Krupadam

Senior Scientist, National Environmental Engineering Research Institute Nagpur, India and Faculty, Academy of Council of Scientific & Innovative Research, New Delhi. Major research areas include studies on reactions at environmental surfaces controlled by the structure and composition of the interface and use of experimental and computational studies of interface structure, thermodynamics and structure-reactivity relationships, and how these properties are evident in field scale analysis of trace element speciation, Environmental impacts of human activities through improved understanding of the fate and transport of emerging environmental contaminants such as polycyclic aromatic Hydrocarbons, Environmental Materials, Molecularly imprinted polymers, biosensors, Prediction of secondary pollutants formation in the atmosphere using molecular modeling and simulations.

12. Dr. Ravikumar S

Professor, Catholic University of Degue. Major research interests include Bio sensing of Heavy Metals in water by Microorganisms; a topic that has of late achieved wide attention as eco-friendly and efficient sensor systems. Dr. Ravi Kumar has detailed the intricacies in the biotechnological aspects of pollution sensing and abatement.

13. Dr. Raj Mohan B

Associate Professor, Department of Chemical Engineering, NITK Surathkal has over 14 years of teaching and research experience. Major research areas include pollution abatement, sensing, Air pollution control and management. Has also proven his expertise in the studies on

efficient extraction of biological form natural resources, development of nano-materials for metal detection and mycoremediation.

14. Dr. T.K. Jagannathan

Assistant Professor, Department of Chemical Engineering, NITK Surathkal. Major research interests include Molecular simulations, Polymers and nano-composites and Ultrasound assisted processes.

15. Dr. Venkat Reddy

Professor, Department of Civil Engineering, NITK Surathkal. Major research areas include geology, earthquake sciences. With over 30 years of teaching and research experience, Dr. Reddy has a proven expertise in the field of Landslides, Debris, Floods, Earthquakes and Tsunamis Emergency Preparedness Plan.

16. Dr. Dwarakish

Professor, Department of Applied Mechanics, NITK Surathkal, Dr. Dwarakish is specialized in Coastal Engineering, Remote Sensing & GIS. Member of various reputed Professional Bodies like Indian Society of Remote sensing, Hydraulics, Geomatics, Remote sensing etc. Has initiated various on and Off-shore projects related to remote sensing and environmental sensing.

**Summary of the Lecture Delivered**

Title of the Lecture	Weather Prediction and Modeling of Water Cycle
Resource Person	Dr. S.C. Kar
Summary	<ul style="list-style-type: none"> <li>• Weather events occurs in variety of space and timescales</li> <li>• Resolution of weather models constrain the predictions of weather events in all scales</li> <li>• India has attained some skill in predicting rainfall in short and medium range</li> <li>• These forecasted rainfall can be of use for hydrological forecasts and for water cycle.</li> <li>• For basin-scale hydrological forecasting, input provided by weather models are too coarse.</li> <li>• One needs to use statistical downscaling approaches to downscale the weather model products to catchment/sub-basin level</li> <li>• A lot has to be done before integrating the weather model and hydrological model before developing an integrated modeling system for water cycle.</li> </ul>
Title of the Lecture	Stability Analysis of Cut Slopes in Mountainous areas
Resource Person	Dr. TN SINGH
Summary	<ul style="list-style-type: none"> <li>• Rockfall studies are critical in locations where overhangs are present and proper precautionary measures should be taken like implementation of catching fences, berms and even ditches by the sides of roads to mitigate probable damages.</li> <li>• The value of safety factor based on deterministic approach was around 1.3, which puts the slope section in stable field. But to further verify this, probabilistic analysis was done because of the range of scattered values for several parameters. Joint parameters were given more</li> </ul>

	<p>importance in this regard and proper PDF was defined for each case.</p> <ul style="list-style-type: none"> <li>• Results show that there is about 13% chance of failure suggesting the value of safety factor can go beyond 1 for several cases. For long term stability of slopes, a stable safety factor is generally taken as 1.3.</li> <li>• Therefore, while designing any structure for long term stability, joint data should be carefully studied and probabilistic approach should be preferred.</li> </ul>
Title of the Lecture	REMOTE SENSING, GIS & GPS
Resource Person	Dr. Dwarakish
Summary	<ul style="list-style-type: none"> <li>• The thermal, optical and microwave remote sensing was discussed.</li> <li>• General Applications of Remote sensing include Agriculture, Water Resources, Forestry, Soil, Geology, Urban Planning, Floods, Cyclone, Earthquake, EIA, Coastal Erosion.</li> <li>• Helps SELECTION OF SUITABLE SITES FOR: Dams, Rainuage Stations, Flow Measurements, Artificial Recharge Areas, New settlements, Dairy, Distillery, Dumping of Municipal Solid waste.</li> </ul>
Title of the Lecture	Sources, transport and fate of major ions, inorganic and organic components in a river- a geochemical approach
Resource Person	Dr. Balakrishna
Summary	<p>STEPS TO SAVE WATER:</p> <ul style="list-style-type: none"> <li>• Individual discipline and concern for the environment</li> <li>• Domestic wastewater treatment plants in all towns- reuse of treated water</li> <li>• Stricter norms and monitoring of industrial effluents and their treatment</li> <li>• Stringent laws and punishment for offenders</li> <li>• Restrict agricultural effluents by controlling soil erosion</li> </ul>
Title of the Lecture	Landslides-Debris Flows Floods Earthquakes and Tsunamis of Indian Sub-Continent- Emergency Preparedness Plan--A Typical Analysis
Resource Person	Dr. Venkat Reddy

Summary	<p>General Flood Management Measures practiced in India-Central Water Commission-Government of India:</p> <ul style="list-style-type: none"> <li>• The engineering measures for flood control which bring relief to the flood prone areas by reducing flood flows and thereby the flood levels are</li> </ul> <ol style="list-style-type: none"> <li>1. An artificially created reservoir behind a dam across a river</li> <li>2. A natural depression suitably improved and regulated, if necessary or</li> <li>3. By diversion of a part of the peak flow to another river or basin, where such diversion would not cause appreciable damage.</li> <li>4. By constructing a parallel channel by passing a particular town/reach of the river prone to flooding.</li> <li>5. Administrative / Non-structural Measures</li> </ol> <ul style="list-style-type: none"> <li>• The administrative methods endeavor to mitigate the flood damages by;</li> </ul> <ol style="list-style-type: none"> <li>1. Facilitating timely evacuation of the people and shifting of their movable property to safer grounds by having advance warning of incoming flood i.e. flood forecasting, flood warning in case of threatened inundation</li> <li>2. Discouraging creation of valuable assets/settlement of the people in the areas subject to frequent flooding i.e. enforcing flood plain zoning regulation</li> </ol>
Title of the Lecture	Measuring carbon stockpile of trees in forests
Resource Person	Dr. Sekar
Summary	<ul style="list-style-type: none"> <li>• Though introduced from tropical Northern South America <i>A. saman</i> provides a considerable ecosystem service to CMC through C storage and sequestration.</li> <li>• This study estimated monetary values of just two ecosystem services of <i>A. saman</i>, study that concentrates on all ecosystem services is needed to assess total actual ecosystem service values.</li> </ul>
Title of the Lecture	Hydrometeorological Disasters
Resource Person	Dr. Lakshman Nandagiri



Summary	<ul style="list-style-type: none"> <li>• Rainfall – most important natural phenomenon</li> <li>• Rainfall is subject to natural variations in spatial and temporal domains</li> <li>• Such historical variations have been responsible for evolution of climates and landscapes</li> <li>• We have devised mechanisms to adjust to such variabilities</li> <li>• Patterns of rainfall excess and deficit are intimately linked to the occurrences of natural disasters such as floods and droughts</li> <li>• Large scale anthropogenic activities are bringing about changes in climate and rainfall</li> <li>• Can humanity and other life forms sustain and adapt to such changes?</li> <li>• Will the frequency and magnitudes of such disasters increase in future?</li> <li>• Patterns of rainfall excess and deficit are intimately linked to the occurrences of natural disasters such as floods and droughts</li> <li>• Large scale anthropogenic activities are bringing about changes in climate and rainfall</li> <li>• Can humanity and other life forms sustain and adapt to such changes?</li> <li>• Will the frequency and magnitudes of such disasters increase in future?</li> </ul>
Title of the Lecture	Air Pollution Disaster Potential- Case study of a Tier-II city
Resource Person	Dr. G. Srinikethan
Summary	<ul style="list-style-type: none"> <li>• There are 48 urban cities referred to as mega or tier-I cities with more than one million population</li> <li>• All Tier-I cities are having RSPM well above the limits of NAAQS. (Population and Congestion)</li> <li>• Tier-II cities are urbanizing rapidly and witnessing the high rise in pollution especially RSPM and hence proper planning required.</li> <li>• Steps to be taken:</li> <li>• Fuel policies</li> <li>• Pay off Obligations</li> <li>• Phasing out the older vehicle and encourage mass transport system</li> </ul>

	<ul style="list-style-type: none"> <li>• Rerouting of vehicles</li> <li>• Zoning strategies and policies</li> <li>• Continues online monitoring of emissions and use of proper control equipments</li> <li>• EIA studies to be strengthened</li> <li>• Industrial siting criteria with impact zone assessment</li> <li>• CAAQS to be implemented in most of the cities.</li> <li>• Siting of monitoring location to be established based on the meteorological factors for a particular location</li> <li>• Interdisciplinary approach in terms of health perspectives</li> </ul>
Title of the Lecture	Engineering bacteria : Sense and Remove heavy metal
Resource Person	Dr. Ravikumar S
Summary	<ul style="list-style-type: none"> <li>• Environmental Biotechnology required to eliminate the hazardous wastes (like heavy metals) produced by our other technologies.</li> <li>• distinguish between similar species and ensure species are not at risk of extinction.</li> <li>• create alternative energy sources (i.e. Biofuel).</li> <li>• Devised system for sensing and removing heavy metals namely zinc and copper through two component regulatory system.</li> <li>• All of the presented results indicated that the strategy used could be successfully applied to the sensing and bio-adsorbtion of heavy metal in the environment.</li> </ul>
Title of the Lecture	Atmospheric Aerosols
Resource Person	Dr. Raj Mohan B
Summary	<ul style="list-style-type: none"> <li>• Atmosphere is the most rapidly changing component of the climate system, because of its gaseous state. Apart the main elements N<sub>2</sub>, O<sub>2</sub>, and Ar it contains in very small quantities a number of other gases and particles.</li> <li>• Although particulate matter is made up of many chemical species, there</li> </ul>

	<p>are 5-6 key contributors to PM mass and haze. Carbonaceous compounds (Elemental carbon and Organic compound), Secondary sulphate, nitrate and ammonium particles, sea salt, crustal materials or mineral dusts and biological materials.</p> <ul style="list-style-type: none"> <li>• Aerosols Particle Size determination: Condensation Particle Counter, Optical Particle Counter, Aerodynamic Particle Sizer, Scanning Mobility Particle Sizer.</li> </ul>
Title of the Lecture	Atmospheric Aerosols
Resource Person	Dr. Raj Mohan B
Summary	<ul style="list-style-type: none"> <li>• Atmosphere is the most rapidly changing component of the climate system, because of its gaseous state. Apart the main elements N<sub>2</sub>, O<sub>2</sub>, and Ar it contains in very small quantities a number of other gases and particles.</li> <li>• Although particulate matter is made up of many chemical species, there are 5-6 key contributors to PM mass and haze. Carbonaceous compounds (Elemental carbon and Organic compound), Secondary sulphate, nitrate and ammonium particles, sea salt, crustal materials or mineral dusts and biological materials.</li> <li>• Aerosols Particle Size determination: Condensation Particle Counter, Optical Particle Counter, Aerodynamic Particle Sizer, Scanning Mobility Particle Sizer.</li> </ul>
Title of the Lecture	Disaster Risk Mitigation (earthquakes)
Resource Person	Dr. Katta Venkataramana
Summary	<ul style="list-style-type: none"> <li>• Mitigation is primarily a proactive process, to do the needful before a disaster strikes</li> <li>• Mitigation must be implemented at local level, where reactive attitudes prevail.</li> <li>• Disaster Mitigation should be seen in the proactive approach, before disasters occur, and not as a reactive measure after the disaster has taken place.</li> </ul>

	<ul style="list-style-type: none"> <li>• But Mitigation measures should be considered in recovery phase, especially in reconstruction planning &amp; practices.</li> </ul>
Title of the Lecture	Receptor Modeling in Atmospheric Pollution
Resource Person	Dr. Selvaraju
Summary	<ul style="list-style-type: none"> <li>• Receptor model analysis and comparison has been carried out for better source contribution estimates</li> <li>• Optimization using Genetic Algorithm is working successfully for better source contribution estimates from CMB model</li> <li>• Wind velocity estimates for distinct source profile using coupled receptor-dispersion model approach has been carried out</li> <li>• Emission rate estimates from Area source emission using receptor-dispersion (area source) approach has been validated</li> </ul>
Practical Training and Demonstration	Practical Training and Demonstration on Fire Disaster Management
Conducted by	Divisional Fire Service, Mangalore
Summary	<p>The following aspects of fire disaster management were demonstrated</p> <ul style="list-style-type: none"> <li>• Causes Of Fire</li> <li>• Uneven Distribution Of Incidents</li> <li>• Conditions Needed For A Fire</li> <li>• Classes Of Fire</li> <li>• Types Of Fire Extinguishers</li> <li>• Fire Fighting Strategies</li> <li>• Using An Extinguisher</li> <li>• Precautions While Fighting A Fire</li> <li>• Deciding Whether To Fight The Fire Or Leave The Site</li> <li>• During The Fire</li> <li>• When On Road</li> </ul>

Field Trip	<p>Coastal Vulnerability (Ullal, Panambur, Shashithulu)</p> <ul style="list-style-type: none"><li>• The west coast of India, selected as a study area, is well known for sandy beaches, aquaculture ponds, lush greenery, temples and major and minor industries.</li><li>• The coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions were discussed</li><li>• A relative measure of the system's natural vulnerability to the effects of sea-level rise were observed.</li><li>• The high and low vulnerable areas and area of inundation due to future sea level rise, and land loss due to coastal erosion were monitored.</li></ul>
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## Papers Proceedings

## Sources, Transport and Fate of Major Ions, Inorganic and Organic Components in a River- A Geochemical Approach

DR K BALAKRISHNA

Associate Professor

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### Overview

Water originated in the earth about 4 billion years ago, and since then has enveloped about 75% of the earth's surface. Rivers originated after the primordial atmosphere was created over the earth's surface. Primordial atmosphere contained hydrogen and carbon dioxide molecules which formed the water molecules and formation of rains.

Rivers get their chemistry from the chemical weathering of rocks. The silicate and carbonate rocks react with atmospheric / soil carbon dioxide and water to form carbonic acid, which leaches the cations and anions from the rocks and contribute to the chemistry of the river. Water gets polluted when anthropogenic sources enter the river. The main sources are industrial, domestic and agricultural effluents. Rivers can break-down these contaminants and cleanse itself through its ability of self-purification. Dilution, adsorption and precipitation to sediments, microbial and solar degradation are some of the processes of self-purification in the rivers. Unfortunately, in rivers like the Ganga the pollution has exceeded the carrying capacity, leading to the collapse of water quality.

My group has worked on estimating the riverine pollution in Nethravati and Swarna

rivers. Precautions were taken in collecting representative samples from the river as per the established procedures. Samples were measured on-site for pH, conductivity, DO, alkalinity and filtered. These were done on-site to prevent the degradation of water. Results have proved that these rivers are unpolluted and the main chemistry of the rivers are contributed by the leaching of rocks (Gurumurthy et al 2012, 2014; Tripti et al 2013a, 2013b). Most of the measured elements behaved according to the discharge. Heavy metals like uranium and thorium increased in concentrations along with the discharge, whereas major ions like  $\text{Na}^{2+}$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  behaved inversely. The radionuclide elements were sourced from the rocks, which leached during the monsoon, and carried along with the monsoonal flow, whereas the major ions were higher during the dry season on account of pre-concentration during the low flow season.

Estuaries are complex systems where there is a sudden change in the physico-chemical conditions because of the sea water ingress into the estuary during high tides. This has made estuaries either as a source or sink for pollutants. The salinity in the estuary can either precipitate metals like Fe and Mn (sink) or desorb some metals from the sediments into the water column.



Recently scientists have observed the formation of anoxic zone in the Arabian Sea (Bange et al 2005). Increased utilization of nitrogen based fertilizers for agricultural activities on the banks of the river has led to the influx of nutrients like nitrates and phosphates into the river which is carried into the Arabian Sea and accumulated. Nutrients have fuelled rich growth of phytoplanktons in the Arabian Sea, which leads to eutrophication and anoxic zones. This has resulted in fish kill and loss of livelihood to the fishermen who are dependent on it.

Recently, emerging contaminants like pharmaceuticals and personal care products (PPCPs) are entering the rivers. A preliminary study from my group has confirmed the presence of PPCPs in the wastewater treatment plant outlets of Manipal region (Prabhasankar et al 2013). It is also observed from our studies that some bacteria are transforming itself into superbugs and becoming resistant to various antibiotics. The PPCPs are bringing unknown consequences on the local

communities and the biodiversity of the river-estuarine and oceanic ecosystem. Studies made elsewhere have found that low doses of pharmaceutical compounds in the rivers, sourced from the domestic and hospital effluents, have been ingested by various river and ocean dwelling species like fish leading to birth defects, stunted growth and low reproduction (Santos et al 2010).

Overexploitation of water resources in coastal Karnataka is causing increased incidences of salt-water intrusion into the dug wells and tube wells. Strict regulations have to be enforced to curtail the rampant sinking of tube wells in the coastal region.

Solution to all these problems lies in individual discipline and concern for the environment. Government has to actively participate in the environmental conservation and impose severe punishment for the offenders. Government has to invest on underground drainage systems to every villages and towns, state-of-the-art treatment facilities to treat the sewage generated and reuse the treated water including power generation.

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# ATMOSPHERIC AEROSOLS

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Atmosphere is the most rapidly changing component of the climate system, because of its gaseous state. Apart the main elements N<sub>2</sub>, O<sub>2</sub>, and Ar it contains in very small quantities a number of other gases and particles.

*Aerosol” is defined as the dispersion of both particles and gas, but in common practice it is used to refer to the particles only!*

**Primary aerosol** – atmospheric particles that are emitted or injected directly into the atmosphere.

**Secondary aerosol** – atmospheric particles that are created by in situ aggregation or nucleation from gas phase molecules (gas to particle conversion).

Some of the forms of aerosols are Dust, Fumes, Bio aerosol, Smoke, Spray, Smog, Cloud, Mist & Fog and Haze.

The Global Particle production of aerosols has also been discussed.

Source	Estimate Flux (Tg/yr)	Particle Size Category
<b>Primary</b>		
Soil dust (mineral aerosol)	1000-3000	Mainly coarse
Sea salt	1000-10000	Coarse
Volcanic dust	2-10000	Coarse
Biological debris	26-80	Coarse
<b>Secondary</b>		
Sulfates from biogenic gases	80-150	Fine
Sulfates from volcanic SO <sub>2</sub>	5-60	Fine
Organic matter from biogenic VOC	40-200	Fine
Nitrates from NO <sub>x</sub>	15-50	Fine and coarse
<b>Total Natural</b>	<b>2200-23500</b>	<b>Best estimate 3100</b>
<b>Anthropogenic</b>		
<b>Primary</b>		
Industrial dust etc. (except soot)	40-130	Fine and coarse
Soot	5-20	Mainly fine
<b>Secondary</b>		
Sulfates from SO <sub>2</sub>	170-250	Fine
Biomass burning	60-150	Fine
Nitrates from NO <sub>x</sub>	25-65	Mainly coarse
Organics from anthropogenic VOC	5-25	Fine
<b>Total anthropogenic</b>	<b>300-650</b>	<b>Best estimate 450</b>
<b>Total</b>	<b>2500-24000</b>	<b>Best estimate 3600</b>

Aerosols – Size Distribution - Aerosol particles (AP) have diameters in the range from 1 nm to several hundred μm. It has been found useful to distinguish atmospheric aerosol particles in different modes according to their diameters:

Modes	Particle Sizes
Nucleation mode	10–3μm - 10–2μm
Aitken mode	10–2μm - 0.1 μm
Accumulation mode	0.1 μm - 1 μm
Coarse mode	Particles > 1 μm

## Formation Mechanism

### Nucleation mode (0.01-0.1 μm)

Newly formed nucleation mode particles are very small about 1-2 nm in diameter, but rapid growth occurs to form larger particles by coagulation and condensation. 20-30 nm in diameter

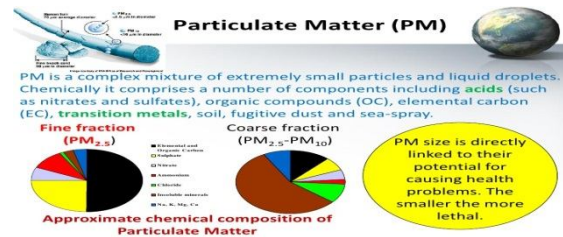
### Accumulation mode (0.1-2μm)

Low number concentration, do not grow, have low rates of loss due to wet and dry deposition and therefore possess a longer atmospheric lifetime of several days and travel over very long distances within the atmosphere

### Coarse mode (>2μm)

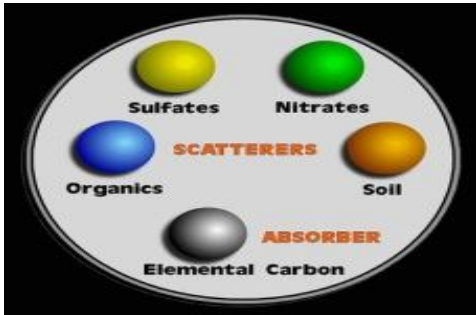
Shorter atmospheric lifetime, especially particles larger than 10 μm.

## Particulate Matter



### Chemical Composition of PM:

Although particulate matter is made up of many chemical species, there are 5-6 key contributors to PM mass and haze. Carbonaceous compounds (Elemental carbon and Organic compound), Secondary sulphate, nitrate and ammonium particles, sea salt, crustal materials or mineral dusts and biological materials.



### Particle Size Determination

The Particle sizes are usually measured by using inertia based equipments (Cascade Impactors, Virtual impactors) and also other equipments like

- Condensation Particle Counter
- Optical Particle Counter
- Aerodynamic Particle Sizer
- Scanning Mobility Particle Sizer

The Expert member has discussed everything about the equipments used for the particle size determination and their collection.

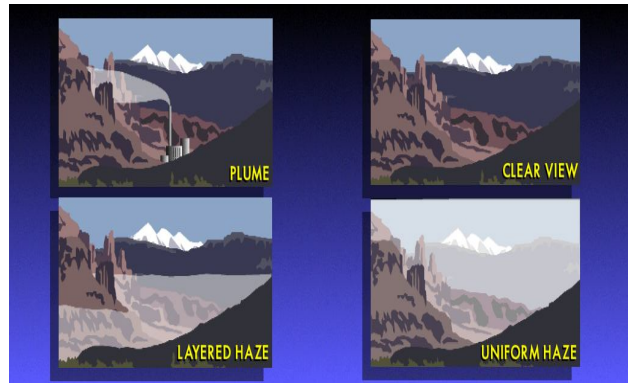
### Surface Visibility

Molecules in the earth’s atmosphere scatter light limiting the maximum distance you can see even under natural conditions. The scattering of light by air molecules is called “Blue Sky” or “Rayleigh” scattering. Large particles in the atmosphere are able to scatter all wavelengths of white light equally this is called Mie Scattering.

The Various Types of Scattering of Visible Light			
TYPE OF PARTICLE	PARTICLE DIAMETER (MICROMETERS, μm)	TYPE OF SCATTERING	PHENOMENA
Air molecules	0.0001 to 0.001	Rayleigh	Blue sky, red sunsets
Aerosols (pollutants)	0.01 to 1.0	Mie	Brownish smog
Cloud droplets	10 to 100	Geometric	White clouds

### Types of Haze:

There are three types of haze



**Visibility Impairment:** generally associated with discoloration, haziness, and loss of color and detail.

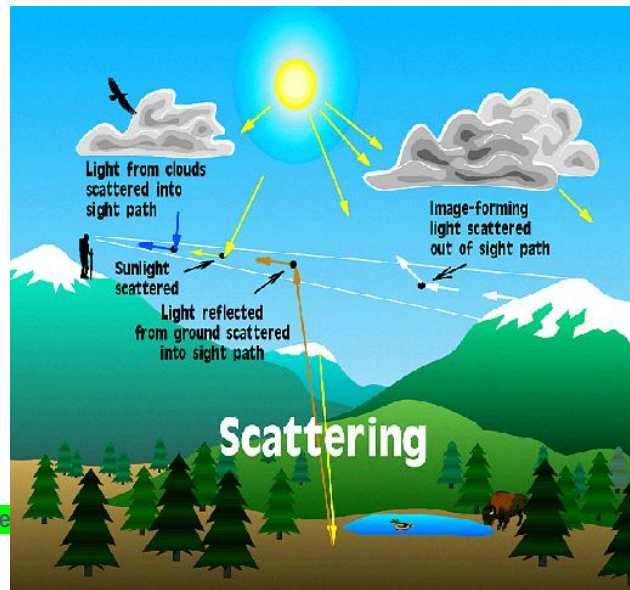
**Plume:** Pollutants are constrained in a tight elevated layer that can often be traced to a nearby source

**Uniform Haze:** Pollutants are uniformly distributed from the ground to a height well above the highest terrain feature

**Layered Haze:** Pollutants are often trapped near the ground beneath a temperature inversion. The top edge of the pollutant layer is visible.

### How Pollutants Cause Haze

Particles and gases in the atmosphere can scatter or redirect image forming light as it travels to the eye. Through scattering some image forming light is removed from the





view path. In addition, extra light, sunlight, and light reflected from the clouds and ground are added to the sight path which interferes with the ability to view the scene.

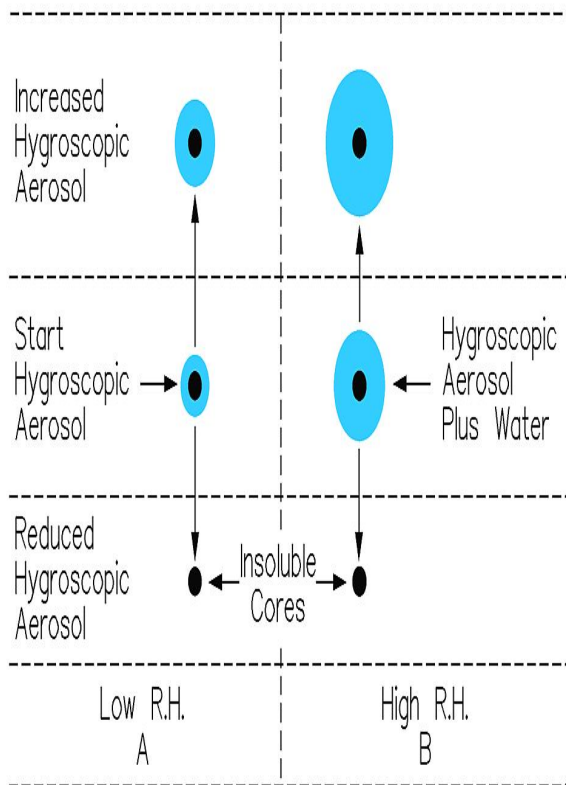
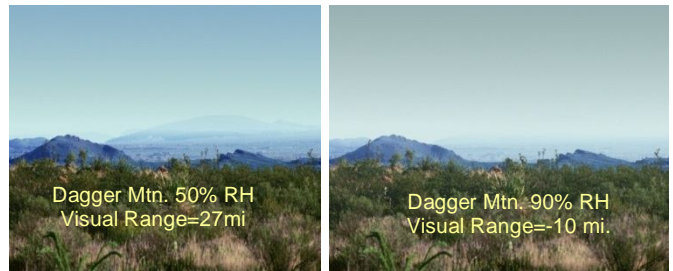
**Hygroscopic Aerosols**

- Water uptake by particles in the atmosphere
- Aerosol particles grow and scatter more light
- Deliquescence - the RH value at which the crystal begins to absorb water and becomes a solution droplet
- Hysteresis - water is retained on the

particle at RH values lower than predicted by equilibrium

**Relative Humidity Affects Visibility:**

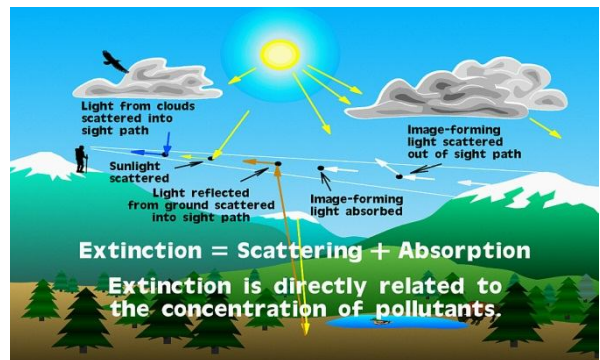
Fine sulfate and nitrate particles are hygroscopic. They readily attract and absorb water molecules. Under high relative humidity conditions they quickly grow to a size that is very efficient at scattering light.



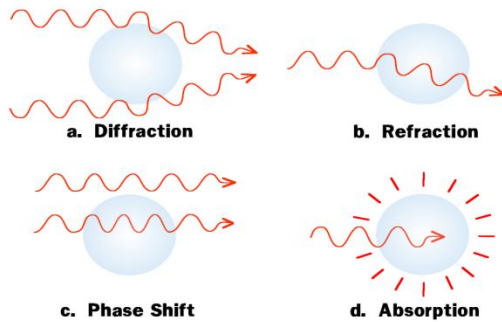
The fine sulfur levels in all views are the same ( $20 \mu\text{g}/\text{m}^3$ ). The relative humidity changes from 10%, to 50%, to 90%.

**Extinction:**

Extinction is a visibility metric used to describe the combined effect of scattering and absorption. It is proportional to the total amount of light removed as light passes through the atmosphere and is related to the concentration of pollutants.



**Components of Scattering and Extinction:**



**Scattering Efficiency Factor:**

The extinction coefficient for a single particle is then

$$b_{ext} = (\pi D^2/4) Q_e(n_i, \chi, \lambda)$$

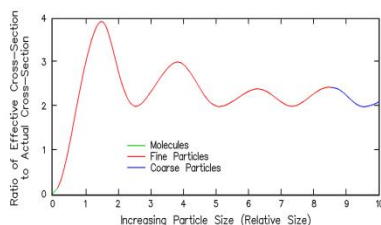
Where D is the particle diameter and  $\chi$  is a size parameter defined as  $2\pi r/\lambda$ .

Extinction Coefficient is an important metric for visibility

Because most atmospheric monitoring programs measure particle mass concentrations it is convenient to express this equation in terms of mass extinction efficiency or extinction per unit mass  $E(n, \chi, \lambda)$ .

**Extinction Coefficient:**

The extinction coefficient is made up of particle and gas scattering and



absorption:

$$b_{ext} = b_{sg} + b_{ag} + b_{sp} + b_{ap}$$

Where s, a, g, and p refer to scattering, absorption, gases, and particles, respectively.

**Extinction summed overall size:**

$$B_{ext,i} = \frac{\pi}{4} \int_0^\infty D^2 Q_e(m_i, \chi) n_i(D) d(D)$$

$$B_{ext,i} = \int_{-\infty}^\infty E_e(m_i, x, \lambda) \bar{f}_i(x) dx$$

Where  $E_e$  is mass extinction efficiency,  $f_i(x)$  is the aerosol mass distribution  $dm/dx$  of the  $i^{th}$  species,  $x = \ln[D/Do]$ , and  $\lambda$  is the wavelength.

**Externally Mixed Model:**

$$B_{ext,i} = \alpha_i m_i$$

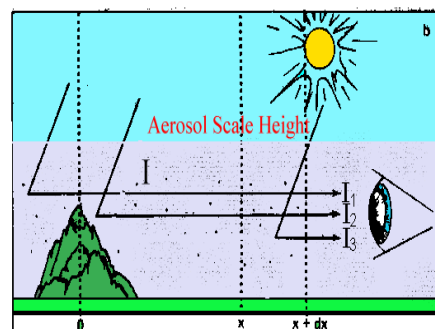
Where

$$\alpha_i = \int_0^\infty E_e(m_i, x, \lambda) \bar{f}_i(x) dx$$

and for multiple species

$$B_{ext} = \sum_i \alpha_i m_i$$

**Radiation Transfer:**



$$-dI = b_{ext} I dx$$

Where,  $-dI$  = decrease in intensity (extinction)

$b_{ext}$  = extinction coefficient

$I$  = original intensity of beam

$dx$  = length of short interval

$$dI = b_{ext} [W \int Q(\theta) I d\Omega] dx$$

Bracketed parameters  $[ ]$  = the sum of light intensity from all directions scattered into the line of sight. This depends on aerosol and air scattering parameters ( $W \int Q(\theta)$ ), and illumination intensity and angle ( $I_v, \theta_v$ ) summed over all directions ( $\Omega$ ).

$$dI = -dI (\text{extinction}) + dI (\text{air light})$$

**Contrast**

$$C_r = C_o (BT / b_{ext} x / B_o)$$

Where  $C_r$  = apparent contrast at observer distance

$C_o$  = initial contrast at object

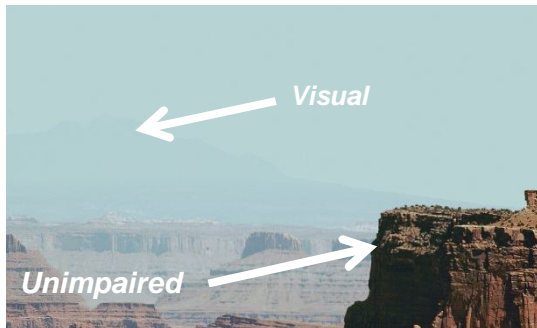
$BT/B_o$  = ratio of sky brightness at target object to that at

observer (usually 1 for distance less than 50-100 km).

$b_{ext}$  = extinction coefficient

$x$  = observer-object distance

**Threshold:**



Bouguer, in 1729, stated that if one looks carefully, a tree-covered mountain is visible if the difference between the brightness of the mountain and background sky is about 1 part in 50 or a contrast of 0.02!

**The Visual Range Concept:**

The distance at which  $C_r$  approaches a threshold contrast of between -0.02 or -0.05 defines the visual range,  $V_r$ . If  $|C_o| = 1$  (black object) and -0.02 is taken to be a threshold contrast, then the previous equation becomes

$$V_r = \frac{3.912}{b_{ext}}$$

**Method for deriving mass extinction efficiencies ( $m^2 g^{-1}$ ):**

Specific mass scattering efficiency can be defined as the ratio of light scattering coefficient ( $b_{sp}$ ) to mass concentration ( $M$ ):

$$\alpha_{sp\_spec} = \frac{b_{sp}}{M}$$

Either the average  $b_{sp}$  is divided by the average mass, or a linear regression is performed on the data and the slope is interpreted as the specific mass scattering efficiency

Represent an average aerosol that could be changing due to variations in RH, size distribution and composition.

## Hydro-Meteorological Disasters

Extracted from

National Institute of Disaster Management

([http://nidm.gov.in/PDF/Disaster\\_hymet.pdf](http://nidm.gov.in/PDF/Disaster_hymet.pdf))

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### **FLOODS**

Floods are among the most frequent and costly natural disasters. Conditions that cause floods include heavy or steady rain for several hours or days that saturate the ground. Flash floods occur suddenly due to rapidly rising water along a stream or low-lying area.

A flood is an excess of water (or mud) on land that's normally dry and is a situation wherein the inundation is caused by high flow, or overflow of water in an established watercourse, such as a river, stream, or drainage ditch; or ponding of water at or near the point where the rain fell. This is a duration type event. A flood can strike anywhere without warning, occurs when a large volume of rain falls within a short time.

### **Types of Floods**

#### Flash Floods:

Floods occurring within six hours, mainly due to heavy rainfall associated with towering cumulus clouds, thunderstorms, tropical cyclones or during passage of cold weather fronts, or by dam failure or other river obstructions. This type of flood requires a rapid localized warning system.

#### River Floods:

Floods caused by precipitation over a large catchment area, melting of snow or both. Built up slowly or on a regular basis, these floods may continue for days or weeks. The major factors of these floods are moisture, vegetation cover, depth of snow, size of the catchment, etc.

#### Coastal Floods:

Floods associated with cyclonic activities like Hurricanes, Tropical cyclones, etc. generating a catastrophic flood from rainwater which often aggravates wind-induced storm and water surges along the coast.

#### Urban Floods:

As land is converted from agricultural fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. Urbanization decreases the ability to absorb water 2 to 6 times over what would occur on natural terrain. During periods of urban flooding, streets can become swift moving rivers, while basements can become death traps as they fill with water.

#### Ice Jam:

Floating ice can accumulate at a natural or human-made obstruction and stop the flow of water thereby causing floods. Flooding too



can occur when there the snow melts at a very faster rate.

#### Glacial Lake Outbursts Flood (GLOF):

Many of the big glaciers which have melted rapidly give birth to a large number of glacier lakes. Due to the fast rate of ice and snow melting, possibly caused by the global warming, the accumulation of water in these lakes increases rapidly and results in sudden discharge of large volumes of water and debris and causing flooding in the downstream channel.

#### **Characteristics of floods**

Depth of water-Building foundations and vegetation will have different degrees of tolerance to holding inundated water.

Duration-Damage to structures, infrastructure and vegetation is related to duration of time of water inundation.

Velocity-High velocities of flow create erosive forces, hydrodynamic pressure, which destroy foundation supports and may occur on floodplains or in the main river channel.

Frequency of occurrence-The frequency of occurrence measured over period of time determines types of construction or agricultural activities on the floodplain.

Seasonality-Flooding during a growing season destroy crops while cold weather, floods seriously affect the community.

#### **Causes of Floods**

Inadequate capacity of the rivers to contain within their banks the high flows brought down from the upper catchment areas following heavy rainfall, leads to flooding. The tendency to occupy the flood plains has been a serious concern over

the years. Because of the varying rainfall distribution, many a time, areas which are not traditionally prone to floods also experience severe inundation.

Areas with poor drainage facilities get flooded by accumulation of water from heavy rainfall. Excess irrigation water applied to command areas and an increase in ground water levels due to seepage from canals and irrigated fields also are factors that accentuate the problem of water-logging. The problem is exacerbated by factors such as silting of the riverbeds, reduction in the carrying capacity of river channels, erosion of beds and banks leading to changes in river courses, obstructions to flow due to landslides, synchronisation of floods in the main and tributary rivers and retardation due to tidal effects.

The primary causes for floods are:

- Intense rainfall when the river is flowing full.
- Excessive rainfall in river catchments or concentration of runoff from the tributaries and river carrying flows in excess of their capacities.
- Cyclone and very intense rainfall when the El Nino effect is on decline.
- Synchronization of flood peaks in the main rivers or their tributaries.
- Landslides leading to obstruction of flow and change in the river course.
- Poor natural drainage system.
- Backing-up of water in tributaries at their confluence with the main river.

## Flood prone areas

India is one of the most flood prone countries in the world. The principal reasons for flood lie in the very nature of natural ecological systems in this country, namely, the monsoon, the highly silted river systems and the steep and highly erodible mountains, particularly those of the Himalayan ranges. The average rainfall in India is 1150 mm with significant variation across the country. The annual rainfall along the western coast and Western Ghats, Khasi hills and over most of the Brahmaputra valley amounts to more than 2500 mm. Most of the floods occur during the monsoon period and are usually associated with tropical storms or depressions, active monsoon conditions and break monsoon situations.

Floods occur in almost all rivers basins in India. The main causes of floods are heavy rainfall, inadequate capacity of rivers to carry the high flood discharge, inadequate drainage to carry away the rainwater quickly to streams/rivers. Ice jams or landslides blocking streams; typhoons and cyclones also cause floods. Flash floods occur due to high rate of water flow as also due to poor permeability of the soil. Areas with hardpan just below the surface of the soil are more prone to, floods as water fails to seep down to the deeper layers.

Brahmaputra, Ganga, Narmada, Tapti, Mahanadi, Krishna & Cauvery are the most flood prone areas. Survey by Rashtriya Barh Ayog in 1980 says that 40 million hectares areas are flood affected. Heavy rain in Himalayas during South west monsoon causes floods in the rivers of U.P., Bihar, West Bengal & Assam while Central & Southern rivers get flooded by heavy rainfall due to depression in Bay of Bengal during south-west monsoon season. In most flood prone states, land depression, low-pressure

areas are the two most important synoptic systems responsible for floods. In Bihar 100% and in U.P. 82% floods are caused due to land depression and well-marked low pressure. In West Bengal main reason for flood is cyclonic circulation, whereas in Punjab, Gujarat, Rajasthan & Jammu & Kashmir the main reason is low pressure areas. Floods in Orissa and Andhra Pradesh are due to monsoon depression.

## DROUGHTS

It is difficult to provide a precise and universally accepted definition of drought due to its varying characteristics and impacts across different regions of the world, such as rainfall patterns, human response and resilience, and diverse academic perspectives.

Drought is a temporary aberration unlike aridity, which is a permanent feature of climate. Seasonal aridity (i.e. a well-defined dry season) also needs to be distinguished from drought. Thus drought is a normal, recurrent feature of climate and occurs in all climatic regimes and is usually characterized in terms of its spatial extension, intensity and duration. Conditions of drought appear when the rainfall is deficient in relation to the statistical multi-year average for a region, over an extended period of a season or year, or even more.

Drought differs from other natural hazards such as cyclones, floods, earthquakes, volcanic eruptions, and tsunamis in that:

No universal definition exists;

- Being of slow-onset it is difficult to determine the beginning and end of the event;
- Duration may range from months to years and the core area or epicentre changes over time,

reinforcing the need for continuous monitoring of climate and water supply indicators;

- No single indicator or index can identify precisely the onset and severity of the event and its potential impacts; multiple indicators are more effective;
- Spatial extent is usually much greater than that for other natural hazards, making assessment and response actions difficult, since impacts are spread over larger geographical areas;
- Impacts are generally non-structural and difficult to quantify;
- Impacts are cumulative and the effects magnify when events continue from one season or year to the next.

### **Types of Drought**

Meteorological Drought is defined as the deficiency of precipitation from expected or normal levels over an extended period of time. Meteorological drought usually precedes other kinds of drought. According to the legend, meteorological drought is said to occur when the seasonal rainfall received over an area is less than 25% of its long-term average value. It is further classified as moderate drought if the rainfall deficit is 26–50% and severe drought when the deficit exceeds 50% of the normal.

Hydrological Drought is best defined as deficiencies in surface and subsurface water supplies leading to a lack of water for normal and specific needs. Such conditions arise, even in times of average (or above average) precipitation when increased usage of water diminishes the reserves.

Agricultural Drought, usually triggered by meteorological and hydrological droughts, occurs when soil moisture and rainfall are inadequate during the crop growing season causing extreme crop stress and wilting. Plant water demand depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth and the physical and biological properties of the soil. Agricultural drought thus arises from the variable susceptibility of crops during different stages of crop development, from emergence to maturity. In India, it is defined as a period of four consecutive weeks (of severe meteorological drought) with a rainfall deficiency of more than 50% of the long-term average (LTA) or with a weekly rainfall of 5 cm or less from mid-May to mid-October (the kharif season) when 80% of India's total crop is planted or six such consecutive weeks during the rest of the year (NRSC, Decision Support Centre).

### **Impacts of Drought**

Drought produces wide-ranging impacts that span many sectors of the national economy. These impacts are felt much beyond the area experiencing physical drought. The complexity of these impacts arises because water is integral to our ability to produce goods and provide services. Drought produces both direct and indirect impacts. Direct impacts or primary impacts are usually physical / material and include reduced agricultural production; increased fire hazard; depleted water levels; higher livestock and wildlife mortality rates; and damage to wildlife and fish habitats. When direct impacts have multiplier effects through the economy and society, they are referred to as indirect impacts. These include a reduction in agricultural production that may result in reduced income for farmers and agribusiness, increased prices for food and timber,

unemployment, reduced purchasing capacity and demand for consumption, default on agricultural loans, rural unrest, and reduction in agricultural employment leading to migration and drought relief programmes. The more removed the impact from the cause, the more complex is the link to the cause. These multiplier effects are often so diffuse that it is very difficult to generate financial estimates of actual losses caused by a drought.

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## Air Pollution Disaster Potential - Case study of a Tier-II city.

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Much of the 20th century witnessed an increasing trend in urbanization in developing countries. While urbanization can be a stimulus of development, in the process many cities in Asia, Africa, the Near East and Latin America are facing two challenges viz. pollution and congestion (Ashmore 2005). In 1960, less than 22% of developing world's population was urban and the proportion increased to 34% by 1990. The projections are that 50% of the global population will be urban by 2020. The general state of the environment, including air quality, is deteriorating in many cities of the developing countries.

World Bank studies in selected cities of developing countries have shown that swelling urban populations and the growth

of industrial activities and vehicular traffic in Asia have caused serious air pollution (World Bank 2009). Many developing countries including India have experienced a progressive degradation in air quality as a result of rapid pace of development over the last three decades. During this period newly industrialized countries underwent unparallel economic growth, swelling urban populations and generated excessive

emissions from automobiles, factories and refuse burning (World Bank 1996).

The fossil fuel consumption has increased from 75 million tonnes per year in 1964 to 245 million tonnes per year in 1990 (Shrestha et al. 1996). The records of Ministry of surface transport in India show that the numbers of vehicles in the country was 21.3, 53 and 67 million in 1991, 2000 and 2003, respectively. In urban areas, the main sources of air pollution are power plants, industries, motor vehicles and domestic sources. While industrial air pollution is localized, mobile sources have emerged as the most significant contributor to regional air pollution.

The World Health Organization has estimated that air pollution contributes to approximately 800,000 deaths annually (WHO 2002). Currently, in India air pollution is widespread in urban areas where automobiles are the major contributors and in a few other areas with a high concentration of industries and thermal power plants (Partheeban et al. 2012). According to the World Health Organization, air pollution constitutes the 13th leading cause of mortality in the world (WHO 2009). Increased mortality is mostly due to increased cardiovascular diseases

(Araujo and Nel 2009) in the exposed population, particularly those of ischemic nature (Burnett et al. 2004). There are many dramatic evidences which show that ambient air pollution can seriously endanger public health like in Meuse Valley, Belgium in 1930, Donora, Pennsylvania in 1948, and London, England in 1952. In recent past many studies have been carried out to investigate the causes of air pollution and remedial measures for the problems of public health. In fact, as it has been documented, both illness and premature deaths due to ambient PM in the air have increased significantly during the first-half of the last decade in all the mega cities of India (Singh 2008). In terms of health effects, particulate matter air pollution is associated with complaints of the respiratory system (WHO 2000).

In India, the problem of air pollution has assumed serious proportions in most of the major metropolitan cities, where vehicular emissions contributed about 72% and industrial emissions about 20% to the ambient air pollution (Garg et al. 2001). Unplanned outgrowth and expansion of cities have serious impact on the local ecology and on the substances of natural resources (Ramachandra 2012). The impact of urban expansion is observed on large scale on physical environment particularly on conversion of agricultural land, reclamation of water bodies, creation of slums, generation of solid and liquid wastes etc. India's state air monitoring centers have admitted that certain parameters like Respirable Suspended Particulate Matter (RSPM) in Delhi (Tier-I city) are comparable to that of high polluted cities of

the world like Beijing. Most of the Tier-I cities like Bangalore, Kolkata, Chennai, Bombay etc are well above the limits of National Ambient Air Quality System (NAAQS) for RSPM and the reasons are: increase in population, urbanization, increase in the number of vehicles with poor quality of fuel, commercial developments, industrialization and high economic growth. This has led to the requirement of stringent management of air quality, policy changes to be adopted and updated. The urban population in India is growing at a rate of around 2.3% per annum while the global urban population has increased from 13% in 1900 to 49% in 2005 and is projected to escalate to 60% in 2030 (Ramachandra and Kumar 2008).

As per census data of 2011, there are 48 urban agglomerations in India, which are referred to as mega or Tier-I cities with population more than one million. Earlier studies suggest that Tier-I cities, due to the burgeoning population and lack of proper urban planning, have reached the saturation level evident from lack of basic amenities, over congestion due to inadequate infrastructure, higher amount of pollutants in the environment, contamination of water, scarcity of water and electricity, increasing crime rates (Sudhir et al. 2003). In this context there is a need to plan Tier-II cities (Population less than one million) in India which are urbanizing rapidly to ensure that these cities do not face the serious lack of infrastructure and environmental problems as that of Tier-I cities. Even Tier-II cities like Nagpur, Kanpur and Mysore are witnessing rising pollution levels, especially RSPM, and have become the hot spots of



pollution. The investment capital and creation of infrastructure of associated developments are rapidly progressing at a phenomenal rate in the Tier-II cities of India. There is a necessity to understand, plan and implement strategies for effective environmental managements in Tier-II cities. Hubli-Dharwad a Tier-II city in Karnataka state, India, with a typical tropical climate has seen serious rapid changes and the rate of urbanization is exceeding the global average.

AQI is the cumulative effect of all the pollutants, and the related standards can be taken into account (Lohani 1984) and hence can represent air quality in a better way in common man's perspectives. The higher the AQI value, the greater the level of air pollution and the greater the health concern. In the Indian context, the studies on AQIs have been carried out for the city of Mumbai (Sharma 1999), Delhi (Sengupta et al. 2000) and Kanpur (Sharma et al. 2003). It informs the public of the local level of ambient air pollution, and the potential health risk it would impose, particularly on vulnerable groups such as children, the elderly, and those with existing cardiovascular and respiratory diseases. The AQI range calculated by Oak Ridge Index method for Hubli-Dharwad ranges from 19.1 in Green vegetated area to 73.7 in high traffic zones and industrial areas in 2013. It is observed that 50% of the area shows the good air quality and falls under the good health condition and other 50% are in the range of red category as per Oak Index method and falls under unhealthy conditions. Based on the linear analysis of the urbanization, population, number of vehicles and the trend

of air pollutants, the 2030 AQI predicted shows that almost 90% of the region will be under the dangerous level.

The government of India, MoEF, now has launched on 17th October 2014, National Air Quality Index (AQI) by the Environment Ministry which is a huge initiative under 'Swachh Bharat'. They outlined the AQI, as 'One Number- One Colour-One Description' for the common man to judge the air quality within his vicinity. Under the new measurement process, ministry stated that an effort had been made to include a comprehensive set of parameters.

One of the common tools widely used currently throughout the world is the air dispersion modelling to understand the level of accumulation of pollutants (Bluett et al. 2004). Meteorology is fundamental for the dispersion of pollutants because it is the primary factor determining the diluting effect of the atmosphere (Jacobson 2002). Atmospheric stability has significant effects on air flow and dispersion around buildings in urban area. Giri et al. (2008), studied air pollution problem in Kathmandu, Nepal, which is serious since it is in the valley topography wherein the role of meteorological parameters is significant. Pollutant dispersion is a complex process. It is the net effect of topography, Land use / Land cover, meteorological factors, trends and pattern of urbanization, industry and transport. The Zoning Atlas is not only the solution for all the problems caused by haphazard industrial siting, but tackles the cause of the problem itself. There is a need that apart from preventive measures, proper siting of industries / industrial estates should

be done, especially in countries like India where the process of planned industrialization is still in its initial stage.

More attention is currently being directed towards monitoring changes in urban land use/ land cover (LULC) (Stow and Chen 2002). Such studies are particularly important because the spatial characteristics of LULC are useful for understanding the various impacts of human activity on the overall ecological condition of the urban environment (Yeh and Li 1999). The conversion of forest, grasslands and farmland to residential housing, industrial complexes and large commercial centers often lead to an increase in emissions. The Hubli-Dharwad region has shown a drastic change in LULC pattern, the total urbanized area development was from 92.1 km<sup>2</sup> (1975) to 271.07 km<sup>2</sup> (2009) among the 644 km<sup>2</sup> total area. The agricultural land has decreased by 42% from 1989 to 2009. The 2030 predictions of the urbanization with linear correlation indicates that around 500 km<sup>2</sup> will be in urban area. The effect of urbanization on air quality was correlated by superimposing the present level of pollutant concentration in air on the land use pattern in Hubli-Dharwad region to understand the effects and where these pollutants are getting accumulated. The effect of land use and land cover pattern can be studied by superimposing the concentration of RSPM, NO<sub>x</sub> and SO<sub>2</sub>

The requirements for the integrated spatial modelling of air quality in the framework of GIS represent a common geospatial coordinate system, vector themes (points, lines and areas) for description of surface

objects (buildings, bridges, vegetation) supported by raster and TIN surface data (digital elevation models), and vector themes for representation of air pollution inputs (local point, line and area sources of pollution, long-distance transport of air pollution) (Matejicek 2005). DEM data processed using 3D spatial interpolation can be a valuable tool for assessing pollutant distribution in space. It can be used as a screening method to more closely target key areas and to develop more detailed measuring and modeling strategies. Spatial distribution of air pollutants throughout the Burdwan town in both the season was represented by digital elevation model (DEM) using a GIS approach (Chattopadhyay et al. 2010). Based on the Air Quality Index (AQI) a GIS based air pollution surface models were generated in both the seasons by means of Inverse Distance Interpolation (IDINT) technique. From the output surface model it was found that in comparison to pre monsoon there was a significant increase of clean area and decrease of moderately polluted area of the town during post monsoon. The dispersion and dilution of industrial emissions due to the meteorological parameters of the Hubli-Dharwad, indicated that maximum mixing height was around 1700m in summer season with unstable conditions. The lower mixing height in rainy and winter leads to the accumulation of pollutants, because of the topographical effects of the region. The dispersion sensitivity map describes the ability of the area to disperse and dilute air pollutants owing to its ventilating capacity, micro as well as macro level climate, vegetative cover and nature of earth surface.



Areas with high inversion and extreme climatic conditions are critical as far as dispersion of pollutants is concerned. The impact area in different seasons can be considered. The land use sensitivity of an area indicates the likely impacts on the receiving environment due to air pollution. Normally, the impact on the receiving environment due to small air polluting industries extends up to a maximum of 500m from the source. The impact from medium air polluting industries is normally less than 2km and that of high air polluting industries is 5km. The impact of large scale industries units like cement, thermal power plants fertilizer, petrochemical, steel industries are more than 10 km (CPCB 1995). Impact zone created based on the Gaussian models output and existing meteorological data for Hubli-Dharwad region with the change in LULC, suggest that risk zone area is becoming larger which leads to the effect on the urban population and other environmental problems. The

2030 predicted impact zone for Hubli-Dharwad shows that 80% of region is going to be in the risk zone.

The management strategy and policies for a particular region or city like Hubli-Dharwad (Tier-II) is to be proposed for sustainable development. Strategy like creating the industrial buffer zones, proper monitoring and control measures to be adopted by industries, compliance by industries on emissions, EIA based clearance, adoption of cleaner technologies by industries, introduction of mass transport system, clean fuel policies may decelerate the deterioration of air quality and its impact on health and environment. Sustainable urban transport systems with GPS adoption in emergency management and for rerouting, encouraging public transportation formation, pedestrian zones and incentives for use of bicycles and ecofriendly fuels, taxation on new vehicles, regular monitoring of vehicle emissions may lead to sustainability.

## Source Receptor Modeling in Atmospheric Pollution

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The objective of the talk is to discuss about Coupled receptor & dispersion model then holistic approach in receptor model. Receptor modeling techniques like chemical mass balance are used to attribute pollution levels at a point to different sources. Here we analyze the composition of particulate matter and use the source profiles of each source to estimate quantitative source contributions. On the contrary in dispersion modeling the emission rates of various sources are estimated and together with meteorological conditions are used to determine the concentrations levels at a point or in a region. The concentrations predicted by the dispersion model are often found to be significantly different from those measured at a receptor. We attribute this difference to arise from inaccuracies in emission inventory. The predictions using the two different methods can then be reconciled to accurately determine the emission rates. In this work we propose an algorithm for coupling receptor and dispersion models to determine the emission rates accurately. The proposed combined approach will help us to reduce the differences by considering the information from the stand alone receptor and dispersion modeling approaches.

Rapid urbanization and population growth has resulted in a severe deterioration of

air quality in most major cities in India. It is essential to ascertain the contribution of various sources to the air quality to enable us to determine effective control policies. In this work a holistic approach combining Factor Analysis (FA), Positive Matrix Factorization (PMF) and Chemical Mass Balance (CMB) for receptor modeling to identify the sources and their contributions is discussed. Insight from the emission inventory is used to help remove subjectivity in source identification. Each approach has its limitations. Factor Analysis can identify qualitatively a minimal set of important factors which can account for the variations in the measured data. This step uses information from emission inventory to qualitatively match source profiles with factor loadings. The identification of dominant sources from factors is subjective. PMF identifies source profiles and source contributions from the entire receptor data matrix. Information from FA is used for rank reduction in PMF. Emission inventory is used to identify source profiles uniquely, when multiple solutions exist, so that they have a physical relevance. CMB is used to identify the contributions of the sources identified from FA and PMF. The approach proposed here allows us to overcome the limitations of the individual methods by combining them in a synergistic way. The methodology is validated with a synthetic data set and then applied to data obtained from a field study.

## Notes On Global Carbon Cycle

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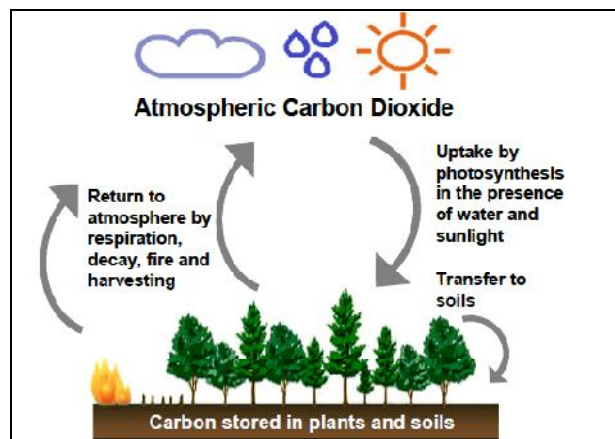
நீர்இன்று அமையாது உலகெனியார்யார்க்கும்  
வான்இன்று அமையாது ஒழுக்கு.

- திருவள்ளுவர்

The veteran tamil poet and philosopher Thiruvalluvar says "Neer Indri Amaiyadhu Ulagu" in Thirukkural. It means that there is no life without water in this world. In addition to water (hydrogen + oxygen) the other important elements which make all living things include carbon, calcium, phosphorous and nitrogen. Out of these elements, Carbon is the most important building block of life which is present in combined form with other elements in the compounds that are essential for life, for example, sugars, fats, proteins, starches. As carbon approximately occupies half of the total dry mass of the living things including all forms, we can understand its importance in life.

Carbon is also present in the Earth's atmosphere, soils, oceans, and crust as fuels and other forms serves as energy resources. When viewing the Earth as a system, these components can be referred to as carbon *pools* (sometimes also called *stocks* or *reservoirs*) because they act as storage houses for large amounts of carbon. Any movement of carbon between these reservoirs is called a *flux*.

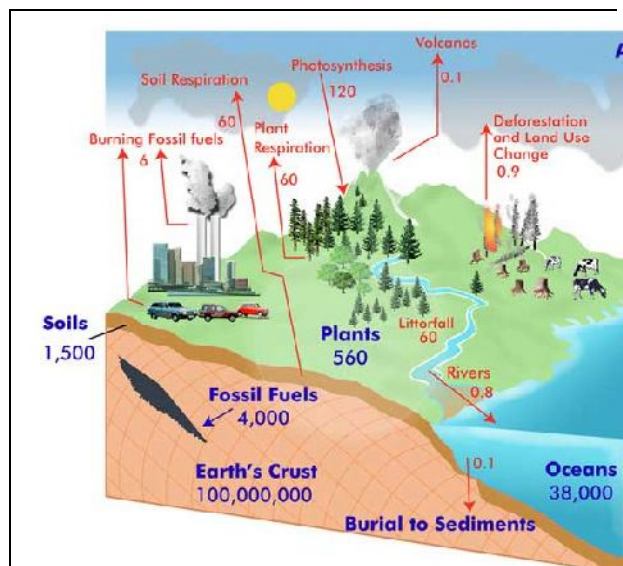
In any integrated system, fluxes connect reservoirs together to create cycles and feedbacks. An example of such a cycle is seen in Figure 1 where, carbon in the atmosphere is used in photosynthesis to create new plant material. On a global basis, this processes transfers large amounts of carbon from one pool (the atmosphere) to another (plants). Over time, these plants die and decay, are harvested by humans, or are burned either for energy or in wildfires. All of these processes are fluxes that can cycle carbon among various pools within ecosystems and eventually releases it back to the atmosphere.



**Figure 1.** A sub-cycle within the global carbon cycle.

Carbon continuously moves between the atmosphere, plants and soils through photosynthesis, plant respiration, harvesting, fire and decomposition.

Viewing the Earth as a whole, individual cycles like this are linked to others involving oceans, rocks, etc. on a range of spatial and temporal scales to form an integrated global carbon cycle (Figure 2).



**Figure 2.** A simplified diagram of the global carbon cycle. Pool sizes, shown in blue, are given in petagrams (Pg) of carbon. Fluxes, shown in red, are in Pg per year. ([www.globe.gov/projects/carbon](http://www.globe.gov/projects/carbon))

On the shortest *time scales*, of seconds to minutes, plants take carbon out of the atmosphere through photosynthesis and release it back into the atmosphere via respiration. On longer time scales, carbon from dead plant material can be incorporated into soils, where it might reside for years, decades or centuries before being broken down by soil microbes and released back to the atmosphere. On still longer time scales, organic matter<sup>1</sup> that became buried in deep sediments (and protected from decay) was slowly transformed into deposits of coal, oil and natural gas, the fossil fuels we use today. When we burn these substances, carbon that has been stored for millions of years is released once again to the atmosphere in the form of carbon dioxide (CO<sub>2</sub>).

The carbon cycle has a large effect on the function and well being of our planet. Globally, the carbon cycle plays a key role in regulating the Earth's climate by controlling the concentration of carbon dioxide in the atmosphere. Carbon dioxide (CO<sub>2</sub>) is important because it contributes to the *greenhouse effect*, in which heat generated from sunlight at the Earth's surface is trapped by certain gasses and prevented from escaping through the atmosphere. The greenhouse effect itself is a perfectly natural phenomenon and, without it, the Earth would be a much colder place. But as is often the case, too much of a good thing can have negative consequences, and an unnatural build-up of greenhouse gasses can lead to a planet that gets unnaturally hot. In recent years CO<sub>2</sub> has received much attention because its concentration in the atmosphere has risen to approximately 30% above natural background levels and will continue to rise into the near future. Scientists have shown that this increase is a result of human activities that have occurred over the last 150 years, including the burning of fossil fuels and deforestation. Because CO<sub>2</sub> is a greenhouse gas, this increase is believed to be causing a rise in global temperatures. This is the primary cause of climate change and is the main reason for increasing interest in the carbon cycle.

The Earth's carbon reservoirs naturally act as both *sources*, adding carbon to the atmosphere, and *sinks*, removing carbon from the atmosphere. If all sources are equal to all sinks, the carbon cycle can be said to be in equilibrium (or in balance) and there is no change in the size of the pools over time. Maintaining a steady amount of CO<sub>2</sub> in the atmosphere helps maintain stable average temperatures at the global scale. However, because fossil fuel combustion and deforestation have increased CO<sub>2</sub> inputs to

the atmosphere without matching increases in the natural sinks that draw CO<sub>2</sub> out of the atmosphere (oceans, forests, etc.), these activities have caused the size of the atmospheric carbon pool to increase. This is what has been responsible for the present buildup of CO<sub>2</sub> and is believed to cause the observed trend of increasing global temperatures. How far will CO<sub>2</sub> levels rise in the future? The answer depends both on how much CO<sub>2</sub> humans continue to release and on the future amount of carbon uptake and storage by the Earth's natural sinks and reservoirs. In short, it depends on the carbon cycle.

<sup>1</sup>.We often refer to carbon occurring in “organic” versus “inorganic” forms. This is a simple way of grouping different forms of carbon into biologically derived compounds (complex substances produced only by the growth of living organisms) and mineral compounds that can be formed in the absence of biological activity (but can sometimes be formed with the assistance of living things, as in the case of sea shells). Organic compounds includes such things as sugars, fats, proteins and starches and are contained in both living organisms and the material that remains after their death and partial decomposition (including the organic matter in soils as well as the deposits of coal and oils we refer to as fossil fuels). Note that complete decomposition of organic matter results in a return to mineral forms, often as CO<sub>2</sub>. Mineral forms of carbon include carbonates contained in rock and seawater as well as CO<sub>2</sub> itself.

### **POOLS, FLUXES AND A WORD ABOUT UNITS**

In order to understand how carbon is cycled and how atmospheric CO<sub>2</sub> will change in the future, scientists must carefully study the places in which carbon is stored (pools),

how long it resides there, and processes that transfer it from one pool to another (fluxes). Collectively, all of the major pools and fluxes of carbon on Earth comprise what we refer to as the global carbon cycle.

As you might imagine, the actual global carbon cycle is immensely complex. It includes every plant, animal and microbe, every photosynthesizing leaf and fallen tree, every ocean, lake, pond and puddle, every soil, sediment and carbonate rock, every breath of fresh air, volcanic eruption and bubble rising to the surface of a swamp, among much, much else. Because we can't deal with that level of complexity, scientists often describe the carbon cycle by lumping similar objects or environments into simpler groups (forest, grassland, atmosphere, ocean) and focusing only on the processes that are most important at the global scale (Figure 2). As you might imagine, part of the trick is understanding just what those processes are.

The following section is a brief overview of some of the important pools and fluxes in the global carbon cycle (and note that, in our discussion, we will use the terms pool, stock and reservoir interchangeably). But first, it's worth taking a moment to consider the numbers and units scientists often deal with. Because the quantities of carbon in the Earth's major carbon pools can be quite large, it is inconvenient to use familiar units such as pounds or kilograms. Instead, we use other units, such as Petagrams, that are better suited for expressing large numbers. For example, a Petagram (Pg), also known as a Gigaton (Gt), is equal to one quadrillion (1,000,000,000,000,000 or 10<sup>15</sup>) grams! Because there are a thousand grams in a kilogram, and a thousand kilograms in a tonne (also known as a metric ton), we can see that a Petagram is equal to a trillion (1,000,000,000,000) kilograms or a billion



(1,000,000,000) tonnes. For those who prefer pounds, knowing that one kilogram is equal to 2.205 pounds tells us that one Petagram equals about 2.2 trillion pounds. In all cases, expressing this as 1 Pg is much simpler than working with that many zeros. Now we will consider carbon stored on Earth in four main reservoirs.

## CARBON POOLS

Depending on our goals, the Earth's carbon pools can be grouped into any number of different categories. Here, we will consider four categories that have the greatest relevance to the overall carbon cycle. Keep in mind that any of these pools could be further divided into a number of subcategories, as we will occasionally discuss.

*The Earth's Crust:* The largest amount of carbon on Earth is stored in sedimentary rocks within the planet's crust. These are rocks produced either by the hardening of mud (containing organic matter) into shale over geological time, or by the collection of calcium carbonate particles, from the shells and skeletons of marine organisms, into limestone and other carbon-containing sedimentary rocks. Together all sedimentary rocks on Earth store 100,000,000 PgC (Petagrams of carbon). Recalling that 1 Pg is equal to a trillion kilograms and over two trillion pounds, this is clearly a large mass of carbon! Another 4,000 PgC is stored in the Earth's crust as hydrocarbons formed over millions of years from ancient living organisms under intense temperature and pressure. These hydrocarbons are commonly known as fossil fuels.

*Oceans:* The Earth's oceans contain 38,000 PgC, most of which is in the form of dissolved inorganic carbon stored at great depths where it resides for long periods of time. A much smaller amount of carbon,

approximately 1,000 Pg, is located near the ocean surface. This carbon is exchanged rapidly with the atmosphere through both physical processes, such as CO<sub>2</sub> gas dissolving into the water, and biological processes, such as the growth, death and decay of plankton. Although most of this surface carbon cycles rapidly, some of it can also be transferred by sinking to the deep ocean pool where it can be stored for a much longer time.

*Atmosphere:* The atmosphere contains approximately 750 PgC, most of which is in the form of CO<sub>2</sub>, with much smaller amounts of methane (CH<sub>4</sub>) and various other compounds. Although this is considerably less carbon than that contained in the oceans or crust, carbon in the atmosphere is of vital importance because of its influence on the greenhouse effect and climate. The relatively small size of the atmospheric C pool also makes it more sensitive to disruptions caused by an increase in sources or sinks of C from the Earth's other pools. In fact, the present-day value of 750 PgC is substantially higher than that which occurred before the onset of fossil fuel combustion and deforestation. Before these activities began, the atmosphere contained approximately 560 PgC and this value is believed to be the normal upper limit for the Earth under natural conditions. In the context of global pools and fluxes, the limit for the Earth under natural conditions. In the context of global pools and fluxes, the increase that has occurred in the past several centuries is the result of C fluxes to the atmosphere from the crust (fossil fuels) and terrestrial ecosystems (via deforestation and other forms of land clearing).

*Terrestrial Ecosystems:* Terrestrial ecosystems contain carbon in the form of plants, animals, soils and microorganisms (bacteria and fungi). Of these, plants and

soils are by far the largest and, when dealing with the entire globe, the smaller pools are often ignored. Unlike the Earth's crust and oceans, most of the carbon in terrestrial ecosystems exists in organic forms. In this context, the term "organic" refers to compounds produced by living things, including leaves, wood, roots, dead plant material and the brown organic matter in soils (which is the decomposed remains of formerly living tissues). Plants exchange carbon with the atmosphere relatively rapidly through photosynthesis, in which CO<sub>2</sub> is absorbed and converted into new plant tissues, and respiration, where some fraction of the previously captured CO<sub>2</sub> is released back to the atmosphere as a product of metabolism. Of the various kinds of tissues produced by plants, woody stems such as those produced by trees have the greatest ability to store large amounts of carbon, because wood is dense and trees can be large. Collectively, the Earth's plants store approximately 560 PgC, with the wood in trees being the largest fraction.

The total amount of carbon in the world's soils is estimated to be 1500 PgC. Measuring soil carbon can be challenging, but a few basic assumptions can make estimating it much easier. First, the most prevalent form of carbon in the soil is organic carbon derived from dead plant materials and microorganisms. Second, as soil depth increases the abundance of organic carbon decreases. Standard soil measurements are typically only taken to 1m in depth. In most cases, this captures the dominant fraction of carbon in soils, although some environments have very deep soils where this rule doesn't apply. Most of the carbon in soils enters in the form of dead plant matter that is broken down by microorganisms during decay. The decay process also releases carbon back to the atmosphere because the metabolism of these

microorganisms eventually breaks most of the organic matter all the way down to CO<sub>2</sub>.

### CARBON FLUXES

The movement of any material from one place to another is called a flux and we typically think of a carbon flux as a transfer of carbon from one pool to another. Fluxes are usually expressed as a *rate* with units of an amount of some substance being transferred over a certain period of time (e.g. g per cm<sup>2</sup> per sec or kg per km<sup>2</sup> per yr). For example, the flow of water in a river can be thought of as a flux that transfers water from the land to the sea and can be measured in liters per second, cubic meters per minute or cubic kilometers per year.

A single carbon pool can often have several fluxes both adding and removing carbon simultaneously. For example, the atmosphere has inflows from decomposition (CO<sub>2</sub> released by the breakdown of organic matter), forest fires and fossil fuel combustion and outflows from plant growth and uptake by the oceans. The size of various fluxes can vary widely. In the previous section, we briefly discussed a few of the fluxes into and out of various global C pools. Here, we will pay more careful attention to some of the more important C fluxes.

*Photosynthesis:* During photosynthesis, plants use energy from sunlight to combine CO<sub>2</sub> from the atmosphere with water from the soil to create carbohydrates (notice that the two parts of the word, *carbo-* and *-hydrate*, signify carbon and water). In this way, CO<sub>2</sub> is removed from the atmosphere and stored in the structure of plants. Virtually all of the organic matter on Earth was initially formed through this process. Because some plants can live to be tens, hundreds or sometimes even thousands of years old (in the case of the longest-living

trees), carbon may be stored, or *sequestered*, for relatively long periods of time. When plants die, their tissues remain for a wide range of time periods. Tissues such as leaves, which have a high quality for decomposer organisms, tend to decay quickly, while more resistant structures, such as wood can persist much longer. Current estimates suggest photosynthesis removes 120 PgC/year from the atmosphere and about 610 PgC is stored in plants at any given time.

*Plant Respiration:* Plants also release CO<sub>2</sub> back to the atmosphere through the process of respiration (the equivalent for plants of exhaling). Respiration occurs as plant cells use carbohydrates, made during photosynthesis, for energy. Plant respiration represents approximately half (60 PgC/year) of the CO<sub>2</sub> that is returned to the atmosphere in the terrestrial portion of the carbon cycle.

*Litterfall:* In addition to the death of whole plants, living plants also shed some portion of their leaves, roots and branches each year. Because all parts of the plant are made up of carbon, the loss of these parts to the ground is a transfer of carbon (a flux) from the plant to the soil. Dead plant material is often referred to as litter (leaf litter, branch litter, etc.) and once on the ground, all forms of litter will begin the process of decomposition.

*Soil Respiration:* The release of CO<sub>2</sub> through respiration is not unique to plants, but is something all organisms do, including microscopic organisms living in soil. When dead organic matter is broken down or decomposed (consumed by bacteria and fungi), CO<sub>2</sub> is released into the atmosphere at an average rate of about 60 PgC/year globally. Because it can take years for a plant to decompose (or decades in the case of

large trees), carbon is temporarily stored in the organic matter of soil.

*Ocean—Atmosphere exchange:* Inorganic carbon is absorbed and released at the interface of the oceans' surface and surrounding air, through the process of diffusion. It may not seem obvious that gases can be dissolved into, or released from water, but this is what leads to the formation of bubbles that appear in a glass of water left to sit for a long enough period of time. The air contained in those bubbles includes CO<sub>2</sub> and this same process is the first step in the uptake of carbon by oceans. Once in a dissolved form, CO<sub>2</sub> goes on to react with water in what are known as the carbonate reactions. These are relatively simple chemical reactions in which H<sub>2</sub>O and CO<sub>2</sub> join to form H<sub>2</sub>CO<sub>3</sub> (also known as carbonic acid, the anion of which is called carbonate, or CO<sub>3</sub>). The formation of carbonate in seawater allows oceans to take up and store a much larger amount of carbon than would be possible if dissolved CO<sub>2</sub> remained in that form. Carbonate is also important to a vast number of marine organisms that use this mineral form of carbon to build shells.

Carbon is also cycled through the ocean by the biological processes of photosynthesis, respiration, and decomposition of aquatic plants. In contrast with terrestrial vegetation is the speed at which marine organisms decompose. Because ocean plants don't have large, woody trunks that take years to breakdown, the process happens much more quickly in oceans than on land—often in a matter of days. For this reason, very little carbon is stored in the ocean through biological processes. The total amount of carbon uptake (92 Pg C) and carbon loss (90 Pg C) from the ocean is dependent on the balance of organic and inorganic processes.



*Fossil fuel combustion and land cover change:* The carbon fluxes discussed thus far involve natural processes that have helped regulate the carbon cycle and atmospheric CO<sub>2</sub> levels for millions of years. However, the modern-day carbon cycle also includes several important fluxes that stem from human activities. The most important of these is combustion of fossil fuels: coal, oil and natural gas. These materials contain carbon that was captured by living organisms over periods of millions of years and has been stored in various places within the Earth's crust. However, since the onset of the industrial revolution, these fuels have been mined and combusted at increasing rates and have served as a primary source of the energy that drives modern industrial human civilization. Because the main byproduct of fossil fuel combustion is CO<sub>2</sub>, these activities can be viewed in geological terms as a new and relatively rapid flux to the atmosphere of large amounts of carbon. At present, fossil fuel combustion represents a flux to the atmosphere of approximately 6-8 PgC/year.

Another human activity that has caused a flux of carbon to the atmosphere is land cover change, largely in the form of deforestation. With the expansion of the human population and growth of human settlements, a considerable amount of the Earth's land surface has been converted from native ecosystems to farms and urban areas. Native forests in many areas have been cleared for timber or burned for conversion to farms and grasslands. Because forests and other native ecosystems generally contain more carbon (in both plant tissues and soils) than the cover types they have been replaced with, these changes have resulted in a net flux to the atmosphere of about 1.5 PgC/year. In some areas, regrowth of forests from past

land clearing activities can represent a sink of carbon (as in the case of forest growth following farm abandonment in eastern North America), but the net effect of all human-induced land cover conversions globally represents a source to the atmosphere.

*Geological Processes:* Geological processes represent an important control on the Earth's carbon cycle over time scales of hundreds of millions of years. A thorough discussion of the geological carbon cycle is beyond the scope of this introduction, but the processes involved include the formation of sedimentary rocks and their recycling via plate tectonics, weathering and volcanic eruptions.

To take a slightly closer look, rocks on land are broken down by the atmosphere, rain, and groundwater into small particles and dissolved materials, a process known as weathering. These materials are combined with plant and soil particles that result from decomposition and surface erosion and are later carried to the ocean where the larger particles are deposited nearshore. Slowly, these sediments accumulate, burying older sediments below. The layering and burial of sediment causes pressure to build, which eventually becomes so great that deep sediments are turned into rock, such as shale. Within the ocean water itself, dissolved materials mix with seawater and are used by marine life to make calcium carbonate (CaCO<sub>3</sub>) skeletons and shells. When these organisms die, their skeletons and shells sink to the bottom of the ocean. In shallow waters (less than 4km) the carbonate collects and eventually forms another type of sedimentary rock called limestone.

Collectively, these processes slowly convert carbon that was initially contained in

living organisms into sedimentary rocks within the Earth's crust. Once there, these materials continue to be moved and transformed through the process of plate tectonics, uplift of rocks contained in the lighter plates and melting of rocks in the heavier plates as they are pushed deep under the surface. These melted materials can eventually result in emission of gaseous carbon back to the atmosphere through volcanic eruptions, thereby completing the cycle. Without this geological recycling, the carbon that becomes bound up in rocks would accumulate and remain there forever, eventually depleting the sources of CO<sub>2</sub> that are vital to life. The recycling of carbon through sedimentary rocks is an important part of our planet's long-term (over millions of years) ability to sustain life. Without it, the carbon that becomes bound up in rocks would accumulate and remain there forever, eventually depleting the sources of CO<sub>2</sub> that are vital to plants. However, because the geological cycle moves so slowly, these fluxes are small on an annual basis and have little effect on a human time-scale.

### **CARBON BUDGETS: THE BALANCE BETWEEN SOURCES & SINKS**

The Earth's carbon cycle is in a constant state of motion. Through processes that take place over seconds, days, years and millennia, carbon is constantly being transferred between all the various pools discussed above. But what does this mean for the size of any given pool? The fact that carbon moves into and out of the Earth's land, atmosphere and oceans doesn't, on its own, mean that these pools are changing. In fact, if the amount of carbon moving into a given pool is matched by an equal amount of carbon moving out, the pool size remains constant. If this condition were true for all carbon pools, the global carbon cycle would be said to be in a state of dynamic

equilibrium; "*dynamic*" because the carbon itself is moving, and "*equilibrium*" because the equal size of all inputs and outputs keeps the system in balance. The size of all carbon pools remains unchanged. When scientists examine whether any system is in a state of change or in one of equilibrium, they typically begin by constructing a budget. Just as in the constructing of a financial budget, a carbon budget is simply a list all pools along with estimates of their size and of all the fluxes that constitute inputs and outputs. Presently, a budget of the Earth's carbon cycle shows that it is far from being in a state of balance. While random variation in natural processes such as climate and forest fires often results in some degree of imbalance on an annual basis, the very large imbalance in today's carbon cycle is due to the processes of fossil fuel combustion and land cover change, as discussed earlier. And this brings us to an interesting question scientists are presently trying to answer. Although CO<sub>2</sub> is indeed building up in the atmosphere, the rate at which it is accumulating is less than the rate at which it is being emitted and the difference is difficult to account for through present estimates of uptake by the land and oceans. The primary hypothesis scientists are exploring is that carbon uptake by forests and other ecosystems is larger than has been estimated and that carbon accumulation in plants and soil has kept the atmosphere from increasing at an even greater pace. But if this is correct, why are present estimates too low and where in the world's ecosystems is the missing carbon going? This mystery has sparked a great deal of research on ecological aspects of the carbon cycle and is an underlying driver for much of the work students involved in the GLOBE Carbon Cycle Project are investigating.

### **GLOSSARY**

**Anthropogenic emissions:** Human-made materials (gases, particles, vapors, chemical compounds, etc.) that come out of smokestacks, chimneys, and vehicle tailpipes.

**Atmosphere:** The mixture of gases surrounding the Earth. The Earth's atmosphere consists of about 79.1% nitrogen (by volume), 20.9% oxygen, 0.036% carbon dioxide and trace amounts of other gases. The atmosphere can be divided into a number of layers. The layer nearest the Earth is the troposphere, which reaches up to an altitude of about 8 km (about 5 miles) in the Polar Regions and up to 17 km (11 mi.) above the equator. The stratosphere, which reaches to an altitude of about 50 km (31 mi.), is above the troposphere. The mesosphere, which extends up to 80-90 km (48-54 mi.), is above the stratosphere, and finally, the thermosphere, or ionosphere, is the layer that forms a poorly defined border with outer space. There is relatively little mixing of gases between layers.

**Biogeochemistry:** The study of natural processes that recycle nutrients from the environment, to organisms, and then back to the environment. Examples are the carbon, oxygen, nitrogen, phosphorus, and hydrologic cycles.

**Boreal forests:** The forest areas of the northern North Temperate Zone, dominated by coniferous trees such as spruce, fir, and pine.

**Carbon cycle:** The exchange of carbon between its four main reservoirs—the atmosphere, terrestrial biosphere, oceans, and sediments. Each of these global reservoirs may be subdivided into smaller pools, ranging in size from individual communities

or ecosystems to the total of all living organisms.

**Carbon dioxide (CO<sub>2</sub>):** A colorless, odorless non-combustible gas that is present in the atmosphere. It is formed by the combustion of carbon and carbon compounds (such as fossil fuels and biomass), by respiration of animals and plants, by the gradual oxidation of organic matter in the soil, and by chemical processes that occur with certain geological components.

**Carbon sequestration:** The uptake and storage of carbon. Trees and plants, for example, absorb carbon dioxide, release the oxygen and store the carbon.

**Carbon sink:** A carbon reservoir that takes in and stores (sequesters) more carbon than it releases. Carbon sinks can serve to partially offset greenhouse gas emissions. Forests and oceans are both large carbon sinks.

**Carbon source:** A reservoir or component of the carbon cycle that releases more carbon than it absorbs. Anthropogenic emissions are a source of carbon.

**Climate:** The average weather, usually taken over a 30 year time period, for a particular region and time period. Climate is not the same as weather, but rather, it is the average pattern of weather for a particular region. Weather describes the short-term state of the atmosphere. It is often challenging to differentiate between weather and climate patterns.

**Climate change** The long-term fluctuations in temperature, precipitation, wind, and other aspects of the Earth's climate. Although it refers to temperature fluctuations in either direction, as well as other climate variation,

the media often uses it interchangeably with the term globalwarming. Scientists use the term both in reference to natural and anthropogenic change.

**Decomposition:** The breakdown of matter by bacteria and fungi. It changes the chemicalcomposition and physical appearance of the materials. It is the process by which carbon isreleased from decaying biological matter.

**Deforestation:** The transformation of forested lands to non-forest uses. This is often cited asone of the major causes of human-induced climate change for two reasons. In the case of slashand burn clearing, the burning and decomposition of plant matter releases carbon dioxide.Also, deforestation removes trees that once consumed and stored carbon dioxide from theatmosphere. Deforestation is a type of land–use change.

**Fossil fuel:** Any hydrocarbon deposit such as petroleum, coal, or natural gas that can be burnedfor heat or power.

**Flux:** The rate of exchange between reservoirs.

**Global warming:** A popular term used to describe the increase in average global temperaturesdue to the greenhouse effect. It is often used interchangeably with the term climate change.

**Greenhouse effect:** A popular term used to describe the roles of water vapor, carbon dioxide,methane, and other gases (greenhouse gases—GHG) in keeping the Earth's surface warmerthan it would be otherwise.

**Greenhouse gases (GHG):** Those gases, such as water vapor, carbon dioxide, tropospheric ozone, nitrous oxide, and

methane, which allow solar radiation to pass through to the Earth,but block outgoing longwave radiation. Their action is compared to that of glass in a greenhouse.

**Greenhouse gas inventory:** A statistical compilation of greenhouse gases emitted by acommunity, state, country, etc. It can have both political and scientific applications.

**Ice core:** A vertical section of ice removed from a glacier or an ice sheet in order to studyclimate patterns of the past. By performing chemical analyses on the air trapped in the ice,scientists can estimate the percentage of carbon dioxide and other trace gases in theatmosphere at that time.

**Intergovernmental Panel on Climate Change (IPCC):** In 1988, the United Nations EnvironmentProgram and the World Meteorological Organization established the IPCC jointly. The purposeof the IPCC is to assess information in the scientific and technical literature related to allsignificant components of the issue of climate change. The IPCC draws upon hundreds of theworld's expert scientists as authors and thousands as expert reviewers. Leading experts onclimate change and environmental, social, and economic sciences from some 60 nations havehelped the IPCC to prepare periodic assessments of the scientific underpinnings forunderstanding global climate change and its consequences. With its capacity for reporting onclimate change, its consequences, and the viability of adaptation and mitigation measures, the

IPCC is also looked to as the official advisory body to the world's governments on the state of

the science of the climate change issue. For example, the IPCC organized the development of

internationally accepted methods for conducting national greenhouse gas emission inventories.

**Kyoto Protocol:** This is an international agreement struck by 159 nations attending the United Nations Framework Convention on Climate Change (held in December of 1997 in Kyoto Japan) to reduce worldwide emissions of greenhouse gases. If ratified and put into force, individual countries have committed to reduce their greenhouse gas emissions by a specified amount. As of now, the United States is the only major industrialized country that hasn't signed-on.

**Longwave radiation:** The radiation emitted in the spectral wavelength greater than 4 micrometers, which corresponds to the radiation emitted from the Earth and atmosphere. It is sometimes vaguely referred to as terrestrial radiation or infrared radiation.

**Soil carbon:** Soil is a major component of the terrestrial biosphere pool in the carbon

cycle. Organic soil carbon estimates, rather than total soil carbon, are generally quoted. The amount of carbon in the soil is a function of historical vegetative cover and productivity, which in turn is dependent upon climatic variables.

**Citation:**

**Retrieved from** <http://globecarboncycle.unh.edu//CarbonCycleBackground.pdf>

**Further Reading**

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## Molecular Cluster Diagnostics for Air Pollution Source Apportionment

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Developing countries suffer from high level of air pollution especially the suspended particulate matter (SPM). In Asian cities some of the highest levels of SPM have been measured in ambient air. Scientific research over the last two decades has demonstrated that air borne SPM is the major pollutant of concern from the health perspective. Due to the small size of suspended particles have higher surface area and can adsorb gaseous pollutants and enrich on them leading much more toxic entities. The emerging pollutants such as polycyclic aromatic hydrocarbons (PAHs) are a group of carcinogenic pollutants that originate from incomplete combustion of fossil fuels. These can adsorb on particulates and further enhances the toxicity level of PAHs bound particles. Sources of particulates and their associated PAHs within the urban environment are predominantly associated with traffic, domestic heating, power generation, and other industrial activities. In addition to PAH emission sources located within the urban centers, point sources (e.g., industrial plants) located at long distances from such centers have also been reported to affect urban air quality.

PAHs are mainly emitted into the environment from incomplete combustion of fossil fuels in which specific PAHs have been suggested as being indicators for certain processes. Air pollutants with long life have advantage to be used as markers. There are two significant concerns regarding the use of PAHs in source apportionment studies. First, the tendency of various PAHs to partition between gas and particulate

phases complicates both the sampling and quantification. The second concern is the loss of PAHs by destruction of photochemical processes. As for example, one method of assessing the degree of photochemical destruction is to evaluate the ratio of benzo(e)pyrene (BeP) to benzo(a)pyrene (BaP), BaP is highly susceptible to photochemical decay, whereas BeP to BaP is much more stable in the atmosphere. Similar ratios of BeP to BaP emissions are reported for a variety of sources. Therefore, changes in source apportionment should have only minor effect on the ambient BeP/BaP ratio relative to the loss of BaP from photochemistry. Several models have been developed to apportion the sources of PAHs associated with particulates. Receptor modeling approach has been often been used for source apportionment of atmospheric pollutants by Chemical Mass Balance (CMB), Principal Component Analysis (PCA), Positive Matrix Factorization (PMF). These methods indicate the number of relative strength of PAH sources to the ambient urban atmosphere.

The present study was carried out in Nagpur (Maharashtra, India), which is characterized high traffic density and many industrial zone near the city and rapid pace of expanding commercial and industrial agglomeration. As shown in Fig.1, industrial development is established along the fringe areas like Kamptee, Hingna, Wadi, Khapri, Butibori and Kalmeshwar. All major highways NH-7 (Varanasi - Kanyakumari ) and NH-6 (Mumbai - Sambalpur - Calcutta) pass



through the city. Nagpur is located precisely at the center of the country with the Zero mile marker (indicating the geographical center of India). Nagpur generally has a dry tropical weather and the climate of Nagpur follows a typical monsoon weather pattern. The peak temperatures are usually reached in May/June and can be as high as 48°C. The onset of monsoon is usually from July and the season extends up to September, with monsoon peaking during July and August. After monsoons, the average temperature varies between 27°C and approx 6 to 7° C right through December and January. Wind blows with maximum (22 km/h or higher) in the month of February and on set of monsoon season i.e. in end of May and first week of June. This is due to generating low pressure area in this region. Rest of time wind speed is below 5 to 7 km/h.

In this study, ultra trace PAHs was used as air pollution marker to identify source of contamination. For this purpose five sampling sites viz. Indoor, residential area, commercial area, traffic line and industrial area were selected to determine the PAHs concentration in the ambient air particulate in Nagpur city (Fig.1). These sites were located at National Environmental Engineering Research Institute (laboratory), Laxminagar (residential), Maskasaath (commercial), Ajani square (traffic) and Maharashtra Industrial Development Corporation office area (industrial). The air pollution monitoring was carried out using low volume sampler to collect particle bound PAHs from ambient urban air. The PAHs were precisely quantified to ultra-trace levels by fluorescence spectrophotometry (Model:F-4500, Hitachi Japan). The average result of suspended particles is highest in Traffic while lowest in Indoor. The average result found for Traffic source were 381 $\mu\text{g}/\text{m}^3$ , which is larger than the data 256  $\mu\text{g}/\text{m}^3$  studied by NAMP in

2008 at same site and same location. Similarly for Industrial source (288  $\mu\text{g}/\text{m}^3$ ), Commercial area (282  $\mu\text{g}/\text{m}^3$ ), Laboratory (158  $\mu\text{g}/\text{m}^3$ ) and Residential are higher than the value of 185  $\mu\text{g}/\text{m}^3$ , 228  $\mu\text{g}/\text{m}^3$ , 165  $\mu\text{g}/\text{m}^3$  and 181  $\mu\text{g}/\text{m}^3$  of NAMP, 2008. In indoor SPM is larger due to the lack of air cross-ventilation and smaller and compact size of the laboratory. Similarly for commercial area, atmosphere make very crowd and air ventilation reduces their dispersion for dilution. In lab source SPM is less at every Saturday and Sunday due to regular holiday in NEERI. For residential area SPM level is approximately uniform due to daily routine work. In Commercial area at every Sunday SPM found less due to the closing market. The concentration of PAHs measured in the suspended particulate matter is presented in Table 1.

The purpose of this study is to give a reasonably clear idea of the total breakdown of emissions from all sources of specific locations. But, it is not possible to do source apportionment with absolute precision. Therefore, using modeling (or any suitable method that is informed by monitoring results) and appropriate analysis, a breakdown of sources affecting a particular receptor or location can be determined in rough percentage terms. After discussing all the methods of source apportionment, a new approach of source apportionment can be introduced which, is simple and easy to understand. A relationship was established between ambient air markers (here, PAHs) vis-à-vis pollution sources based on “molecular cluster signatures (MCS)” approach. The MC signature enables source specific signatures unique based on concentration profile of different constituents molecules of PAHs of the source. The advantage of MC signature method is that it is easy to read and understand the signatures for a source and

similarly differentiate various fuels employed in an industry and/or any industry in an industrial complex.

The study revealed that PAH molecules – e.g., fluoranthene, acenaphthene and benzo[a]pyrene – are predominantly present in a commercial source while benzo[a]pyrene and phenanthrene are predominantly present in traffic sources leaving different molecular signatures. It can be seen from Fig. 2 that for a marker like benzo[a]pyrene, its concentration are source specific and different to obtain distinct MC signatures. The average concentration of benzo(a)pyrene in traffic source was 50 ng/m<sup>3</sup> while in commercial sources it ranged from 30 to 35ng/m<sup>3</sup>. The MC signature methodology produced simple, accurate and self-evident system for air quality apportionment than commonly used Principal Component Analysis (PCA) method.

Further, the study revealed that signatures do follow the trend of air quality in the study region. As shown in Fig. 3, the dominant PAHs found at residential sampling site were acenaphthene and fluorine. Phenanthrene, fluorine and pyrene are characteristic of diesel vehicle exhausts, but high emissions of fluorine and pyrene are also closely associated with domestic wood burning activities. The PAHs concentrations

related to traffic sources were found to be heterogenous, which might be due to different type vehicles using different fuels. The concentrations of PAHs were registered more at night time. This could be due to heavy vehicles movement and lower turbulence of air during night hours. The main PAHs emitted from commercial sampling site were acenaphthene, phenanthrene, anthracene and benzo(a)pyrene. Acenaphthene is dominantly emitted from industrial sources, too, and emissions are homogenous in nature. This may be due to the use of fossil fuels for energy sources in industrial areas. Every Wednesday due to holiday in the Industrial area, concentrations of all PAHs were found lower than other days.

In conclusion, particle bound PAHs were quantified based on the concentration profile of PAHs as a signature specific for source. The receptor-oriented approaches including PCA were utilized to apportion PAHs for different sources like industrial, commercial, traffic and residential. The MC signatures for various sources were compared with the results of unknown samples and >90% signatures were satisfactorily matched. Thus, the knowledge and experience of the methodology about the presence of major sources of pollutants plays an important role while selecting sources and their marker species.

Table 1

Maximum (Max), Minimum (Min), Median(Med), Monthly average(Avg), Standard deviation (SD), of PAHs concentration (ng/m<sup>3</sup>) in the total suspended particulate matter.

PAHs marker		Laboratory	Residential	Commercial	Traffic	Industrial
Acenaphtene	Min	13.55	11.08	11.33	26.24	32.51
	Max	55.77	98.55	90.19	106.2	131.31
	Med	24.80	27.32	37.67	64.92	80.63
	Avg	25.58	28.61	40.33	62.67	79.27
	SD	12.54	15.43	17.70	19.31	24.19
	Min	2.23	4.63	10.72	3.09	14.03



Anthracene	Max	35.86	38.14	55.80	55.71	65.58
	Med	13.12	17.19	29.82	19.27	31.06
	Avg	14.75	19.00	29.71	19.55	33.82
	SD	9.10	9.27	12.29	11.04	13.69
Benzo(a)pyrne	Min	12.24	10.41	10.11	16.29	23.38
	Max	47.95	85.27	57.85	79.66	93.95
	Med	32.24	25.94	31.33	51.60	44.14
	Avg	30.90	27.89	32.67	50.19	45.92
	SD	10.82	15.27	11.92	16.09	13.73
Chrysene	Min	10.89	10.52	12.73	11.00	28.42
	Max	62.21	71.00	84.73	63.67	60.45
	Med	22.14	21.37	42.20	33.39	48.50
	Avg	26.63	23.83	42.79	35.16	48.04
	SD	13.96	13.82	17.48	14.64	8.76
Fluoranthene	Min	10.89	10.52	12.73	11.00	28.42
	Max	62.21	71.00	84.73	63.67	60.45
	Med	22.14	21.37	42.20	33.39	48.50
	Avg	26.63	23.83	42.79	35.16	48.04
	SD	13.96	13.82	17.48	14.64	8.76
Fluorene	Min	10.14	10.60	10.10	9.78	29.05
	Max	62.78	74.54	69.42	68.85	89.64
	Med	34.98	35.88	20.41	42.78	54.62
	Avg	32.98	37.00	27.49	40.60	55.14
	SD	14.22	14.99	17.64	15.83	17.78
Phenanthrene	Min	10.81	11.29	11.53	17.11	22.54
	Max	43.81	42.06	57.65	81.43	91.41
	Med	18.85	22.49	36.19	50.91	63.62
	Avg	22.12	23.62	34.35	48.72	60.02
	SD	9.44	8.75	12.52	15.98	18.64
Pyrene	Min	2.75	4.04	12.03	10.65	10.18
	Max	33.56	39.06	58.73	69.74	63.07
	Med	15.28	17.63	23.45	25.43	17.03
	Avg	17.68	17.43	25.47	30.46	27.05
	SD	9.60	7.69	11.38	16.53	13.09

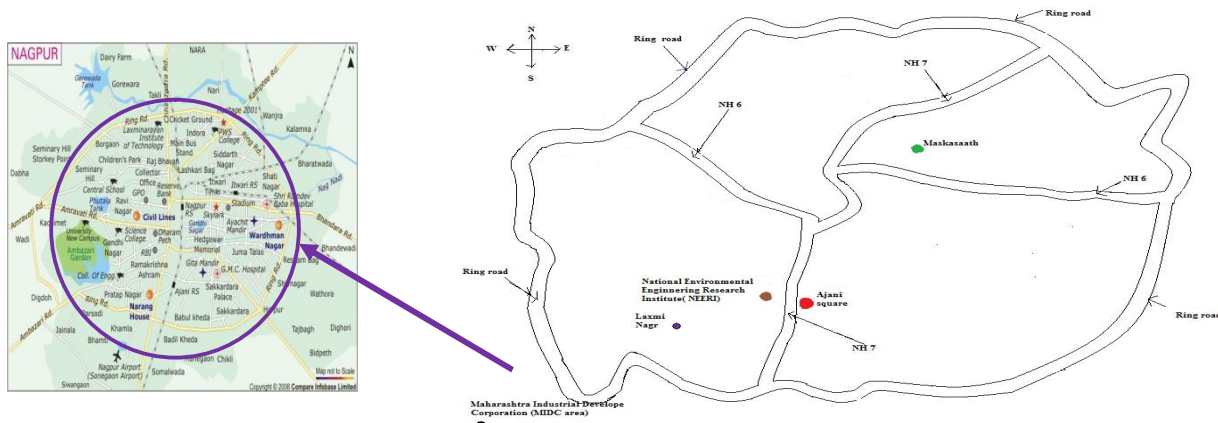


Fig.1. Map showing the sampling location in Nagpur

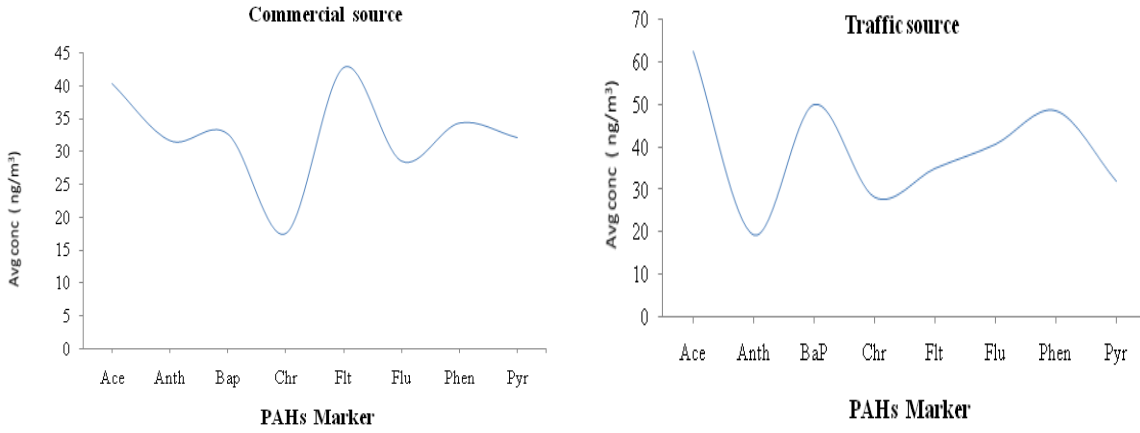


Fig.2: MC signatures of PAHs in commercial and traffic sources

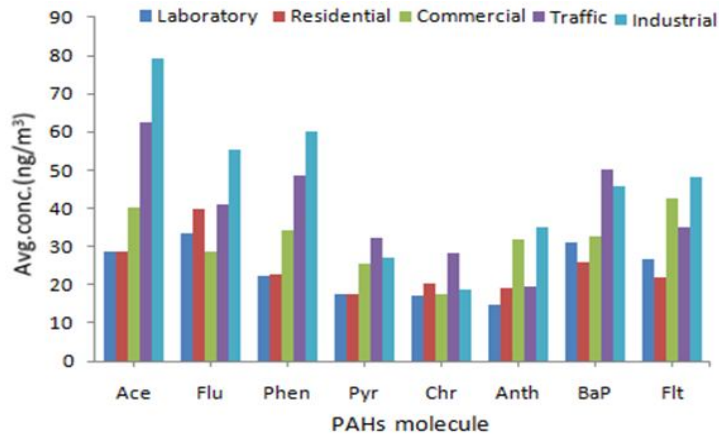


Fig.3: Cumulative concentration profile of PAHs from different sources

## Landslides-Debris Flows Floods Earthquakes and Tsunamis of Indian Sub-Continent- Emergency Preparedness Plan – A Typical Analysis

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**Abstract:** *Natural Disaster has received substantial attention from the scientific community in recent past. It has also provoked policy makers to think about it. Natural disasters have conquered much of scientific and political debate on global level due to its overall impact. India has been traditionally vulnerable to natural disasters on account of its unique geo-climatic conditions. Floods, droughts, cyclones, earthquakes and landslides have been recurrent phenomena. About 60% of the landmass is prone to earthquakes of various intensities; over 40 million hectares is prone to floods; about 8% of the total area is prone to cyclones and 68% of the area is susceptible to drought. India has the highest mountain chain on earth, the Himalayas, which are formed due to collision of Indian and Eurasian plate, the northward movement of the Indian plate towards China causes continuous stress on the rocks rendering them friable, weak and prone to landslides and earthquakes, Fast moving flows of mud and rock, called debris flows or mudslides are among the most numerous and dangerous types of landslides in the world. They are particularly dangerous to life and property because of their high speeds and the sheer destructive force of their flow. About 40 million hectares or nearly 1/8th of India's geographical area is flood-prone. The Kosi River (The Sorrow of Bihar) is well-known in India for rapid and frequent avulsions of its course and the extensive flood damages it causes almost every year. The Kosi is one of the major tributaries of the Ganga River, and rises in the Nepal Himalayas. Among the various natural disaster/hazards that our planet earth is subjected to, an earthquake happens to be the most devastating natural impact, resulting in heavy loss of human life and material. India is unique as far as earthquakes are concerned. The latest version of seismic zoning map of India given in the earthquake resistant design code of India [IS 1893 (Part 1) 2002] assigns four levels of seismicity for India in terms of zone factors. In other words, the earthquake zoning map of India divides India into 4 seismic zones. India has long coast line of nearly 7,500 km along which several million people live and are engaged in various activities. The Indian coastline may be divided into east coast and west coast. Geological evidence of ancient marine sediments on land reveals that the continents of the world were once submerged beneath the sea. The continental seas and coastlines of the world have fluctuated greatly in the past, time after time the marginal seas grew and shrank over a period of million years. Rock records-stratigraphic evidence show that the magnitude of these marine floods was greater in earth's earlier history than in more recent times. Integrated coastal zone management involves prevention of marine eco-system-protection from erosion, tides, cyclones, tsunamis and maintains the coastal resources and meets the needs of present and future generation. Emergency preparedness plans and effective management of natural disasters of Indian – sub-continent must be prepared with micro-level geological geomorphological--seismological-meteorological, hydrological, studies.*

**Keywords:** *Natural disasters, landslides, debris flow, floods, droughts, earthquakes and tsunamis*

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**INTRODUCTION:**

Landslides, debris flows, droughts, floods, earthquakes, tsunamis Cyclones, come under natural hazards s category. Some of these events can be predicted and preventive measures can be taken. Hazards like earthquakes, avalanches, landslides, flash floods are difficult to predict due to varied reasons. Our country is affected by almost all the hazards. As such, to face these hazards one should know in depth the mechanism associated with a particular event`s origin and its strength in creation of damages .I discuss below category wise hazards, present technical knowledge in understanding a particular event and available technological capabilities to decipher in advance various data sets to face an event and in executing post event mitigation works.(Reddy,2013).A detailed analysis of natural hazards and their impact and effective –management plans are suggested.

**Landslides:**

India has the highest mountain chain on earth, the Himalayas, which are formed due to collision of Indian and Eurasian plate, the northward movement of the Indian plate towards China causes continuous stress on the rocks rendering them friable, weak and prone to landslides and earthquakes. The slow motion of the Indian crust, about 5 cm/year accumulates stress to which natural disasters are attributed. Some landslides make unique and unparalleled catastrophes. Landslides and avalanches are among the major hydro-geological hazards that affect large parts of India besides the Himalayas, the North-eastern hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats and the Vindhyan, in that order, covering about 15 % of the landmass. The Himalayas alone count for landslides of every fame, name and

description- big and small, quick and creeping, ancient and new. The Northeastern region is badly affected by landslide problems of a bewildering variety. Landslides in the Darjeeling district of West Bengal as also those in Sikkim, Mizoram, Tripura, Meghalaya, Assam, Nagaland and Arunachal Pradesh pose chronic problems, causing recurring economic losses worth billions of rupees. A different variety of landslides, characterized by a lateritic cap, pose constant threat to the Western Ghats in the South, along the steep slopes overlooking the Konkan coast besides Nilgiris, which is highly landslide prone.(NDMA-2014).

The Kedarnath -Uttaranchal-India-Landslide/debris flows/Flood disaster in Uttarakhand, 2013 -Brief Case in point

In June 2013, a multi-day cloudburst centered on the North Indian state of Uttarakhand caused devastating floods and landslides in the country's worst natural disaster since the 2004 tsunami. Though some parts of Himachal Pradesh, Haryana, Delhi and Uttar Pradesh in India experienced the flood, some regions of Western Nepal, and some parts of Western Tibet also experienced heavy rainfall, over 95% of the casualties occurred in Uttarakhand. As of 16 July 2013, according to figures provided by the Uttarakhand government, more than 5,700 people were "presumed dead." This total included 934 local residents.

Destruction of bridges and roads left about 100,000 pilgrims and tourists trapped in the valleys leading to three of the four Hindu Chota Char Dham pilgrimage sites. The Indian Air Force, the Indian Army, and paramilitary troops evacuated more than 110,000 people from the flood ravaged area. NASA satellite imagery of Northern India on 17 June, showing rainclouds that led to the disaster is presented in fig 1.



Fig 1. NASA satellite imagery of Northern India on 17 June, showing rainclouds that led to the disaster (Fig Courtesy of NASA, 2012)

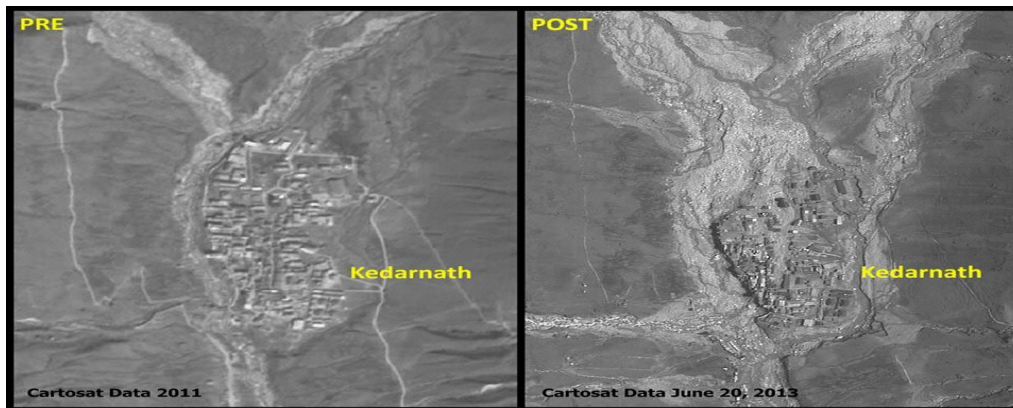
Pre and post Kedarnath-Landslide/debris flows/floods –data recorded by ISRO-Cartosat-released for public domain for information is presented in the figure. Detailed analyses of pre and post Kedarnath mass land slide/debris flows clearly illustrate the impact .Several experts are given their opinions and analyses for the ever known India’s landslide disaster which claimed huge loss of lives and property. National Disaster Management Agency, NDMA, Govt of India coordinating in our country with several organization experts institutes, government agencies developing action plans-during emergencies. Scientific/technical publications are available on line for public domain/individual to know more about the related disasters and precautionary measures. A generalized information to public are also released how to manage during disasters and suggested to do or don’t do –few hints. Details of NDMA –are also listed.

Indian Space Research Organization-ISRO Semi-automatic detection of landslides using standard algorithms was used in order to detect the landslides and generate the

outputs. The detected landslides shown here include existing landslides of which some are reactivated. In the preliminary assessment, a total of 2266 landslides have been identified along the river valleys of Mandakini, Basuki Ganga, Mandani, Kali, Madhyamaheshwar, Bhillangana, parts of Alaknanda (and its tributaries like Kalpa Ganga and Kalapani Gad) from Srinagar to Chamoli (and around Jakhpur, Kalpeshwar) and parts of Bhagirathi around Gangotri. The major towns included in this area are Kedarnath, Sonprayag, Gaurikund, Okhimath, Guptkashi, Mansuna, Phata, Agastmuni, Rudraprayag, Srinagar, Gauchar, Karnaprayag, Nandprayag, Chamoli, Jakhpur, Kalpeshwar, Gangotri etc. Note: Currently the sections along the river valleys of Mandakini, Basuki Ganga, Mandani, Kali, Madhyamaheshwar, Bhillangana, parts of Alaknanda (and its tributaries like Kalpa Ganga and Kalapani Gad) from Srinagar to Chamoli (and around Jakhpur, Kalpeshwar) and parts of Bhagirathi around Gangotri are completed and uploaded for visualization in Bhuvan web site (NRSC,2013.Pre and post Kedarnath-Landslide/debris flows/floods –



data recorded by ISRO-Cartosat-presented in the figure.



*Fig 2. Pre and post Kedarnath land slide disaster ISRO released for public information (ISRO)*

Some spectacular events of tragedies are reported as Varnavat landslide, Uttarkashi District, Malpha landslide Pithoragarh district, Okhimath landslide in Chamoli district, UK and Paglajhora in Darjeeling district as well as Sikkim, Aizawl sports complex, Mizoram. These are some of the more recent examples of landslides. The problem therefore needs to be tackled for mitigation and management for which hazard zones have to be identified and specific slides to be stabilized and managed in addition to monitoring and early warning systems (NDMA, 2014).

#### **Landslides in India-Disaster Mitigation Measures:**

India has the highest mountain chain on earth, the Himalayas, which are formed due to collision of Indian and Eurasian plate, the northward movement of the Indian plate towards China causes continuous stress on the rocks rendering them friable, weak and prone to landslides and earthquakes. The slow motion of the Indian crust, about 5 cm/year accumulates stress to which natural disasters are attributed. Some landslides make unique, and unparalleled catastrophes. Landslides and avalanches are among the major hydro-geological hazards that affect large parts of India besides the Himalayas, the Northeastern

hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats and the Vindhyans, in that order, covering about 15 % of the landmass. The Himalayas alone count for landslides of every fame, name and description- big and small, quick and creeping, ancient and new. The Northeastern region is badly affected by landslide problems of a bewildering variety. Landslides in the Darjeeling district of West Bengal as also those in Sikkim, Mizoram, Tripura, Meghalaya, Assam, Nagaland and Arunachal Pradesh pose chronic problems, causing recurring economic losses worth billions of rupees. A different variety of landslides, characterized by a lateritic cap, pose constant threat to the Western Ghats in the South, along the steep slopes overlooking the Konkan coast besides Nilgiris, which is highly landslide prone (NDMA-2014).

#### **Debris Flows-and their impact:**

Debris flows are fast-moving landslides that occur in a wide variety of environments throughout the world. They are particularly dangerous to life and property because they move quickly, destroy objects in their paths and often strike without warning. USGS –US Geological Survey scientists are assessing debris –flows hazards in the country and elsewhere, and developing real-time



techniques for monitoring hazardous areas so that road closures, evacuations, or corrective or correlative actions can be taken (USGS-2008)

### **Causes of Debris flows:**

Some landslides moves slowly and cause damage gradually ,whereas others move rapidly that they can destroy property and take lives suddenly and un expectedly .Debris flows ,sometimes preferred to as mudslides, mudflows ,lahars or debris ,or debris avalanches ,are common types of fast-moving landslides. These flows generally occur during periods of intense rainfall or rapid snowmelt .They usually start on steep hill sides as shallow landslides that liquefy and accelerate to speeds that are typically about 10mph or kmp-or 16 kmh but can exceeds 35 mph-or 56.31 kmh. The consistency of debris flows ranges from water mud thick to thick ,rocky mud that can carry large items such as boulders trees etc .Debris flows from different sources can combine in channels where their destructive power may be greatly increased .They continue flowing down hills and through channels ,growing in volume with the addition of water ,sand ,boulders ,trees and other materials .When the flows reach canyon mouths or flatter ground ,the debris spreads over a broad area ,sometime accumulating in thick deposits that can wreak havoc in developed areas(USGS-2008)

### **Characteristic features of fast moving debris flows**

Fast moving flows of mud and rock, called debris flows or mudslides are among the most numerous and dangerous types of landslides in the world. They are particularly dangerous to life and property because of their high speeds and the sheer destructive force of their flow. These flows are capable of destroying homes, washing out roads and bridges, sweeping away vehicles, knocking down trees and obstructing streams and road ways with thick deposits of mud and rocks. Debris flows are typically associated with periods of heavy rain fall or rapid snow melt and tend to worsen the effects of flooding that often accompanies these events (USGS-2013).

Debris flows are one of the most hazardous types of landslides in mountainous areas of western North America because they are fast moving and can occur with little warning. Field observations and existing literature indicate that three primary types of non – volcanic debris flows affect areas of Western, North America – (i) debris flows that mobilize from landslides-(ii) debris flows that mobilize from slides that erode and entrain hill slope and channel materials and (iii) debris flow that initiate from surface water runoff that erodes and entrains hill slope and channel materials. (Santi et.al, (2008)

**Case in point-USGS;** Columbia River – Dodson ,town, Oregon- debris flows USA-1996 –occurred during February,1996 .The combination of rain fall and snow melt resulting flooding and land sliding throughout the Pacific Northeast. The debris flow show shown here was deposited in a number of separate events over period of 2

days. The flows originated high on the palisade and traveled through the steep canyon. The occupants of the house escaped with their lives when they heard a loud rumbling and crashing of trees and saw the approaching materials through their kitchen window. Boulder, mud and debris from these and several nearby debris flows were deposited across the east-bound lanes of intense highway 84 and blocked highway for 5 days (USGS-1996)

**Case in point-Kedarnath massive debris flows of India -National Remote Sensing Centre (NRSC) of ISRO, 2013**

It is evident from the post-event images of Kedarnath town around the temple that the massive destruction was the result of large-scale debris carried by the huge volume of water from the upper reaches above the town. One of the compounding factors was that the glacial regions above Kedarnath had received fresh and excess snowfall when heavy rainfall hit the region according to scientists of the National Remote Sensing Centre (NRSC) of ISRO. Rainwater, with higher temperature, falling on the snow must have led to heavy snow melt and this runoff would have added to the rainwater runoff, resulting in a huge water flow that carried with it a huge **debris flow**, which struck the town with enormous ferocity. The snow cover has, in fact, increased in general subsequent to the extreme rainfall and flooding events (the satellite image on May 28/June 1 shows less snow cover). According to the NRSC scientists, the detailed dynamics of water flow due to snow melt caused by rain, particularly when snowfall is in excess, and the hydrology of it are not well understood. Fig:1 NASA satellite imagery of Northern India on 17 June, showing rainclouds that led to the disaster (Fig Courtesy of NASA,2012)

Mitigating/Precautionary Measures –  
Landslides & Debris flows

What can you do if you live near steep hills? - United States Geological Survey-suggestions

**Prior to Intense Storms**

Become familiar with the land around you. Learn whether debris flows have occurred in your area by contacting local officials, State geological surveys or departments of natural resources, and university departments of geology. Slopes where debris flows occurred in the past are likely to experience them in the future.

Support your local government in efforts to develop and enforce land use-and building ordinances that regulate construction in areas susceptible to landslides and debris flows. Building should be located away from steep slopes, streams and rivers, intermittent-stream channels and the mouths of mountain channels

Watch the patterns of storm-water drainage on slopes near your home, and note especially the places where run-off water coverage, increasing flow over soil-covered slopes. Watch the hill sides around your home for any signs of land movements such as small landslides or debris flows or progressively tilting trees.

Contact your local authorities to learn about the emergency-response and evacuation plans for your area and develop your own emergency plans for your family and business.

**During Intense Storms:**

Stay alert and stay awake\*Many debris – flow fatalities occur when people are sleeping. Listen to a radio for warnings of intense rainfall. Be aware that intense short bursts of rain may be particularly dangerous, especially after longer periods of heavy rain fall and damp weather,

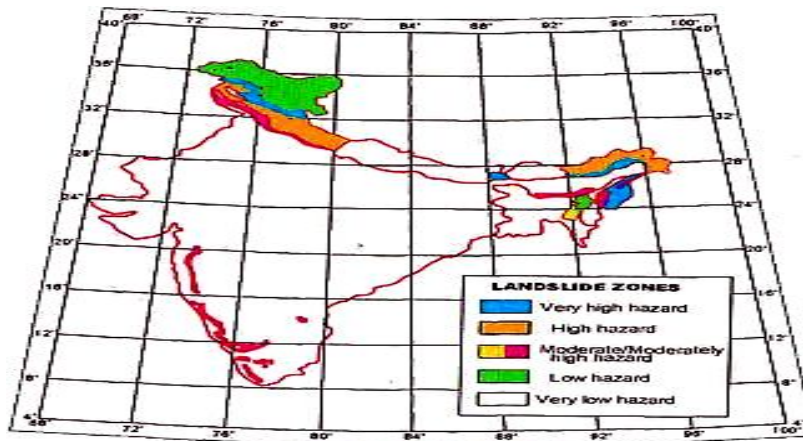
1. If you are in areas susceptible to landslides and debris flows, consider leaving if it is safe to do so. Remember that driving during an intense storm can itself be hazardous.

2. Listen for any unusual sounds that might indicate moving debris, such as trees cracking or boulders knocking together. A trickle of flowing or falling mud or debris may precede larger flows. If you are near stream or channel, be alert for any sudden increase or decrease in water flow and for any change from clear muddy water. Such changes may indicate landslide activity up stream, so be prepared to move quickly .Don't delay\* save yourself\* not your belongings.
3. Be especially alert when driving .Embankments along mud sides are particularly susceptible to landslides. Watch the road for collapsed pavements, mud, fallen rocks, and other indications of possible debris flows.(Lynn M .Highland, Stephenson D. Ellen, Sarah B. Christian and William M.BrownIII,USGS-176-97 developed for public information)

**Mitigating/Precautionary Measures  
Landslides & Debris flows Suggestions  
NDMA Govt. of India**

India has the highest mountain chain on earth, the Himalayas, which are formed due to collision of Indian and Eurasian plate, the northward movement of the Indian plate towards China causes continuous stress on the rocks rendering them friable, weak and prone to landslides and earthquakes. The slow motion of the Indian crust, about 5

cm/year accumulates stress to which natural disasters are attributed. Some landslides make unique and unparalleled catastrophes. Landslides and avalanches are among the major hydro-geological hazards that affect large parts of India besides the Himalayas, the Northeastern hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats and the Vindhyan, in that order, covering about 15 % of the landmass. The Himalayas alone count for landslides of every fame, name and description- big and small, quick and creeping, ancient and new. The Northeastern region is badly affected by landslide problems of a bewildering variety. Landslides in the Darjeeling district of West Bengal as also those in Sikkim, Mizoram, Tripura, Meghalaya, Assam, Nagaland and Arunachal Pradesh pose chronic problems, causing recurring economic losses worth billions of rupees. A different variety of landslides, characterized by a lateritic cap, pose constant threat to the Western Ghats in the South, along the steep slopes overlooking the Konkan coast besides Nilgiris, which is highly landslide prone coast besides Nilgiris, which is highly landslide prone. General Landslide Hazard map of India-NDMA-Govt of India, is presented in fig 3.



**Fig 3.** General Landslide Hazard map of India (Source: NDMA, Govt. of India)

Some spectacular events of tragedies are reported as Varnavat landslide, Uttarkashi District, Malpha landslide Pithoragarh district, Okhimath landslide in Chamoli district, UK and Paglajhora in Darjeeling district as well as Sikkim, Aizawl sports complex, Mizoram. These are some of the more recent examples of landslides. The problem therefore needs to be tackled for mitigation and management for which hazard zones have to be identified and specific slides to be stabilized and managed in addition to monitoring and early warning systems to a general landslide hazard map of India shown fig marks the areas of different hazard zones in various states of India; one may note that Himalayas of Northwest and Northeast India and the Western Ghats are two regions of high vulnerability and are landslide prone. India can be grouped into 5 distinct land prone areas such as very high hazard, high hazard, moderately high hazard, low hazard and very low hazard. We can stop loss of life and prepare ourselves in the wake of landslides. The Government of India has made plans to identify the areas where landslides occur repeatedly. This is achieved through Landslide Hazard Zonation (LHZ) maps which show areas in different colours. Red, Yellow and Green signify as dangerous, caution and safe in Hilly regions of Coast, Himalayas and rough terrain. NDMA has published Guidelines on Landslides and

Snow Avalanches placed for information to all.

### **Recovery and Rebuild as suggested by NDMA, Govt. of India**

Remain calm and be alert and awake, listen to warnings of heavy and prolonged period of rainfall from weather station, if your home is located below a debris covered area move away to safer place, listen to sounds of rock fall, moving debris and cracking of trees, or cracks in ground or any movement. Keep a battery operated ready for the night.

\*Call and help rescue teams, keep drinking water containers, first aid kit and essential medicines and avoid entering damaged houses.

\*Watch for flooding if close to river, help others who need help especially elderly people, children and women, seek advice from local authorities for rebuilding damaged houses, roads etc.

\*Report any damage of roads, power and telephone lines to concerned authorities

### **Do and don't do during disasters- suggested by NDMA-Govt of India**

- Keep drains clean,
- Direct storm water away from slopes,

- Inspect drains for - litter, leaves, plastic bags, rubble etc.
- Keep the weep holes open.
- Don't let the water go waste or store above your house.
- Grow more trees that can hold the soil through roots,
- Identify areas of rock fall and subsidence of buildings, cracks that indicate landslides and move to safer areas. Even muddy river waters indicate landslides upstream.
- Notice such signals and contact the nearest District Head Quarters.
- Ensure that toe of slope is not cut, remains protected, don't uproot trees unless vegetation is planned.

**Emergency Kit--suggested by NDMA-Govt of India**

1. Battery operated torch
2. Extra batteries
3. Battery operated radio
4. First aid kit and manual
5. Emergency food (dry items) and water (packed and sealed)
6. Candles and matches in a waterproof container
7. Knife
8. Chlorine tablets or powdered water purifiers
9. Can opener.
10. Essential medicines
11. Cash, Aadhar Card and Ration Card
12. Thick ropes and cords
13. Sturdy shoes(NDMA-2014)

**Floods:**

Floods have been recurrent phenomenon in many parts of India, causing loss of lives and public property and bringing untold misery to the people, especially those in the rural areas. There is also a larger economic impact, as they derail economic activities, thus affecting growth. Indian continent has peculiar climatic conditions since it has floods in some parts whereas drought in

other parts. Over the years, several expert Committees have studied the problems caused by floods and suggested various measures for their management to the Government. However, despite the various steps undertaken over the last five decades, the trend of increasing damage and devastation brought by floods has posed a challenge to the Government as well as to the people. The approaches to flood management presently exercised in India also need to give a re-look to have an integrated strategy for policy and management related to floods (CWC-2013)

**Floods in India in particular Bihar:**

Floods are probably the most recurring, widespread, disastrous and frequent natural hazards of the world. India is one of the worst flood-affected countries, being second in the world after Bangladesh and accounts for one fifth of global death count due to floods. About 40 million hectares or nearly 1/8th of India's geographical area is flood-prone. The plains of north Bihar are some of the most susceptible areas in India, prone to flooding (.,of floods during the last 30 years. The total area affected by floods has also increased during these years. Drained by two major rivers, the Kosi and Gandak, and several smaller systems such as Burhi Gandak, Baghmati and Kamla-Balan, the plains of north Bihar have experienced extensive and frequent loss of life and property over the last several decades (Sinha and Jain, 1998). The Kosi River (The Sorrow of Bihar) is well-known in India for rapid and frequent avulsions of its course and the extensive flood damages it causes almost every year. The Kosi is one of the major tributaries of the Ganga River, and rises in the Nepal Himalayas. After traversing



through the Nepal Himalayas, it enters India near Bhimnagar. Thereafter, it flows through the plains of north Bihar and joins the Ganga River near Kursela, after traversing for 320 km from Chatra. The river has been causing a lot of destruction by lateral movement and extensive flooding. As its waters carry heavy silt load and the river has a steep gradient, the river has a tendency to move sideways. Thus, in about 200 years the river has moved laterally by about 150 km (Gole and Chitale, 1966; Wells and Dorr, 1987).

Flood causes considerable damage to human lives and property almost every year. Since adoption of National Flood Policy by Government of India in 1954, it was realized that a total protection against flood by structural means alone is not possible and that optimum solution would consist of a mixture of structural and non-structural measures. Therefore, stress has been laid on non-structural measures like flood forecasting and warning, which is most important among such means to minimize the damage potential from floods. Accurate and timely flood forecasts and advance warning have, therefore, to be aimed for providing valuable time to the people and to civil authorities in taking preventive measures like evacuation, relief and rehabilitation measures, preparedness for flood fighting by engineering authorities etc. and thus mitigating such losses from floods (Anon Flood forecasting-CWC, 2013)

#### **Indian-River Systems and Associated Flood Problems Central Water Commission Govt. of India**

The Government of India set up Central Water Commission as presently named in

1945 for achieving the goal of furthering and promoting measures of flood control, conservation and utilization of water resources throughout the country in the areas of beneficial uses, irrigation and hydropower generation, flood management and river conservation. As a national apex engineering organisation in the field of water resources development, the CWC with its vast experience gained in its strides towards progress in more than six decades, has developed considerable know-how in planning, investigation, management and design of water resources development schemes and made valuable contribution in the country's remarkable progress in this field besides sharing the expertise with developing nations of the world (CWC, Govt. of India 2013).

#### **Existing Flood Management Mechanisms in India**

In India, a two tier system of flood management exists as briefly described below:

**State Level Mechanism** - The State Level Mechanism includes the Water Resources Departments, State Technical Advisory Committee and Flood Control Board. In some States, the Irrigation Departments and Public Works Departments look after flood matters.

**Central Government Mechanism** – The Union Government has set up following organizations and various expert committees to enable the State Governments in addressing flood problems in a comprehensive manner:

- i. Central Water Commission (CWC)
- ii. Brahmaputra Board
- iii. Ganga Flood Control Commission
- iv. Farakka Barrage Project Authority

#### **V. National Disaster Management Authority (NDMA):**



CWC coordinated organizations have listed 4. flood prone area of India presented in the fig



Fig 4. Flood prone areas in the India, CWC Govt. of India Courtesy CWC Govt. of India, 2013

**National Disaster Management Authority (NDMA) Govt. of India- Role in Prevention and Mitigation of floods in India**

For prevention and mitigation effects of disasters including flood disasters and for undertaking a holistic, coordinated and prompt response to any disaster situation, the Government of India has set up a National Disaster Management Authority (NDMA) in 2005 under the Chairmanship of Hon'ble Prime Minister of India.

The functions of the National Disaster Management Authority –Govt of India:

- (i) lay down policies on disaster management;
- (ii) Approve national Plan;

- (iii) Approve plans prepared by the Ministries or departments of the Government of India in accordance with the National Plan;
- (iv) lay down guidelines to be followed by the State Authorities in drawing up the State Plan;
- (v) Lay down guidelines to be followed by the different Ministries or departments of the government of India for the purpose of integrating the measures for prevention of disaster or the mitigation of its effects in their development plans and projects;
- (vi) Coordinate the enforcement and implementation of the policy and plan for disaster management;
- (vii) Recommend provision of funds for the purpose of mitigation;

- (viii) Provide such support to other countries affected by major disasters as may be determined by the central Government;
- (ix) Take such other measures for the prevention of disaster, or the mitigation, or preparedness and capacity building for dealing with the threatening disaster situation or disaster as it may consider necessary;
- (x) Lay down broad policies and guidelines for the functioning of the National Institute of Disaster Management.

The NDMA has issued guidelines in January, 2008 for management of floods and the roles of various Central and State agencies have been specified for preparation of flood mitigation plans and taking relief measures during flood disasters.

The flood forecasting and warning system is used for alerting the likely damage centers well in advance of the actual arrival of floods, to enable the people to move and also to remove the moveable property to safer places or to raised platforms specially constructed for the purpose. At present in India, there are 166 flood forecasting stations on various rivers in the country which includes 134 level forecasting and 32 inflow forecasting stations. On an average, 6000 forecasts at various places in the country are issued during the monsoon season every year (NDMA-2008).

### **General Flood Management Measures practiced in India-Central Water Commission-Government of India**

Different measures have been adopted to reduce the flood losses and protect the flood plains. Depending upon the nature work, Flood protection and flood management measures may be broadly classified as under:

- (a) Engineering / Structural Measures
- (b) Administrative / Non-Structural Measures

#### **(a) Engineering /Structural Measures**

The engineering measures for flood control which bring relief to the flood prone areas by reducing flood flows and thereby the flood levels are

- (a) An artificially created reservoir behind a dam across a river
- (b) A natural depression suitably improved and regulated, if necessary or
- (c) By diversion of a part of the peak flow to another river or basin, where such diversion would not cause appreciable damage.
- (d) By constructing a parallel channel by passing a particular town/reach of the river prone to flooding.

#### **Administrative / Non-structural Measures**

The administrative methods endeavor to mitigate the flood damages by;

- (a) Facilitating timely evacuation of the people and shifting of their movable property to safer grounds by having advance warning of incoming flood i.e. flood forecasting, flood warning in case of threatened inundation
- (b) Discouraging creation of valuable assets/settlement of the people in the areas subject to frequent flooding i.e. enforcing flood plain zoning regulation.

Providing absolute protection to all flood prone areas against all magnitude of floods is neither practically possible nor economically viable. Such an attempt would involve stupendously high cost for construction and

for maintenance. Hence a pragmatic approach in flood management is to provide a reasonable degree of protection against flood damages at economic cost through a combination of structural and non-structural measures

### **Earthquakes-Seismicity-Earthquakes and seismicity of Indian Sub-continent:**

Among the various natural disaster/hazards that our planet earth is subjected to, an earthquake happens to be the most devastating natural impact, resulting in heavy loss of human life and material. India is unique as far as earthquakes are concerned. Earthquake damage has yet to be reduced to the expected level by the application of modern seismo-geotechnology. Efforts on going in this field to minimize loss of life and property by designing earthquake resistant structures (Venkat Reddy, 2008). After 120 years of unsuccessful endeavor, a paradigm is required before earthquakes can be predicted. The most sensitive diagnostic of low level changes of stress in insitu rock variations in micro crack geometry, can be monitored by analyzing shear wave splitting. When sufficient shear –wave source earthquakes are available, increasing time delays also show an abrupt decrease shortly before impending earthquake occurs (Stuart Crampin et. al, 2008). This is not fully understood but is thought to be caused by stress relaxation as micro cracks coalesce onto the eventual fault break. The new result confirming these ideas ,and justifying ,the paradigm shift ,is that logarithms of durations of both increase and decreases in time delays are found to be proportional (self-similar) to magnitudes of impending earthquakes (Stuart Crampin, Yuan Gao & Sheila Peacockm 2008). On-going research and development in this field may result

some mechanism to stress –forecasting (not predicting) earthquakes. Records of earthquakes have been kept in India for only about 2000m years, a very short period for estimation of seismic hazard. in north –east India a large number of earthquakes have occurred in this 200 yearperiod but data available for only 60-65 years .A recent seismic zoning map of India was prepared according to the Bureau of Indian Standards ,in which India was grouped into five zones. Government of India had formulated disaster risk management programme with UNDP and located more sensitive and vulnerable cities for earthquakes.

### **Disaster Risk Management Programme – Urban Earthquake vulnerability reduction in earthquake prone cities of India-Government of India-UNDP**

The Government of India – United Nations Development Programme (GOI-UNDP) Disaster Risk management Programme is a national initiative to reduce vulnerabilities of communities in some of the most hazard prone districts of India (169 cities and 17 states).The programme aims to contribute to social and economic development goals of National and State Governments, enable them to minimize losses to development gains and reduce their vulnerability to natural disasters. The programme relies upon a communities based approach to disaster management, and seeks to build capacities of communities, government functionaries at all levels, and other stake –holders in disaster management, at all levels, in an organized manner. The Indian sub-continent is highly prone to natural disasters. Floods, cyclones and earthquakes are recurrent phenomena .As per the latest seismic zoning map brought out by the Bureau of Indian Standards (BIS), over 65% of the country is

prone to earthquakes of intensity MSK VII or more .Some of the most intense earthquakes of the world have occurred in India, but fortunately, none of these have occurred in any of the major cities. India has highly populous cities including the national capital of New Delhi, located in zones of high seismic risk. Typically, the majority of the constructions in these cities are not earthquake resistant. Thus an earthquake striking in one of these cities would turn into a major disaster.

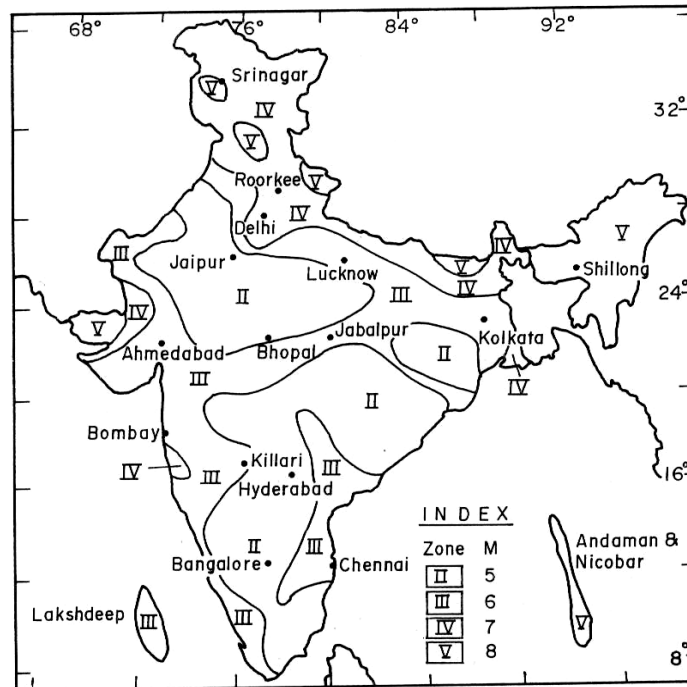
It is most important in the medium and long term to formulate strategies to reduce the vulnerability to and losses arising from a possible earthquake striking one of these cities. Six major earthquakes have struck different parts of India over a span of the last 15years .The damages caused by these earthquakes reiterate the scale of vulnerability. However, if any of these earthquakes had struck populous centre the damage in terms of human lives and property would have been colossal.

Frequent disasters lead to erosion of development gains and restricted options for

disaster victims. Physical safety, especially of the vulnerable groups –is routinely threatened by hazards. Disasters such as Gujarat Earthquake have very clearly illustrated that we need mitigation, preparedness and response plans so that the threat to human life and property is minimized (Anon, 2002-07).

The latest version of seismic zoning map of India given in the earthquake resistant design code of India [IS 1893 (Part 1) 2002] assigns four levels of seismicity for India in terms of zone factors. In other words, the earthquake zoning map of India divides India into 4 seismic zones (Zone 2, 3, 4 and 5) unlike its previous version which consisted of five or six zones for the country. According to the present zoning map, Zone 5 expects the highest level of seismicity whereas Zone 2 is associated with the lowest level of seismicity. The latest seismic zoning map can be accessed from The India Meteorological Department and Bureau of Indian Standards and Indian Seismological Department websites. Revised Seismic zone map is presented in the figure

Seismic Zoning Map (BIS, 2002)



**Indian Seismic Zones-BIS-suggested-2002**

**Indian Seismic Zone 2:** This region is liable to MSK VI or less and is classified as the Low Damage Risk Zone. Regions which may suffer earthquakes of intensity MM 1- VI or less were classified as the Low Damage Risk Zone. Most parts of peninsular India and the Lakshadweep islands fall under this zone. This region is liable to MM VI and is classified as the Low Damage Risk Zone. The IS code assigns zone factor of 0.10 (maximum horizontal acceleration that can be experienced by a structure in this zone is 10% of gravitational acceleration) for Zone 2 (BIS-2002).

Richter’s scale-4-4.9 =Equivalent of IV-V –Mercalli Intensity scale it will affect, noticeable shaking of indoor objects and rattling noises. Felt by most people in the affected area. Slightly felt outside.

Generally causes none to minimal damage, Moderate to significant damage very unlikely. Some objects may fall off shelves or be knocked over.

If we compare, Richter’s Scale 4 =releases energy equivalent 6.309573e+10 joules, .equivalent yield

About 1.508024e+1 Tons of TNT.If Richter’s scale of maginitue5 –releases energy equivalent 1.995262e+12 joule-its equivalent yield = 4.768791e+2 Tons of TNT

**Richer scale 5-5.9** equals –MM scale VI-VIII-It will cause damage of varying severity to poorly constructed buildings. Slight damage to all other buildings, Felt by everyone, casualties range from none to a few. Revised seismic zone map (BIS-2002) –Zone 1 is excluded .Zone 2



comprises under Richter scale of magnitude-M=5. Note the impact up to Richter Scale of Magnitude 4-4.9 and 5-5.9 Richter scale of Magnitude=5.

**Indian Seismic Zone-3** The IS code assigns zone factor of 0.16 for Zone 3. This zone is classified as Moderate Damage Risk Zone which is liable to MM VII-IX. Zone 3 comes under Richter's scale of magnitude=6. The IS code assigns zone factor of 0.16 for Zone 3. If we compare, Richter's Scale 6 releases energy equivalent  $6.309573e+13$  joules, equivalent yield  $1.508024e+4$  Tons of TNT. It is significant to note the impact equals to M6 and above. If M=6 and above may, damage to a moderate number of well, built structures in populated areas. Earthquake-resistant structures survive with slight to moderate damage. Poorly-designed structures receive moderate to severe damage. Felt in wider areas; up to hundreds of miles/kilometers from the epicenter. Strong to violent shaking in epicentral area.

The Andaman and Nicobar Islands, parts of Kashmir, Western Himalayas and Punjab fall under this zone. Ahmedabad, Vadodara, Rajkot, Bhavnagar, Surat, Mumbai, Agra, Bhiwandi, Nasik, Kanpur, Pune, Bhubaneswar, Cuttack, Asansol, Kochi, Kolkata, Varanasi, Bareilly, Lucknow, Indore, Jabalpur, Vijayawada, Dharwad, Chennai, Coimbatore, **Mangalore**, Kozhikode, Trivandrum

#### Indian Seismic Zone - 4

This zone is called the High Damage Risk Zone and covers areas liable to MSK VIII. The BIS code assigns zone factor of **0.24 for Zone 4**. Richter's scale of Magnitude=7, releases energy equivalent  $1.995262e+15$

joules, equivalent yield  $4.768791e+5$  Tons of TNT

Magnitude of 6 and above may cause damage to most buildings, some to partially or completely collapse or receive severe damage. Well-designed structures are likely to receive damage. Felt across great distances with major damage mostly limited to 250 km from epicenter. The Indo-Gangetic basin and the Rajasthan, Dehradun, New Delhi, Jamnagar, Patna, Meerut, Jammu, Amritsar, Jalandhar are covered under this zone.

#### Indian Seismic Zone 5

Zone 5 is the worst prone zone in the country. It covers the area with the highest risk zone that suffers earthquakes of intensity MSK - IX or greater, Richter's Scale=8. of Magnitude=8, releases energy equivalent  $6.309573e+16$  joules, equivalent yield  $1.508024e+7$  Tons of TNT. The IS code assigns zone factor of 0.36 for Zone 5. Structural designers use this factor for earthquake resistant design of structures in Zone 5. The zone factor of 0.36 is indicative of effective (zero periods) [peak horizontal ground accelerations](#) of 0.36 g (36% of gravity) that may be generated during MCE level earthquake in this zone. It is referred to as the Very High Damage Risk Zone (BIS-2002).



**Indian Seismic Zone 5** Zone 5 is the worst prone zone in the country. It covers the area with the highest risk zone that suffers earthquakes of intensity MSK - IX or greater, Richter's Scale=8. of Magnitude=8 , releases energy equivalent  $6.309573e+16$  joules, equivalent yield  $1.508024e+7$  Tons of TNT.. The IS code assigns zone factor of 0.36 for Zone 5. Structural designers use this factor for earthquake resistant design of structures in Zone 5. The zone factor of 0.36 is indicative of effective (zero periods) peak horizontal ground accelerations of 0.36 g (36% of gravity) that may be generated during MCE level earthquake in this zone. It is referred to as the Very High Damage Risk Zone (BIS-2002).

It is estimated about TNT for seismic energy releases 15 mega tons ,joule equivalent of 63PJ.General panic, damage slight to moderate (possibly heavy) in well-designed structures, well-designed structures thrown out of plumb, damage moderate to great in substantial buildings, with a possible partial collapse. Some buildings may be shifted off foundations. Walls can fall down or collapse.. The state of Kashmir, the western and central Himalayas, the North-East Indian region and the Rann of Kutch fall in this zoneGuwahati and Srinagar .List of towns located in seismic zones III-IV and V- BMPTC-2006-presented in the table.

**Table List of towns located in seismic zones III-IV and V-BMPTC-2006.**

S.No.	Town	Zone	S.No.	Town	Zone
1	Agra	III	39	Kanpur	III
2	Ahmedabad	III	40	Karwar	III
3	Almora	IV	41	Kohima	V
4	Ambala	IV	42	Kolkata	III
5	Amritsar	IV	43	Lucknow	III
6	Asansol	III	44	Ludhiana	IV
7	Bareilly	III	45	Mandi	V
8	Belgaum	III	46	Mangalore	III
9	Bhatinda	III	47	Monghyr	IV
10	Bhubaneswar	III	48	Moradabad	IV
11	Bhuj	V	49	Mumbai	III
12	Bijapur	III	50	Nainital	IV

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<b>13</b>	Bikaner	III	<b>51</b>	Nasik	III
<b>14</b>	Bokaro	III	<b>52</b>	Nellore	III
<b>15</b>	Bulandshahr	IV	<b>53</b>	Osmanabad	III
<b>16</b>	Burdwan	III	<b>54</b>	Panjim	III
<b>17</b>	Calicut	III	<b>55</b>	Patiala	III
<b>18</b>	Chandigarh	IV	<b>56</b>	Patna	IV
<b>19</b>	Chennai	III	<b>57</b>	Pilibhit	IV
<b>20</b>	Coimbatore	III	<b>58</b>	Pune	III
<b>21</b>	Cuddalore	III	<b>59</b>	Rajkot	III
<b>22</b>	Darbhanga	V	<b>60</b>	Roorkee	IV
<b>23</b>	Darjeeling	IV	<b>61</b>	Sadiya	V
<b>24</b>	Dharwad	III	<b>62</b>	Salem	III
<b>25</b>	Dehra Dun	IV	<b>63</b>	Simla	IV
<b>26</b>	Dhararnpuri	III	<b>64</b>	Solapur	III
<b>27</b>	Delhi	IV	<b>65</b>	Srinagar	V
<b>28</b>	Durgapur	III	<b>66</b>	Surat	III
<b>29</b>	Gangtok	IV	<b>67</b>	Tarapur	III
<b>30</b>	Guwahati	V	<b>68</b>	Tezpur	V
<b>31</b>	Goa	III	<b>69</b>	Thane	III
<b>32</b>	Gaya	III	<b>70</b>	Thiruvananthapuram	III
<b>33</b>	Gorakhpur	IV	<b>71</b>	Tiruvannamalai	III
<b>34</b>	Imphal	V	<b>72</b>	Vadodara	III
<b>35</b>	Jabalpur	III	<b>73</b>	Varanasi	III
<b>36</b>	Jorhat	V	<b>74</b>	Vellore	III
<b>37</b>	Kakrapara	III	<b>75</b>	Vijayawada	III
<b>38</b>	Kalpakkam	III			

(Source-BMPTC-ISD-IMD, 2-013)

Recently stable continental peninsular shield earthquakes of our country necessitated for review and up gradation of seismic zoning and seismic hazard mapping of the country. National and international conferences, seminars and workshops were organised to discuss the various parameters of earthquakes and effective mitigate measures. The Ministry of Urban Affairs, GOI, has recently prepared a vulnerability atlas giving state and district wise hazard to buildings and other infrastructure due to natural disasters. Guidelines for hazard resistant constructions and land use zoning have also been suggested.

**General Principles for earthquake resistant designs and construction (IS 4326-1976, Bureau of Indian Standards)**

1. The building, particularly roofs and upper storeys, shall be as light as possible.
2. As far as possible, the building shall be tied together in such a manner that the building shall act as one unit. Crumple sections shall be provided.
3. Projecting parts shall be avoided and if that is not possible they shall be properly reinforced and firmly tied to the main structure. Suspended ceilings and ceiling plaster shall be avoided.
4. To minimise torsion, the building should have a simple rectangular plan and be symmetrical with respect to mass and rigidity coincide with each other.
5. Buildings with plans with shapes like L, T, E and T shall preferably be separated into rectangular parts by providing separation sections at appropriate places.
6. The structure shall be designed to have sufficient strength against earthquakes along both the horizontal and vertical axes.

7. The main structural elements and their connections shall be designed to have a ductile failure. This will allow the structure to absorb energy during earthquakes and avoid sudden collapse of the structure.
8. Suitable details shall be worked out to connect the non-structural parts with the structural framing so that the deformation of the structural frame leads to minimum damage of the non-structural elements.
9. Fire frequently follows an earthquake. Therefore, buildings shall be constructed to make them fire-resistant.

In view of all ,we need to have a realistic, reliable and appropriates technology cell to integrate pre-disaster information’s and its analysis will be certainly provide some indication and information about the health of the natural system and to have suitable system to face the natural disaster.

Unplanned, non-scientific approach should be stopped and replaces by simple, scientific and systematic approach to undertake the natural disaster. The generalistic approach should be completely eliminated and to accept only specialized approach is today need to fight from such type of natural events.

**Tsunamis and coastal zone- effective warning, preparedness and management programmes:**

On December 26,2004 ,a massive 9.0 magnitude earthquake under the Indian Ocean generated a tsunami that caused great destruction and loss of life .The disasterstruck more than 10 countries ,killed at least 283,000 people and displaced a further 1.1 million in the countries bordering

the Indian Ocean (Green-Hough et al 2005). Studies of the tsunami concluded that there is a need for more effective warning and preparedness to evacuate threatened populations (Cyranoski2005;Kintisch2005; Bhattacharjee2005;Kerr2005; Danielsen (2005), Krishna (2005): Levy and Goopalakrishnan 2005) Lorch Marris 2005). In addition, better hazard mitigation practices could have prevented development of the most highly hazardous locations and required construction of more hazards – resistant structures such as steel reinforced concrete buildings (Zhenghon Tang et al 2008).

Tsunami triggered Indian Ocean on December 26, 2004 killed 10136 people as per official estimate, lakhs of people lost their shelter and home. People have not even informed about it well in advance due to poor coordination among working agencies Before the 2004, Indian Ocean tsunami, tsunami hazard management was a low priority for local governments and not likely to be addressed in local plans. In part, this neglect was due to lack of public concern .For example, Johnston et al.(2005) surveyed 300 residents and visitors in 2001 to assess their perceptions of tsunami hazards in coastal Washington and found the level of preparedness were low to moderate hazard. However, the Connor (2005) evaluation of tsunami hazard awareness program in Oregon documented significant increase in coastal resident’s knowledge about tsunami behaviour and appropriate protective actions attributable to news media coverage of the 2004 tsunami. Since the

Indian Ocean tsunami, some studies have begun to address tsunami hazard management (Darienzo et al.2005,Jonientz-Trisler et al.2005,Ramirez and Perez 2004) With respect to risk communication, it is important to recognize that the public generally fails to participate in hazard mitigation planning despite obvious evidence of perils to life and property from frequent natural hazards (Gods chalk et al.2003).However,,it is also advisable to develop pre impact plans and procedures for disaster recovery (Lindell et.al2006).These include procedures for damage assessment ,infrastructure restoration and economic recovery(Zhenghong Tang et al 2008).

Tsunami hazard management can be divided into mitigation, preparedness, response and recovery, with each of these functions being promoted by regulations, incentives, and risk communication (Lindell and Perry, 2004).Regulations can take a variety of forms-land use permits ,seismic or coastal zoning ,subdivision regulations ,and building codes-that restrict households and businesses land use and building construction practices(Lindell et al.2006).Site assessment and tsunami hazard review procedures can be used as regulatory tools in the post tsunami recovery phase .Tsunami legislation can provide a legal support for local regulatory efforts(Jonientz-Trisler .2005)

### **Indian Tsunami-Warning System- Indian National Center for Ocean Information Services (INCOIS)**

As part of the Indian Tsunami Early Warning System, a real time network of Deep Ocean Assessment and Reporting

System has been established by National Institute of Ocean Technology (NIOT). The network is designed to detect measure and monitor tsunamis. The network comprises of 12 BPRs transmitting real time data through satellite communication to NIOT at Chennai and INCOIS at Hyderabad simultaneously for processing and interpretation. Each BPR is strategically placed at 30 minute and 60 minute tsunami wave arrival times (from hypothetical tsunami sources), so that they offer sufficient warning time and redundancy. At the same time, they are far enough from the earthquake zone so that the tsunami wave signal can be clearly distinguished from the seismic Rayleigh wave. In addition to Indian BPR network, INCOIS is also receiving real time data from internationally coordinated networks like DART (Deep Ocean Assessment and Reporting Tsunamis) in Indian Ocean via Internet. Currently, NIOT has deployed four BPRs out in Bay of Bengal and two BPRs in the Arabian Sea (Anon INCOIS-2012).

**Tsunami- Safety rules suggested by Indian Tsunami-Warning System- Indian National Center for Ocean Information Services (INCOIS-Government of India)**

1. All earthquakes do not cause tsunamis, but many do. When you know that an earthquake has occurred, stand by for a tsunami emergency message.
2. An earthquake in your area is one of nature's tsunami warning signals. Do not stay in low-lying coastal areas after a strong earthquake has been felt.
3. Tsunamis are sometimes preceded by a noticeable fall in sea level as the ocean retreats seaward exposing the seafloor. A

roar like an oncoming train may sometimes be heard as the tsunami wave rushes toward the shore. These are also nature's tsunami warning signals.

4. A tsunami is not a signal wave, but a series of waves that can come ashore for hours. The first wave may not be the largest. Stay out of danger areas until an "all-clear" is issued by a recognized authority.
5. A small tsunami at one point on the shore can be extremely large a few kilometers away. Don't let the modest size of one make you lose respect for all.
6. All warnings to the public must be taken very seriously, even if some are for non-destructive events. The tsunami of May, 1960 killed 61 people in Hilo, Hawaii because some thought it was just another false alarm.
7. All tsunamis are potentially dangerous, even though they may not damage every coastline they strike.
8. Never go down to the shore to watch for a tsunami. When you can see the wave you are too close to outrun it. Most tsunamis are like flash floods full of debris. Tsunami waves typically do not curl and break, so do not try to surf a tsunami.
9. Sooner or later, tsunamis visit every coastline in the Pacific and all oceans. If you live in a coastal area, be prepared and know nature's tsunami warning signals.
10. During a tsunami emergency, your local civil defense, police, and other emergency organizations will try to save your life. Give them your fullest cooperation. **(Anon-INCOSIS-2012)**

**Tsunami Modelling Management - Experts Analyses**

INCOIS – NIOT - network- supercomputer implementation of most models allows the efficient computation of many scenarios.

This capability will perform multiple-run sensitivity studies of two closely related but separable processes off shore wave dependence, on distant earthquake magnitude and position and site specific inundation dependence on off-shore wave characteristics. The result will be organized into electronic data base and associated software will be developed for analysis and visualization of this data base, including the assimilation of real-time data streams (Venkat Reddy, 2010).

Tsunami hazard management can be divided into mitigation, preparedness, response and recovery, with each of these functions being promoted by regulations, incentives and risk communication (Lindell and Perry, 2004).

Regulations can take place a variety of forms and land –use permits, seismic or coastal zoning, sub-division regulations and building codes that restrict permits seismic or coastal zoning, subdivision regulations and building codes –that restrict households and business land use and building construction practices (Lindell, 2006). Site assessment and tsunami hazard review procedures can be used as regulatory tools in post tsunami recovery phase. Tsunami legislation can be provides a legal support for local regulatory efforts (Jonientz-Trisler, 2005).

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### **Coastal Regulation Zones – Guidelines:**

CRZ guidelines were notified in Feb, 1991 as per the notification, the entire country coast divided into four zones depending on the density of the population and ecology.

**Zone-I-** This zone includes most of the sensitive areas with mangroves and coral where no development is permitted up to 500 meters from HTL and land between Low Tide Levl-LTL-It means the position on the land up to which the highest water line reaches during high tides

**Zone-II-** It includes towns and cities where buildings are already touching the sea and this zone permits the maximum of development.

**Zone-III -** It includes underdeveloped areas and tourist places where the permission for development is allowed on a case –to case basis.

**Zone-IV-** The Andaman and Nicobar Islands and Lakshadweep islands lie in this zone .The ministry also amended the notification to allow developmental activities for tourism on seven islands of the



Andaman and Nicobar groups and some in Lakshadweep.

**How to proceed for coastal zone management:**

- a. Reliable knowledge on coastal process
- b. Effects of beach sand mining and decrease in sediment supply to beaches
- c. Conditions of existing wetlands changes that may take place throughout time and space.
- d. A reliable sand budget for coastal littoral cells .This requires quantitative information on sand in puts and out puts. Information on tsunamis, there in puts on coastal zones and the protective measures (Jayappa,1998 & Venkat Reddy, 2005)

**Conclusions:**

Disasters and hazards are two types; manmade disasters/ destructions and Natural Hazards. Management of these setbacks requires basic understanding of these activities, proper planning using “Disaster Continuum” approach and judicious execution of preventive and remedial measures in addition to post disaster mitigation practices through crisis management approaches. To address these setbacks considerable effort has been made by the government, with the support of scientists, planning and administrative authorities (Reddy, 2014)

**Early Warning of natural Hazards-Suggested by United States Geological Survey-USGS:**

When a hazard looms, advanced warning can make a critical difference in saving lives and protecting property .A primary goal of USGS science is to provide warnings further in advance of the onset of hazard event priorities include:

**Earthquakes:** Develop new methodologies that use seismic data telemetry to reduce the response time for earthquake notification, in some cases before shaking begins.

**Floods:** Provide real time information from stream gauges and others to use in making forecasts and issuing flood warnings.

**Landslide and Debris Flows:** Develop and fully deploy debris flow early warning systems

**Volcanoes:** Provide a five minute notification of ash –producing volcanic eruptions so that air traffic control centres can provide airline pilots and dispatchers enough lead time to alter flight plans.

**Forecast Coastal Change Resulting from Hurricanes, cyclones:** Forecast the expected locations and relative magnitudes of extreme coastal changes 48 hours before hurricane landfall by using hurricane track and intensity forecasts supplied by the National Hurricane Centre.

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## COASTAL EROSION – SEAWALL PROTECTION & ITS PERFORMANCE

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### Introduction

In the never-ending struggle for new domains of control, land and sea have been ever busy marking new frontiers on the face of the earth. During the course of this struggle, countless times they have shifted the shorelines landward and seaward. And, man having opted the coastal tracks as his favourite habitat, could not remain indifferent to these numerous changes. Many a time he lost his land and improvements, which were important to his life and living and which sometimes, for hundreds of years, were his major support for living. Man has started putting up shore protection structures. These in turn triggered off a series of reactions on the shore, which were sometimes unexpected and undesirable. There have been many instances where shore stability problems have been endangered by shore protection works. A study of performance of existing protection works will therefore be helpful in providing a clearer understanding of shore processes when different types of protective measures have been put in place. Such a study will particularly be useful to a region like west coast of India in general and southern Karnataka coast in particular, which has been suffering from shore erosion during the past many years and spending considerable sums of money on stabilization of its shoreline.

### *Coastal Erosion: Southern Karnataka Coast*

The primary causes of coastal erosion in any given area could be the following:

- Direct wave action
- Interception of littoral drift
- Sea level changes
- River mouth changes
- Sand mining.

The erosion reported on southern Karnataka coast (hereafter referred as coast), is mainly due to direct wave action and changes at the river mouths. The erosion on the coast is along isolated stretches and not continuous all along the coast (Subba Rao, 2002). In open coasts, beaches have been fully restored to their original position during post monsoon seasons after the erosion in monsoon seasons. The only reports of permanent loss of land due to erosion on the coast have been at the river mouths and beaches adjacent to it. The erosion on the open coasts is mainly due to direct wave action. The beaches adjacent to the coast parallel rivers are more susceptible to erosion due to higher pore pressures and higher exit gradients (Dattatri et. al., 1994).

The areas, which are susceptible to coastal erosion on the coast are classified under three categories.

- a) *Open Beaches*
- b) *Beaches Adjacent to Shore Parallel Rivers*
- c) *Beaches Adjacent to River Mouths*

If the eroded beaches are fully recovered after the monsoon season, the question that arises and needs to be analyzed fully is where then is the problem? The real



problem of erosion is where the developmental and agricultural activities like coconut plantations have been allowed in the active zone of the beach.

### **Coastal Protection Works along the Coast**

Coastal protection work is divided into three parts:

1. **Armouring:** The hard measure of constructing a protective structure like a seawall or groyne.
2. **Nourishment:** The soft measure of widening the beach by feeding the required sand to the beach.
3. **Retreat:** Withdrawal beyond the active coastal zone.

The best option is the retreat as envisaged in the Coastal Regulation Zone (CRZ) act of 1991 wherein, the Govt. of India which has declared the coastal stretch up to 500 m on the landward side from high tide line as the CRZ and has put several restrictions on the developmental activities in this zone.

The next best option is the soft option of artificial nourishment, though very expensive is often preferred, as it is most environment friendly. This is most suitable where the erosion is due to interception of littoral drift.

As the erosion along coast is primarily due to direct wave action, the most suitable options economically viable are the hard options. Among these, groynes are not suitable due to lack of littoral drift and to build offshore breakwaters, specialized equipments are required which will make them very costly. Therefore, seawalls appear to be the best coastal protection method that can be used to protect the vulnerable areas.

### **Seawalls**

Generally seawalls are on-shore structures with the principal function of preventing or alleviating overtopping and

flooding of the land and protecting structures on the leeside from storm surges and waves. Seawalls are built parallel to the shoreline as a reinforcement of a part of the coastal profile. Quite often seawalls are used to protect roads and houses constructed seaward and / or adjacent to the natural beach profile as in Ullal as shown in Fig. 8A. Seawalls range from vertical face structure such as massive gravity concrete walls, tied walls using steel or concrete piling and stone-filled work to sloping structures, with typical surfaces being reinforced concrete slabs, concrete armour units, or stone rubble.

### **Seawalls along the Coast**

As erosion of the coast is primarily due to direct wave action, the most suitable option economically viable is the seawall. The reason for this is already explained.

The minor irrigation department (MID) of the Govt. of Karnataka has been adopting a standard seawall design as evolved by the Karnataka Engineering Research Station (KERS), Mysore. Seawalls have protected a total of about 20 KM length of the coast so far. The design cross-section of the seawalls constructed along the coast is shown in Fig.1.

### **Performance of Seawalls**

The best solution for protection of property on the Karnataka coast would be the seawalls and seawalls have been exclusively used by minor irrigation department. The availability of good quality rock in sufficient quantities at distances fairly close by is also one reason for adopting seawalls with natural rock as the main armour.



Along the coast, seawalls have completely sunk at Padukere and Moolur near Kapu. At other places, partial settlement is observed. Also, at a number of places, the seawalls are in good conditions and performing satisfactorily.

The seawalls at Padukere and Moolur, where total failure has occurred, are those with 650kg armour laid in a single layer to a slope of 1:3.5. In the Kapu area, a long offshore rocky outcrop exists. This is likely to have a pronounced effect on the wave diffraction and refraction effects which result in concentration of wave energy. At these places where wave energy is concentrated, the width of the beach that is subject to the annual cyclic erosion process is very large. The Karnataka Engineering Research Station (KERS), Mysore, studies have shown that, in the Thannirbavi area, the width of beach that undergoes this cyclic change is of the order of 100 metres. The Koppalangady fisheries road near Kapu runs on the beach ridge which is a part of the active zone of the beach. Failure of the seawalls at these locations is not surprising. The Seawalls at Mukka and Sasihitlu shown in Fig. 6, being close to the institute have been monitored more closely. On this reach also, the seawalls have suffered damage and this has also been reported by the Minor Irrigation Department (MID). The majority of these failures, start initially as toe failure and this progressively leads to settlement of the wall and finally total failure due to overtopping. The Engineers of the MID have reported that the toe portion in the type design adopted now is not satisfactory. The design of seawall that is presently adopted for the coast is already shown in Fig. 1. As can be clearly seen in this figure, the toe which should be the strongest is actually the weakest portion in the structure.

The toe failure generally occurs because of scour and collapse of the stones at the toe into the same scour hole. Also, quick sand conditions may prevail at the toe accelerating the failure. Quick sand conditions exist when the uplift forces on the sand particles balance the weight of the sand particles, rendering the sand bed ineffective in supporting any additional weight. There are four ways of providing protection against toe failure. These are as follows.

1. Provide cut off walls or sheet piles at toe which go below maximum scour level. This will no doubt be very effective but would be very costly.
2. Provide large weight stones at the toe which will only settle partially into the scour hole but will still be effective.
3. Provide an additional reserve of stones at the toe to make up for the sinking and settlement.
4. Replenish the lost stones by regular maintenance every year.

U.S. Army Corps of Engineers (1984), in Shore Protection Manual, clearly states: "At a rubble slope seawall, scour may undermine the toe stone, causing the stones to sink to a lower, more stable position. The resultant settlement of stone on the seaward face may be dealt with by over building the cross section to allow for settlement. Another method is to provide excess stones at the toe to fill the anticipated scour trough....."

It is strongly suggested that the toe portion be provided with two layers of armour stones as shown in Fig. 2. The role of the High Density Polythene (HDP) mat mesh, i.e., the Geofabric filter is to prevent the loss of sand from the base of the seawall due to return flow. The return flow, i.e., the

flow from the land towards the sea would be heavy if there is overtopping of seawall and/or surface runoff from rains. The effectiveness of the geofabric filter has been proved through studies all over the world. The only fault with the design adopted on the coast is that it is not provided up to the crest portion and should be rectified. The basis for deciding the weight of armour stone is the Hudson's formula. This formula was derived for the rubble mound breakwaters but is also used for the design of seawall. U.S. Army Corps of Engineers do not give any specific recommendation regarding the stability coefficient ( $K_D$ ) values to be used for design of seawalls. The Karnataka Engineering Research Station which has provided the design for the seawalls on the coast has used a value  $K_D = 3.0$ , based on the guidelines suggested by Central Water and Power Research Station, Pune. For rubble mound breakwaters, U.S. Army Corps of Engineers recommend  $K_D = 2.0$  for breaking waves, and  $K_D = 4.0$  for non-breaking waves, and adopting a value of  $K_D = 3.0$  for seawall design is reasonable. The design wave height is based on the maximum possible depth of water at toe of the seawall.

The Karnataka Engineering Research Station design does not provide any provision for the possible depth of scour. The weight of armour for 1:5 slopes of seawall works out to be 570Kg. These calculations have been checked and found to be correct.

U.S. Army Corps of Engineers suggest as a general guide, the maximum depth of a scour trough below the natural bed is about equal to the height of the maximum unbroken wave that can be supported by the original depth of water at toe of the structure. The maximum scour depth is the ultimate

limit and no doubt a fail safe design must incorporate this. But the weight of armour stones become too heavy and would require cranes for handling. It should be noted that the MID had changed the armour weight from 1360Kg to 600Kg in 1987 based on the experience that 1360Kg stones were too heavy to handle.

If the weight of the armour is to be restricted to 570Kg, then suitable methods must be adopted to prevent scour. U.S. Army Corps of Engineers suggests placement of a rock blanket with adequate bedding material seaward from the toe of the structure will prevent erosion at toe and will result in a more stable structure.

The present design using 570 Kg armour stones can be continued as it has proved effective and in cases where collapse of seawall has taken place, maintenance work to be carried out to make up the cross-section. This is a more economical and a practical approach than adopting a too costly fail safe design. The suggestions regarding the modifications at the toe and continuing of HDP mat below crest would further improve the stability.

### *Placement of Sea Wall*

According to U.S. Army Corps of Engineers, the best location for the construction of seawall is at the back of the beach, just beyond the active zone of the beach as shown in Fig. 3. In contrast seawalls built seaward at section A, between points C and D, will have constant problems related to frontal and end scour. There may be two reasons for locating the seawalls seaward: 1) Due to encroachment, and 2) To avoid significant amount of excavation to expose back of beach for the ideal location of seawall. Not only in India, but also from

U.S.A. (Tait and Griggs, 1990), there are reports of severe damage to seawalls built seaward.

The Seawall construction along the coast can be classified under two categories:

- i) Emergency works
- ii) Regular works.

### ***Emergency Works***

To meet the ever increasing public demand for immediate protection against erosion during severe monsoon periods, emergency works are carried out. Such constructions invariably follow the top down approach in these adverse situations and the specifications regarding the weight of stones, the best location and the different graded layers cannot be followed. Whatever stones that are available are used for the emergency protection. These constructions are not only in the active zone of the beach, but to upgrade them later to the standard cross-section is also very difficult. These sections will be the ones to get damaged first in the subsequent monsoons as in Ullal.

### ***Regular Works***

The construction of the seawalls is generally done in the post-monsoon season when the eroded beach would have recovered fully. Construction in this period would require a significant amount of beach to be excavated to expose the back of the beach for the ideal location of the seawall. Only a strict supervision can endure this. The weight of the two layer primary armour stones used in the present construction are 570 Kg. In most of the locations, cranes are not available to handle these stones. They are manually handled. Forming the two layer

profile using these stones with manual labour is a tough task and more often, the required slopes are not obtained. Formation of the toe suffers in the manual construction, as it is the farthest from the land side, which is also under the water. For proper construction of the seawalls to the required profile, mechanical equipment like cranes are essential.

### ***Pell-Mell Vs Hand Packed Construction***

There is a feeling among some of the engineers involved in the construction of the seawalls that the armour stones should be hand packed as in the case of dry masonry. This would increase wave reflection, wave run-up and the associated dangers. Voids are essential for dissipation of wave energy. The efficiency of the highly successful artificial armour units like the Tetrapods, Dolos and Tribars is primarily due to high degree of voids. As a matter of fact, the present aim in development of new type of artificial armour units is to create maximum voids consistent with structural stability. Smith and Chapman (1982) mention about a field study on the Australian coast where the conventional seawalls are grouted assuming that this would render them more stable. Smith and Chapman report that these grouted seawalls failed more rapidly than the standard seawalls.

### ***Ends of Seawalls and Fishing Gaps***

Depending on the financial allocation each year, short stretches of seawalls 200m to 500m in length in each of the affected areas are taken up for construction each year. In such situations, it is not possible to properly anchor the ends or make any special provision to protect the end portions. These

end portions are more vulnerable to damage particularly if the seawall has been located in a forward position. The same situation exists in the gaps left in the seawalls for taking the fishing boats to the sea. Where specific gaps for fishing activities are allowed, the ends must be protected with armour units for stability.

### ***Shape, Size and Grading of Stones***

The armour stones must be as far as possible cubical. It is found that there is a strong tendency to use excessively flat stones as these are more easily obtained by blasting in the quarries. These stones are invariably placed with their large flat areas parallel to the slopes. These increase reflection, run-up and in addition, provide large surface areas on which wave forces can be large. The flat stones should be avoided and cubical or near cubical stones are to be used.

It is generally specified that 75% of the stones should be of weight equal to or greater than the design weight (570 Kg in the present design and the remaining 25% between 430 Kg and 715 Kg). These specifications are those for breakwaters which are generally built to steeper slopes (1:2). In the absence of specifications for a seawall, the same are adopted. On very flat slopes such as 1:5 with the component of weight parallel to slope being very small, there is no interlocking effect between neighbouring stones. Each stone will depend on the component of weight normal to slope for stability. In such situations, the design armour is likely to be displaced more quickly. On very flat slopes, undersized stones should be avoided. Such a wide variation in weights should be avoided. A lower limit of 500 Kg may be better, considering that it is a under design which is shown in Fig. 1.

### **Failure of Seawalls in General**

Engineering design philosophy has basically evolved around the analysis of failures. Each mode of failure is analysed in order that adequate factor of safety is provided for satisfactory performance of the engineering structures under design. The success of such a design depends on the ability to visualize all failure modes and to account for each satisfactorily. The same procedure can be adopted with regard to seawalls also.

Coastal protection works fail due to one or more of following reasons.

1. Design failure occurs when either the structure as a whole, including its foundation or individual structure components, cannot withstand load conditions within the design criteria. Design failure also occurs when the structure does not perform as anticipated.
2. Load exceedance failure occurs because anticipated design load conditions were exceeded.
3. Construction failure arises due to incorrect / bad construction / construction materials.
4. Deterioration failure is the result of structure deterioration and lack of project maintenance

In the design process, all possible failure modes must be identified and evaluated in order to obtain balanced design. Some failure modes are common to several types of structure. Examples include displacement of armour stones and toe erosion, which are relevant to most rubble structures such as seawalls, groynes and breakwaters (Fig. 4 & Fig. 5).

### **Failure of Seawalls along the Coast**

A study of performance of seawalls as reported in literature and close monitoring of these structures in Southern Karnataka reveal the following as the possible reasons which cause failure of seawalls.

1. Inadequate weight of armour stones which get dislocated due to wave

- action (Displacement damage due to under design).
2. Failure of filter beneath the base or backfill leaching of bed material. The material finds a improper or inefficient filter. Consequently the seawall settles and this may be followed by dislocation of stones and failure of seawall.
  3. Toe failure: either due to inadequacy of filter or due to scour by the downrush and long shore current or a combination of both. Toe failure may be accelerated due to quick sand conditions that invariably exist at these locations.
  4. Overtopping and absence of drainage facilities for overtopping water and the consequent damage to backfill and often to the seawall on the lee side.
  5. Single layer armouring.
  6. Use of excessively flat stones (Length to breadth /depth ratio exceeding 3).
  7. Outflanking at terminals: improper keying.
  8. Steepening of foreshore slope (Caused by wave reflection)
  9. Removal of bed material due to rip currents.
  10. Undernourishment of beach in front and consequent overall depletion of bed.
  11. Concentration of wave energy due to wave refraction.
  12. Use of unsound stones (Disintegration of material under wave action).
  13. Non-conformity to the neighborhood.
  14. Construction phasing / schedule.
  15. Effect of construction in the neighbourhood.
  16. Location of seawall in forward position.

The causes which seem to dominate the failure scenario as far as the Coast is concerned are discussed below.

#### *Role of Filter*

To prevent the bed material from being sucked through the structure, it is essential to provide an efficient filter layer underneath

the seawall. A filter in general holds the in-situ material in position and facilitates relief of hydrostatic pressure, when developed. A multi layer system is normally adopted where large size armour units are used. Any delay in placing the secondary layer would adversely affect the gravel filter.

In recent times the gravel filters have been successfully replaced by the woven fabric of nylon/high density polythene or polyethylene. Most of the seawalls in Southern Karnataka are provided with woven nylon fabric filter (Fig. 1). A thin cushion of in-situ sand over such a filter fabric would prevent damage to filter fabric by rupture when the secondary layer stones are directly placed on the fabric as shown in Fig. 1. The filter has to be provided for the full width of the wall. The only fault with the design adopted on the coast is that, the geofabric is not provided below the crest portion which needs to be taken care and rectified in the repair and maintenance of existing seawalls as well as in the standard design adopted for the future.

#### *Toe Failure*

A major cause of failure of seawalls along the coast is “toe failure”. The scour resulting from waves breaking near the toe, strong currents, wave run-up and run-down often lead to toe failure (Subba Rao et.al; 2012). The toe is subjected to hydraulic forces and also the changing beach profile in front of the seawall due to scour. The stability of toe is crucial for the stability of the seawall. The toe if properly located is mostly under water and lack of visibility may render a high degree of uncertainty over its profile. Generally for flatter slopes, wave reflection is less and smaller would be the toe scour. Rough seaward face with increased voids also reduce reflection and hence scour.

Toe failure manifests itself in damage to primary armour which progressively reaches the portions above still water level. Left unattended, the damage propagates up the slope rendering the seawall ineffective.

U.S. Army Corps of Engineers have



also identified back scour failure and toe failure as major problem areas in seawalls and rubble mound breakwaters as shown in Fig. 4. They also mention that a scouring bottom is a problem by itself. No matter how well the toe is designed, if the local sea materials (sands, silts and clays) are exposed to sufficient energy levels for scour to occur, the toe of the structure is deemed to fail unless the toe berm is extended out to a point where energy levels are below those which will initiate scour. In most cases extending to this length is not practicable or feasible.

In the Indian context, Somayaji (1993), recommends the feasibility of providing a stronger toe with heavier stones to face the brunt of the wave force with the rest of the slope made up of comparatively smaller stones up to and beyond high water level may be examined. But the study feels that it is doubtful whether this will work. The failure is because of scour, loss of support and slippage of armour material and not due to inadequate weight of armour stone. A better solution is a toe berm below low waters, so that the stones in the berm will fill the scour hole and the integrity of the main seawall is protected. A cut off or sheet pile wall at toe is an alternate solution but will be costly. But this would require excavations of sea bed material and underwater constructions are cost intensive.

Smith and Chapman (1982), based on monitoring of seawalls in Australia, report that, initial failure of seawalls was always triggered by subsidence of toe and this has caused the armour to slide down thus causing settlement and overtopping. Once overtopping starts, total failure is quick with 5m. high walls disappearing in 20 minutes. The collapse mode of these walls as shown schematically by Smith and Chapman is shown in Fig. 5. Smith also mentions that initiation of toe failure may also be triggered by semi-fluid or quick sand conditions during which 5 ton boulders have been observed to completely disappear in less than 150 seconds.

Welsby et. al. (1987), in their survey of

coastal protection works in U.K mention that the main enemy of the seawalls has been long term erosion of beach immediately in front of the seawalls, with the subsequent exposure of the toe of the wall followed by undermining. They also mention that the traditional solution to this problem has been to encase the existing wall within a larger structure, often with an “apron” at its base.

Toyoshima (1984) reviewing the seawalls built in Japan, particularly those prior to 1975, mentions that these seawalls had a steep front slope which reflected the waves and this resulted in scour and toe failure. According to Toyoshima, many field experiences in Japan has highlighted the following aspects to be considered in the seawall design

- i) To decrease the reflected waves from the front of seawalls as much as possible.
- ii) To make the front face more rough.
- iii) To make the front face more permeable.
- iv) Some partial collapse should be allowed but never be such as to destroy the whole body of seawall.
- v) Maintenance should be easy.

#### *Maintenance of Seawalls*

Lack of maintenance of seawalls in India is another major cause of failure (Somayaji, 1993). Seawalls, like any other civil engineering structure, do need proper maintenance. The maintenance of seawalls would primarily be placement of additional armour units to restore the design profile. Seawalls in India have rarely been maintained. After a few years of sustained wave attack, even the best designed and best constructed seawall would require maintenance. No seawall is maintenance free. Regular maintenance will prevent total collapse of seawalls which would require rebuilding at an enormous cost. The resources crunch is the main reason for lack of maintenance.

#### *Overtopping of Seawalls*



Seawalls built with crest elevations which are lower and seawalls which have suffered heavy settlements will have significant overtopping and absence of drainage facilities for overtopped water, will result in the overtopped water finding its way to the sea through the seawall itself. Inefficient filter will cause leaching out of the in-situ bed material. Somayaji mentions about failure of seawalls south of Beypore in Kerala due to overtopping. He also mentions that seawalls in Kerala since 1970's have been built with crest elevation at +3.35m instead of +2.74m and this has reduced the overtopping of seawalls. The problem of overtopping would be severe if the land areas behind the seawalls are at a lower elevation compared to the crest of the seawall. There have been very few instances of seawall overtopping in the coast (Subba Rao et.al; 2012).

#### *Location of Seawall*

Another important factor that has significant influence on the stability and performance of the seawall is its location. U.S. Army Corps of Engineers (Shore Protection Manual, 1984) recommends that seawall should be constructed along that line landward of which further recession of the shoreline must be stopped. Tait and Griggs (1990) based on 4 years monitoring of seawalls in California, U.S.A., have come to the following conclusion: "One of the most critical factors controlling the impact of a seawall on the beach is its position on the beach profile relative to the surf zone. The best place for a seawall, if one is necessary, is at the back of the beach where it provides protection against the largest of the storms". The best location for the seawall is therefore at the landward limit of the active zone of the beach. But in a majority of locations on the coast, due to human encroachment, buildings and roads, the seawalls are built in the active zone of the beach. Such seawalls are highly

vulnerable to failure under the attack of monsoon waves.

Referring to Fig. 3, if the structure is located at A which is in the active zone of the sea, then the foundation of the structure must be taken to greater depths in order to account for the scour shown as dashed line. This will not be economical. Instead, if the structure is constructed beyond location D, which is outside the active zone, the structure will be safe against the wave forces acting on it as there will be a protective beach in front of it and economical with respect to material consumption.

#### *Outflanking of Seawalls*

The ends of seawalls if improperly keyed are vulnerable to erosion. Along the coast, only short lengths of seawalls are taken up for construction at a time, in a long range programme. It is not possible to spend money to properly key the ends, and terminal erosion results. Similar situation prevails at fishing gaps left in the middle of seawalls in Kerala, where gaps exist along seawalls without any protection to the terminal points at the gaps.

#### *Steepening of Beach in Front of Seawall*

Due to wave reflection, the sea bed in front of the seawall may take a steep slope due to scour and if this continues over years, there is a possibility of the toe of the seawall sliding into it leading to progressive failure. Central Water and Power Research Station (CWPRS), Pune, has reported that such steepening of sea bed has occurred extensively in front of the seawalls in Paradip, Orissa, east coast of India. Such conditions may also occur on the west coast, particularly in places where there is concentration of wave energy due to wave refraction. The authors have conducted a detailed field study of determining the beach profile for over two year's duration at locations where seawalls are present. The study has revealed that the presence of seawalls do not affect either the adjoining shoreline configuration or the seabed profile

in the front (Subba Rao, 2002). It has also been found that the beaches are in the state of dynamic equilibrium (Subba Rao et. al., 2003).

### Conclusions

There are significant natural changes that occur in river mouths in Karnataka coast. These assumes serious proportions when these areas are encroached by population. Coastal erosion if any on Karnataka coast is due to direct wave action. In certain stretches there is concentration of wave energy due to refraction and these areas are more vulnerable to erosion. Beaches adjacent to coast parallel rivers are also more vulnerable to erosion due to higher water tables that exist when the rivers flow full in monsoon. Littoral drift and sea level changes do not pose any problems along Karnataka coast

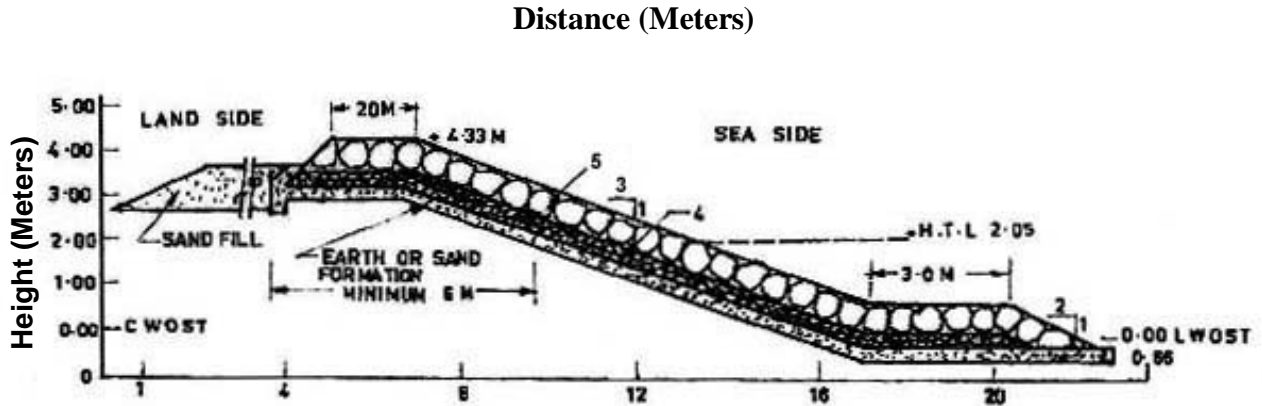
No seawall however well constructed can be expected to be 100% efficient and completely maintenance free. Necessary care must be exercised in proper location and construction of seawalls. The present design, except for the toe portion, adopted for the coast seems to be adequate as in majority of locations, it seems to be performing satisfactorily. Maintenance of seawalls for a few years after construction is essential before a stable structure is formed. Geofabric should be provided below the crest portion also which needs to be taken care and rectified in the repair and maintenance of existing seawalls as well as in the standard design in future.

The toe portion of the present design needs to be modified to conform to the earlier designs where two layers of the armour of weight 570 Kg must exist. The HDP mat must be continued below the crest portion also.

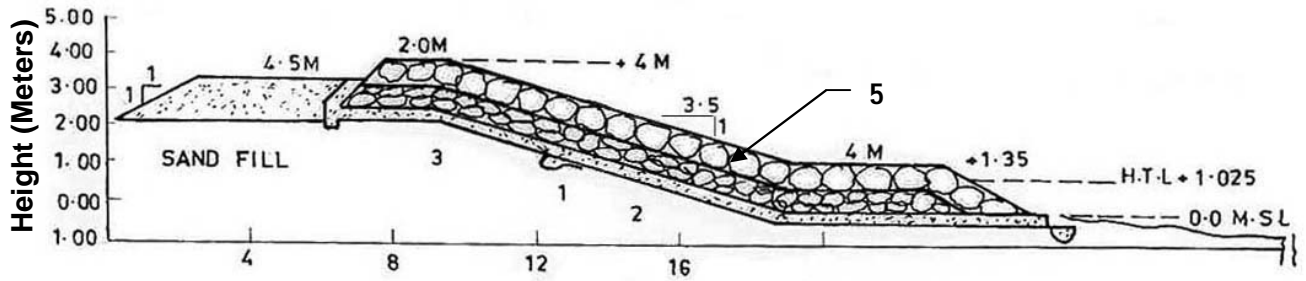
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Cross-section A



Distance (Meters)

Cross-section B

Particulars	Cross-section A	Cross-section B
1. FILTER	0.3M THICK FASCINE MATTER	HIGH DENSITY POLYTHENE 40 MESH OR TO SUIT BEACH SAND
2. SAND CUSHION BELOW H.T.L	0.3M MAX. SIZE 15.0 M	0.3M THICK SAND CUSHION
3. QUARRY RUN FILTER ABOVE H.T.L	0.3M THICK ( 52 Kg. STONE WT. )	0.3M THICK ( 15mm TO 15 cm )
4. SECONDARY LAYER	0.66M THICK W 520 Kg. 75% W > 520 Kg. REST BETWEEN 650 & 390 Kg.	0.6M THICK ( 65 Kg STONE WT )
5. SINGLE LAYER ARMOUR		0.75M THICK ( W = 650 Kg. ) 75% W > 650 Kg. REST BETWEEN 850 & 490 Kg.

UNIT WEIGHT OF ARMOUR STONES = 2.65 T / CUM  
W = WEIGHT OF ARMOUR STONES

Fig. 1 Details of seawall cross-section constructed along the coast

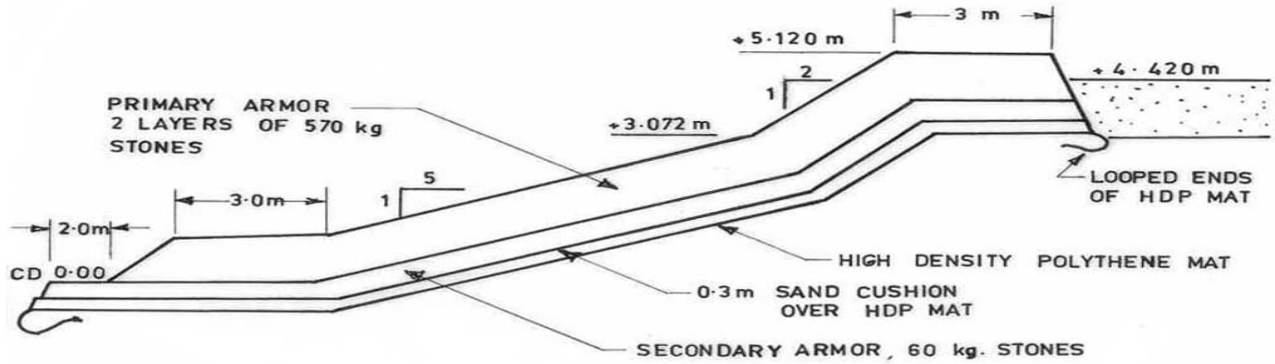


Fig. 2 Suggested modifications to existing seawall design

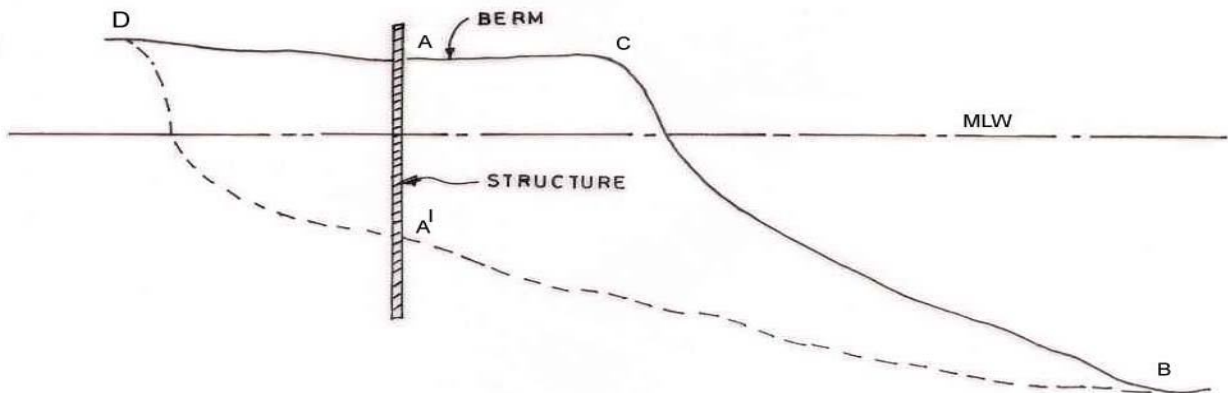
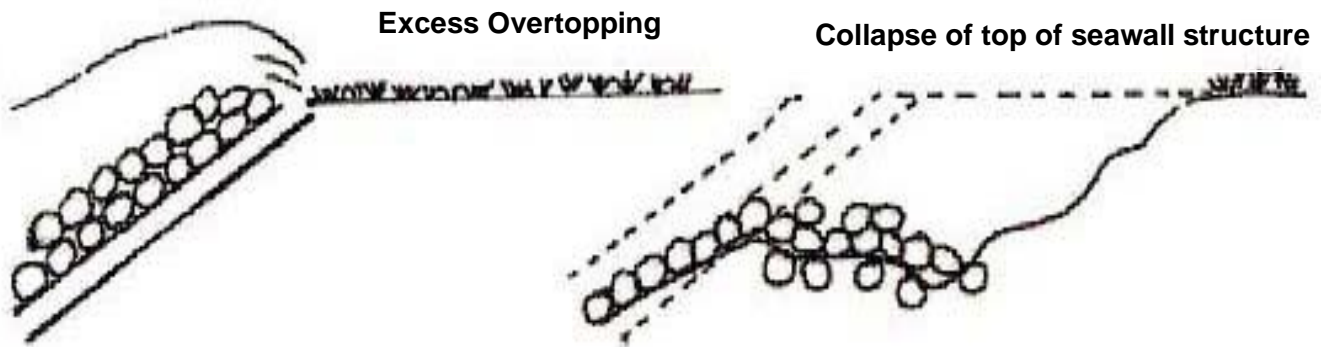
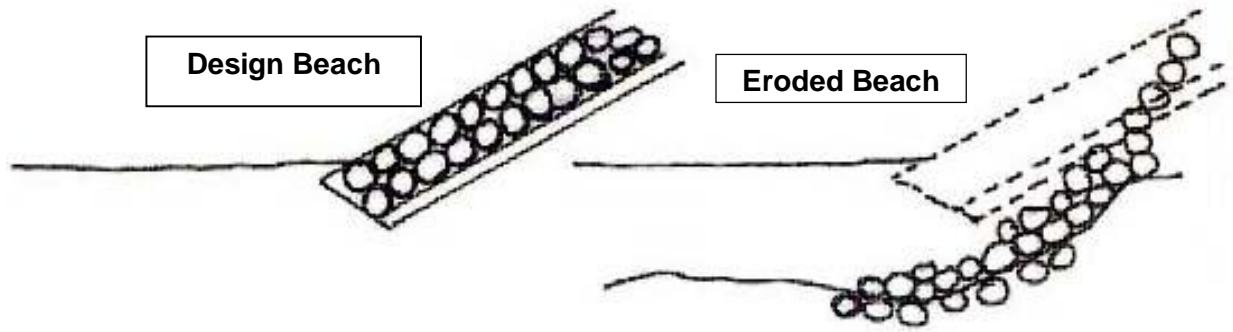


Fig. 3 Location of seawall structure on the beach



A. Back scour failure due to overtopping



**B. Toe erosion failure of rubble slope**

**Fig. 4 Failure modes of rubble slope**

(Courtesy : U.S. Army Corps of Engineers - Shore Protection Manual, 1984)



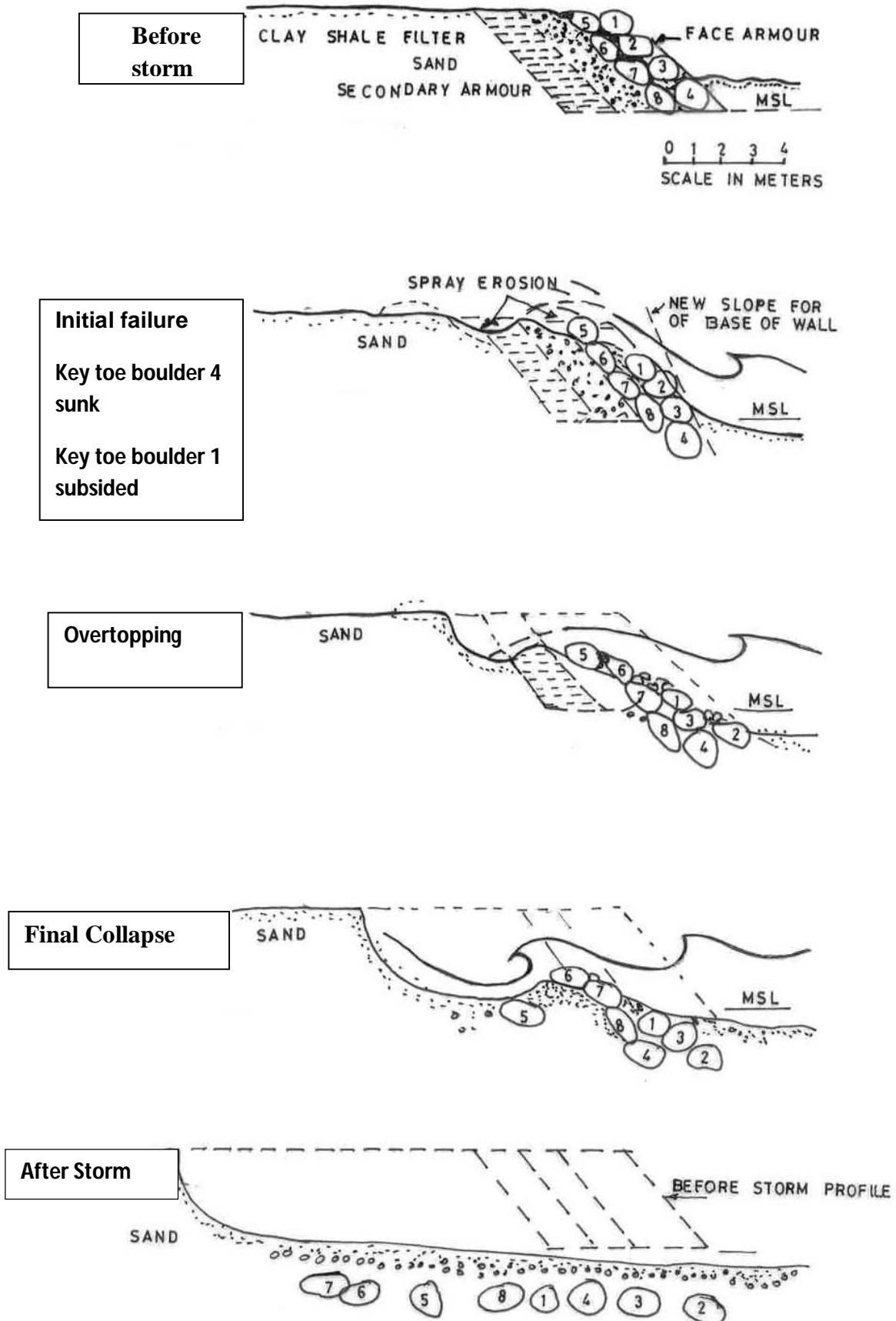


Fig. 5 Collapse mode of toe of seawall (Courtesy : Smith and Chapman, 1982)

Full stretch of completed seawall



Failure stretch of seawall



Figure 6 Seawalls at Mukka

**List of Participants**

S.No.	Name	Designation
<b>EXTERNAL PARTICIPANTS</b>		
1	Dr. T.Benarji Patrudu	Asst. ProfessorGITAM University
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3	Dr.P.Thamilarasu	Professor, Paavai Engineering College
4	Dr.V.Dharmalingam	Professor, Paavai Engineering College
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13	Mr. Jithin Jose	Resarch Scholar, Mangalore University

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14	Hajira Sajini S	Resarch Scholar, Mangalore University
15	Shwetha B Shetty	Resarch Scholar, Mangalore University
16	Mr. Rajesha R	Resarch Scholar, Mangalore University
17	Dr. B. R. Manjunatha	Professor, Mangalore University
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21	Mr. Balaji.S	Asst Professor, Kumaraguru College of Technology
22	M. Rameshkumar	Asst Professor Kumaraguru College of Technology
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<b>INTERNAL PARTICIPANTS</b>		
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28	Bhagyshri I Chavan	Student, NITK Surathkal
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30	Sunaina Patil	Student, NITK Surathkal
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49	Chinna Pandi	Student, NITK Surathkal
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53	Jaya Mary Jacob	Student, NITK Surathkal
54	Neethu N.S	Student, NITK Surathkal
55	Ashima	Student, NITK Surathkal
56	H.M.Kadlimatti	Research Scholar, NITK Surathkal

### Feedback of the Participants

- Feedback forms were distributed among participants.
- The average response of all the participants for the various factors were noted as follows:

	5	4	3	2	1
EXPERT LECTURE QUALITY		√			
ACCOMODATION		√			
FOOD			√		
LACAL TRIPS/MOCK DRILL		√			
HOSPITALITY		√			

5: Very good; 4: Good; 3: Satisfied; 2: Not satisfied; 1: Unable to judge

- Participants came up with active and fruitful discussions with the expert panel suggesting the overall success of the workshop. It was opined to include more discussion sessions in all future workshops.



## Overall Conclusion of the Workshop

Rapid industrialization, occupational and population demands have made India a critically pretentious forerunner in the field of atmospheric and earth sciences. A very notable transformation in the total quality of environment is the climate change and the problems associated with it. This alteration and its associated effects are particularly relevant in a country like India where nearly 700 million people out of over one billion population lives in rural areas and their livelihood directly depend on climate sensitive sectors like agriculture, forests, and fisheries and many other natural resources such as water, biodiversity, mangroves, coastal zones, grasslands for their subsistence and livelihoods. However, little efforts have been devoted to examine how climate change affects agricultural land use patterns and forest conversion. Addressing this issue is essential for assessing the sustainability of the agricultural activities and to evaluate the impact of climate change on farmers' well-being. This trend in deceleration in terms of quality led by anthropogenic sources is evident in the other strata of the environment like air, water and soil. In this context, understanding the scenario and its driving forces and predicting the future changes can be attributed to as the prime priority for the environmental research community. RCAES 2014 was successful enough to increase the awareness of the scientific community regarding the current aspects related to the following through active scientific discussions, presentations, case study analysis and problem solving methodology. The thrust areas under consideration were:

- 1) Hydrological aspects due to Climate Change
- 2) Atmospheric Aerosols and Climate Change
- 3) Land use patterns a changing scenario in Indian context.

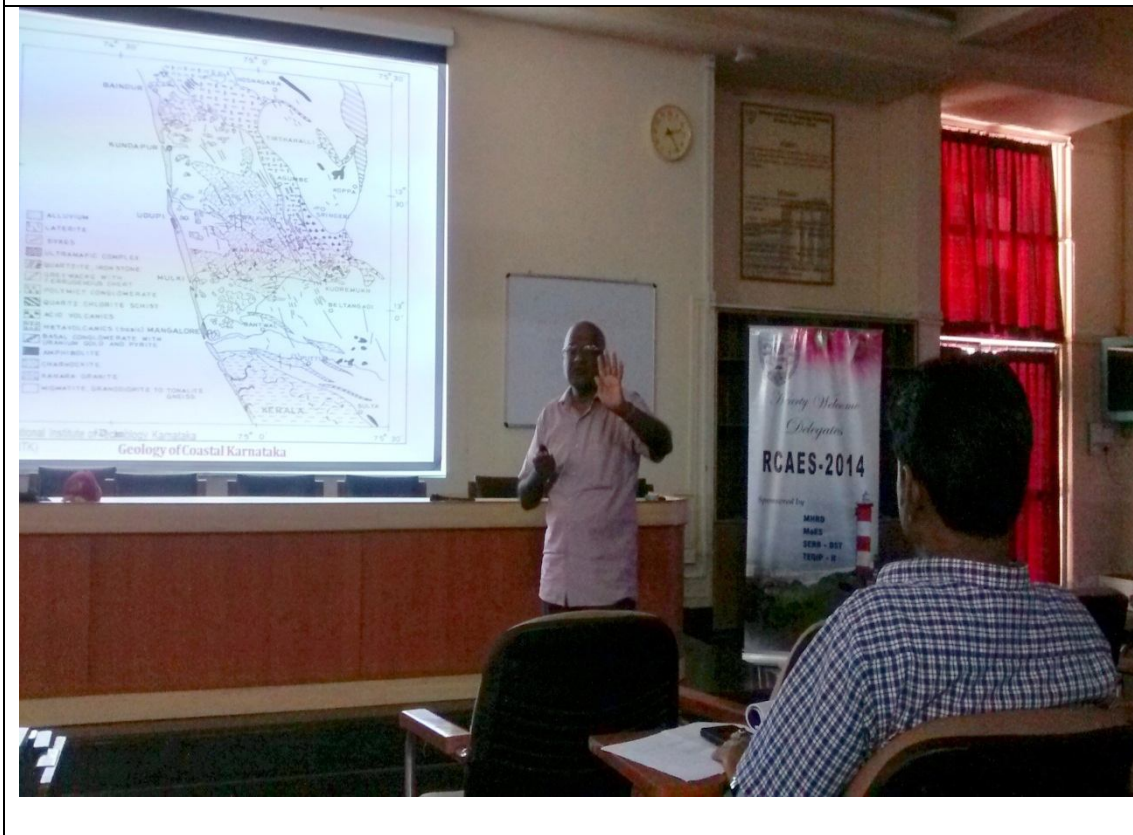
- 4) Climatic models for regional adaptation
- 5) Reduction, Loss and Extinction in Terrestrial Biodiversity
- 6) Geo-scientific techniques to measure inundation vulnerability in coastal regions
- 7) Disaster Management Techniques and Practices
- 8) Insights into “The Global Carbon Cycle”

The projected objectives could very well be explained in the context of Mangalore, a city embodied with rich biodiversity, the elegance of which has largely suffered the after effects of rapid industrialization and development in the recent years. The city stands sole evidence for the decrease in air quality, changes in monsoon patterns, loss in biodiversity and other anthropogenic mediated environmental quality deterioration. However, the proportional increase in the number of educational and research institutes in the area in pace with other developmental activities has proven to be a silver lining with increasing number of educated regional population taking part in means to prevent any future catastrophes. Thus, bearing significance to these perspectives, the organizers of RCAES 2014 could initiate a valuable step to make a link between expert advice and practical use of research tools from expertise belong to various organizations across the country and set the scene for fruitful discussions on how to make the best use of the existing information, how to prioritize the filling of gaps and how to develop a common understanding on the effectiveness of such knowledge in relation to policy and management actions and programs.

**9. Few Photographs :  
INAUGURAL FUNCTION**



## EXPERT LECTURES





**DISASTER MANAGEMENT DEMO**



**FIELD TRIP**





## PARTICIPANTS

