



# Manual on **Emission Inventory**



**GREEN SKILL DEVELOPMENT PROGRAMME (GSDP)**  
**Ministry of Environment, Forest & Climate Change**  
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*Manual on*  
**Emission Inventory**

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## FOREWORD

Air is a mixture of various gases, important for survival of human race and life on the Earth. In a fixed proportion, it's a life supporting system, but elevated concentration of certain pollutants has detrimental impact on human health, agriculture and other forms of the life. Most of the anthropogenic activities including fossil fuel, biofuel burning for transportation, industries, power generation, cooking activity emits certain amount of pollutant in to the air. The type and amount of pollutant emitted varies with fuel type and technology used for combustion and hence shows a wide temporal and geographical variation based on social factors. Emission inventory is the most effective scientific tool used to identify and quantify amount of pollutants emitted in to the air.

Emission inventories in our country are available as gross estimate and also with coarser resolution and often done for a limited sector. A high resolution gridded emission inventory at city level is sparse. This is mainly due to the lack of proper methodology and training in development of emission inventory where involvement of trained manpower and youth is essential. The ENVIS-GSDP program of Ministry of Environment, Forest and Climate Change is now fulfilling this gap and entrusted to lead this responsibility to IITM, Pune. Scientists of ESSO-IITM have been involved in the development of high resolution (1kmx1km) emission inventories since past decade and have developed such inventories for major metropolitan cities including Delhi, Pune, Ahmedabad and Mumbai. Emission inventory is the critical input for the air quality forecasting model used for predicting air quality. Quality of forecast depends on accuracy of emission inventory and hence to minimize uncertainties in the emission estimation several months long survey need to be conducted by involving hundreds of students to collect region specific activity data of primary in nature. The aforesaid GSDP training and thereby generating the skilled manpower will go in a long way in helping in this effort.

I appreciate the efforts of our scientist team at IITM for their timely efforts to publish this manual and Director, IITM to encourage this initiative. I thank ENVIS-GSDP Secretariat at Ministry of Environment, Forest and Climate Change (MoEF&CC) for their timely initiative to starting a training course on such a burning topic.



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# 1. INTRODUCTION AND BACKGROUND

## 1.1 ABOUT ENVIRONMENTAL INFORMATION CENTER (ENVIS)

In India, the Ministry of Environment, Forests & Climate Change (MOEF&CC) initiated a Central Sector Scheme known as ENVIS (Environmental Information Systems) which provides scientific and technical information on various environmental issues which facilitates policy formation and environment management. It also provides protection and sustainable growth of the environment necessary for all life forms. ENVIS consists of decentralized network of 67 centers that consists of State Government/UT Administrations, which deals with “State of the Environment and Related Issues”, other centers’ are environment related government and non-governmental organizations with varied thematic mandates pertaining to environment.

IITM, Pune is running one of such ENVIS centers since 2003 on the thematic area “Atmospheric Pollution and Climate Change” and achieved several milestones. Today, ENVIS website of IITM has one of the largest free access data bases on acid rain, air pollution and climate change subject area.

## 1.2 ABOUT GREEN SKILL DEVELOPMENT PROGRAMME (GSDP)

As ENVIS consists of a vast network and expertise in the field of environment, it has taken up an initiative for skill development in the environment sector to enable India’s youth to get employment or self-employment in the environment or forest sector known as GREEN SKILL DEVELOPMENT PROGRAMME (GSDP). The candidates having developed their skills under this programme will have technical knowledge and commitment towards sustainable development.

This program also prepares the candidates for green jobs that contribute to preserving or restoring the quality of the environment, while improving human well-being and social equity. Therefore, the courses under GSDP include process-based green skills such as monitoring, managing activities under environmental management.

### 1.3 AIR WE BREATHE

Clean air is a basic necessity for human health and well-being. When the local concentrations of air pollutants exceed certain threshold limit, it can have adverse effect on the health of human beings, plants and animals. Most of the mega-cities all over the world are experiencing the deterioration of air quality. Air pollution is a concern in most of the countries in the world including India. The atmospheric condition where the concentration of air pollutants found to be much above its natural background concentration and can produce undesirable effects on man and environment is known as air pollution, now-a-days which is a big issue of concern in any urban environment and urban air quality is listed as one of the world's worst toxic pollution problems. Air pollution occurs when harmful substances including particulates, gaseous and biological molecules are introduced into Earth's atmosphere. It may cause diseases, allergies or internal injuries in humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or pristine environment.

An Emission Inventory is the pioneer stage to control the rising air pollution. The emission inventory needs to be implemented through which further action is planned or structured which helps in combating air pollution. This is an important stage which needs to be executed by well trained professionals to know the exact state of the emissions in the environment. Today very few institutes in India regularly carry out such emission inventories, these inventories do help in forming environmental policies depicting its need. It's also recommended by these institutions and expertise that having skilled team which would carry out the inventory on ground would bring real time and qualitative information which will help in gaining a more realistic, efficient output to deliver the results of such inventories giving a good baseline for the expertise and policy makers.

This need is well recognized by the ENVIS Resource Partner (RP) at Indian Institute of Tropical Meteorology (IITM), Pune. IITM has carried out many successful emission inventories which provided a strong base for choosing critical parameters for Air Quality Forecasting system (prevention by intervention)- SAFAR. This program provides city air quality- over all city pollution and location specific air quality (a relative contribution of different environments in a city) for major metro cities of India

like Delhi, Pune, Mumbai and Ahmedabad. While conducting the emission inventories for these metro cities, the institute recognized the need of skilled professionals to carry out the inventories. ENVIS has launched Green Skill Development Programme (GSDP) which will help the youth to gain some technical skills granting them employment in the environment sector. Taking this opportunity ENVIS RP IITM, Pune has launched a course for Emission Inventory; this course will inculcate the necessary skills to execute an air emission inventory.

#### 1.4 WHAT IS EMISSION INVENTORY?

Emissions are the term used to describe the gases and particles which are put into the air or emitted by various sources. An emission inventory is a listing, by source, of the amounts of pollutants actually or potentially discharged. Pollutants are added to the environment through emissions of various natural as well as anthropogenic sources. We must know that what quantities of air pollutants are emitted and where do they come from? The best way to answer these questions is to prepare an air pollutant emission inventory. Emission inventories are now regarded as indispensable tools for a wide range of environmental measures such as management of chemicals as well as the prevention of air pollution. There are two crucial noteworthy applications of emission inventory: (a) It is a basic necessity for formulating environmental policy by the policy makers and regulators and (b) A critical parameters for Air Quality Forecasting system (prevention by intervention). In India the problem of air pollution is more intense particularly in major metropolitan cities.

The pollutants are added to the environment through **emissions** of various natural as well as anthropogenic sources. The anthropogenic emission (emerging from industrial process, auto exhaust, power plants, open fires, cooking, residential burning, heating and domestic sources, etc.) is on the rise. Emission Inventory is one of the most critical factors required for 3-D atmospheric chemistry transport models along with meteorological input to forecasting the air quality for mitigation. Quality of forecasting depends on accuracy and reliability of emission estimation. Emission inventories could also be used for air quality management and formulating environmental policy.

## 1.5 EMISSIONS OF POLLUTANTS

Development of emission inventory is a complex process due to numerous, diverse and widely dispersed emission sources in a metropolitan city and requires huge amount of high resolution activity data, emission factors along with knowledge of fundamental scientific processes. For understanding the Air Quality of any place, there are a few major pollutants whose emissions need to be understood in detail. These are- *Oxides of Nitrogen ( $NO_x$ ); Carbon Monoxide (CO); Black Carbon (BC); Organic Carbon (OC); Particulate Matter <2.5 micron ( $PM_{2.5}$ ); Particulate Matter <10 micron ( $PM_{10}$ ); Sulfur Dioxide ( $SO_2$ ) and Volatile Organic Compounds (VOCs).*

## 1.6 METHODOLOGY DEVELOPMENT AND DATA GENERATION

For the development of emission inventory, a bottom up approach is normally used for which knowledge of GIS (Geographical Information System) software is essential which will be taught in this course. The emissions are estimated for the individual sources and for that purpose, an extensive scientific field campaign need to be carried out to generate those data sets which are not available. This need to be done by skilled persons where each city will need 100-200 volunteers. GSDP will fulfill this gap and it is also likely to work towards a noble cause to inculcate the feeling of scientific temperaments in young mind. The main objective of the campaign should be to generate missing primary data, validate some uncertain secondary data and to collect the available secondary data. During the campaign, information related to following major activities are either generated or collected from relevant institutions regarding the quantity of fuel used, their type and daily usage:

- (1) Transport Sector (CNG, Diesel, Petrol driven vehicles, etc.)
- (2) Industrial (fuel used in cement, steel, bakery, chemical, metal industries, etc)
- (3) Slum Cooking (use and type of kerosene, wood, coal, etc)
- (4) Commercial Cooking (in hotels, restaurants)
- (5) Street vendor fuel usage survey
- (6) Paved /Unpaved Road (Suspended dust)
- (7) Bio-fuel Burning (dung, crop-residue, wood, bio-mass burning, etc).

To know the traffic volume on different major and minor roads and traffic junction in a city, vehicle number density need to be counted using click counter at various traffic junction and busy locations. It is found that 60-70% of vehicular density runs on major road. Major traffic junctions contributing to high emission.

### **1.7 EMISSION INVENTORY –CONCEPT AND NEEDs**

To improve the air quality in any area/ city one should have detailed information of air pollution sources along with the local meteorological condition and topographical factors. Emission sources shows very high spatio-temporal variation and the type of pollutants emitted from specific region and their rate of emission depends entirely on the socio-economic factor and rate of urbanization in the region and makes the process of identification of the problem more complex.

For the purpose the effective science based air quality management is a need of the hour, which can be achieved through comprehensive approach build upon four key areas, viz. (i) Air quality monitoring (ii) development of emissions inventories (iii) atmospheric chemistry-transport modeling and (iv) development of control strategies. Emission inventories helps to identify the emission sources in the region and contribution of each source to the total emission which will eventually guide us to set priorities for the action plan for different sources, evaluating the various options available to reduce the emissions from identified potential sources and formulate and implement the appropriate action plan. Thus, an inventory provides basic information of sources and sink of different gases along with information like what gases to mitigate, how to mitigate, when to mitigate and where the mitigation action should be allocated.

### **1.8 COMMON ANTHROPOGENIC AIR POLLUTION SOURCES**

Rapid urbanization has resulted in increasing urban air pollution in major cities of India. Fossil fuel combustion, biomass burning, waste disposable practices etc. are some of the major pollution sources which are becoming more intense with the population growth and have direct relevance to the socio-economic status of the region. Use of coal, petroleum products including petrol, diesel, oil etc. increased dramatically during past few years. There is a 44% increase in the consumption of crude oil during last 5 years,

whereas primary commercial coal consumption in India is increased by 72% during past 10 years. (Ministry of Petroleum & Natural Gas & Ministry of Coal, Govt. of India. (10743), (ON320)). These values depict the increasing demand of the fossil fuel which is used for industrial production, power generation and transportation. In addition to this wood, charcoal, crop residues are used by majority of people in rural as well as in slum areas of the country for various activities including cooking, heating etc. which on burning emits considerable amount of air pollutants including CO, CO<sub>2</sub>, NO<sub>x</sub>, PM<sub>10</sub>, PM<sub>2.5</sub> etc and also responsible for the formation of ground level O<sub>3</sub>, smog and reduce local visibility. Some of the important and common anthropogenic sources of air pollution found in any urban region are given below,

### 1.8.1 Vehicle /Transport



Vehicles are powered by internal combustion engines which operate on fossil fuel combustion (gasoline, diesel, LPG). They contribute to the emission by three mechanisms; primary emission, secondary formation and fugitive emissions. They emit a range of pollutants including CO, NO<sub>x</sub>, photochemical oxides, air toxics namely benzene, aldehydes, 1-3 butadiene, lead, PM, hydrocarbons, oxides of sulphur and polycyclic aromatic hydrocarbons etc. depending on the vehicle type, engine maintenance and fuel quality. Petrol/Gasoline driven vehicles emits more hydrocarbons and CO whereas diesel driven vehicles predominantly emits NO<sub>x</sub> and PM. The primary particle emission from vehicle exhaust is in the PM<sub>2.5</sub> size range which is very harmful to the human health because of its smaller size along with other primary pollutants whereas large fraction of particles emitted via brake and tire wear also.

Secondary particles are produced in the atmosphere through the reactions of gaseous emissions, e.g. hydrocarbon reacts in the atmosphere to form less volatile species that condenses in to the particle phase, contributing the carbonaceous particle burden. NO<sub>x</sub>

oxidizes to the nitric acid which reacts with ammonia to form ammonium nitrate. The amount of ammonium nitrate in the particle is the function of the temperature.  $\text{SO}_2$  is oxidized to sulfuric acid, which exist primarily in the particle phase.

Re-suspended dust is another major source of Particulate Matter (PM) associated with the vehicular or transport activity. PM gets re-suspended by the turbulence caused by vehicle traffic. In general, re-suspended particulate emissions from paved and unpaved roads originate from the loose material present on the surface and spillage of material. When vehicle travels on unpaved road, the force of the wheel on the road surface causes the pulverization of surface material where the particles are lifted and dropped from the rolling wheels and the road surface is exposed to the strong air currents in turbulent shear with the surface. The amount of dust generated is a function of the amount of fine particles (silt) on or near the roadway. This is a major source of  $\text{PM}_{10}$  and the emissions of  $\text{PM}_{2.5}$  are very less from this source.

### 1.8.2 Industries



Factories and industrial units associated with product manufacturing involve combustion of different types of fuel such as coal, diesel, furnace oil, LPG etc. From such industrial units verity of pollutants get released in to the air through air vents, smokestacks and chimneys. The major air pollutants released from the industrial units are particulate matter,  $\text{CO}_2$  or  $\text{CO}$ , which is mainly produced in combustion processes.  $\text{SO}_2$  comes from the burning of fuel that contains sulfur. Hydrocarbon gases and nitrogen oxides are also frequently emitted by industrial units. They interact with each other to form tropospheric ozone and photochemical smog. Chlorofluorocarbons have also emitted through factories, which are responsible for the destruction of ozone layer. To tackle the air pollution problem from industries Ministry of Environment and Forests (MoEF) has identified 17 categories of polluting industries. Out of which iron and steel plants (sponge iron plants and steel re-rolling mills), cement plants, brick

making units, fertilizer plants, oil refineries, pulp and paper, petrochemicals, sugar, distilleries and tanneries are some major industries which contribute more to the emissions.

### 1.8.3 Thermal Power Plants

Coal based Thermal power plants are another major source of air pollution identified by MoEF.

Each power plant is a highly complex, custom-designed system in which the chemical energy stored in fuels and oxygen of the air is converted successively into thermal energy, mechanical energy and, finally, electrical energy for



continuous use and distribution across a wide geographic area. In India, according to the National Thermal Power Corporation, coal is used for approximately 62.3% of India's electric power generation, oil and gas account for 10.2% whereas, water, nuclear, wind and other power generation methods contribute to the remaining 27.5 % usage.

Electricity generation using carbon based fuels is responsible for emission of varieties of gaseous air pollutants along with particulates. The flue gas from combustion of the fossil fuels discharged to the air contains carbon dioxide (CO<sub>2</sub>), nitrogen oxides (NO), sulfur oxides (SO), chlorofluorocarbons (CFCs), and air-borne inorganic particles such as fly ash, soot, and other trace gas species.

### 1.8.4 Agricultural field burning and forest fires

Post harvesting field burning is a common practice in India. Large agricultural residues are produced annually and burnt openly in the field. In India Around 25% of the crop residue generated during each cultivation are burnt in the agricultural fields (Reddy et al., 2002). Large



amount of particulate matter (PM<sub>10</sub> & PM<sub>2.5</sub>) is released into the atmosphere along with different gaseous pollutants. Many times forest areas are burnt by man for land

cleaning or other purposes releasing considerable amount of the particles and gaseous pollutants in to the air.

### 1.8.5 Biomass burning

Biomass materials are used since millennia for meeting the need of energy. Main sources of biomass energy are wood, crops and animal waste. With rapid increase in fossil fuel use, the share of biomass in total energy declined steadily through substitution by coal in the nineteenth century and later by refined oil and gas during the twentieth century. Despite its declining share in energy, biomass contributes over a third of primary energy in India. In India Biomass



fuels including wood, crop waste and dung cakes are predominantly used in rural households for cooking and water heating, they are also used in traditional industries. Its use accounts for 47% of the total energy consumption. Among the biomass energy sources, wood fuel is most prominently used in India and it contributes 56 % of total biomass energy.

Two main problems associated with the traditional biomass are inefficient combustion technologies and environmental hazards from indoor pollution. In rural India biofuels are burnt in small, open-chamber and Chulhas. Incomplete combustion of Biomass results in the emissions of small particles (PM<sub>2.5</sub>) with a large carbonaceous fraction and inorganic water soluble ions. These pollutants cause considerable damage to health, especially of women and children who are exposed to indoor pollution for long duration. Emissions from the biomass burning are inhomogeneous and show large special and temporal variations.

### 1.8.6 Other Sources

In addition to the above mentioned anthropogenic sources large amount of air pollutants are released in to the atmosphere through municipal solid waste management and construction activities etc.

## 2. GSDP COURSE: EMISSION INVENTORY MODULE

### 2.1 BACKGROUND

The eminence the policies depends on the accuracy and reliability of emission inventories. The development of emission inventory is one of the critical and most sensitive parts for modeling study of air quality and should be as latest as possible. Most of cases, emission inventories are developed for older period and do not include the latest emission scenario. Moreover, available estimations are done mainly at gross level and not gridded as finely as required for various models and hence the task remained unfulfilled.

Although lot of air pollution measurement has been done in our country but knowledge about its measurement technique and management is sparse due to the lack of skilled manpower. In India, emission inventory work is being done for some time but inadequate and a harmonized system to develop and compile inventories that are transparent, comparable enough to air pollution scenario and most importantly, gridded in latitude and longitude has not yet been established. It is necessary to establish such a system in which base line gridded emission inventories are prepared at a first step and then a mechanism by which we can improve them continuously as a second step. The central requirement of such a system is to generate and acquire activity data at smallest possible grid. The necessary data can only be collected from statistics and surveys. This requires a sustainable team of skilled young generation who can survey and generate the activity data enemas in cooperation with administrative and regulatory agencies, and inventory experts.

Hence, the below manual for Emission Inventory course is structured in a way which will train the candidates to extract high quality both primary and secondary data and convert the same on GIS platform which can be used as the base for policies by experts and policy makers.

### 2.2 EXAMINATION

- The assessment will be done through theory, practical and viva exams at the end of the course.

- Students will be assessed regularly through questionnaires on every module in the classroom. Continuous assessment can be done through Group Discussions/ Presentations/Seminars/ Assignments/ Oral test/ Written test.
- For practical examination, the trainers as well as course supervisors will constantly keep a vigil on the trainees. Any errors committed by the trainees will be corrected then and there; learning by doing technique will be adopted for practical assessment.
- In theory, a final examination will be conducted at the end of the course, in which 50% scoring will be as qualifying marks.

### 2.3 COURSE MODULE FOR EMISSION INVENTORY

|                 |                                                                                                                                                                                                                                    |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Unit I</b>   | <b>Development of Emission Inventory</b><br>Introduction to Air pollution and Impact on environment<br>Methodology of emission inventory development                                                                               |
| <b>Unit II</b>  | <b>Emission Estimation Methods</b><br>Point Source<br>Non Point Source<br>Mobile Source<br>Primary and Secondary data collection                                                                                                   |
| <b>Unit III</b> | <b>Sources and Sectors</b><br>Introduction to emission sources and sectors<br>Industry & Power Sector<br>Transport<br>Commercial<br>Street vendor<br>Residential<br>Slum and Other Sectors<br>Field Survey for inventory campaign, |
| <b>Unit IV</b>  | <b>Calculation of Emission and emission factors</b><br>Questionnaire data interpretation,<br>Trends in emission, graphical presentation,<br>Calculation of emission for major sectors                                              |

|               |                                                                                                                                                                                                                                                                                                                                        |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Unit V</b> | <p><b>GIS application to Emission Inventory</b></p> <p>Introduction to GIS for Emission Inventory</p> <p>Development of GIS based statistical Modelling for emissions,</p> <p>Geotagging and geo-referencing,</p> <p>Digitization,</p> <p>Spatial distribution of Emissions</p> <p>Conversion of data</p> <p>Labelling and legend.</p> |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### 3. GSDP COURSE: EMISSION INVENTORY MANUAL

#### Unit I: Development of Emission Inventory

##### *1. Introduction to Air Pollution*

- Types of pollutants:- Primary and Secondary pollutants
- Study of Particulate matters and gaseous pollutants and its interactions in the atmosphere.
- Selection of Criteria Pollutants
- Indoor and outdoor air pollution.
- Sources of air pollutants.
- Lifetime of Pollutants
- Chemical and Dynamical Life time

##### *2. Methodology of emission inventory development*

- How to detect Emissions and Concentration of pollutants in a given urban or rural area
- What is emission inventory? Planning of Emission Inventory
- Sources of Pollutants in urban and rural area.
- Aspects of emissions from - Transport Sector, Biofuel Sector, Industrial sources, Power Sector, Windblown Dust, Trash Burning
- Collection, compilation, verification of Activity Data, Primary and Secondary data.

#### Unit II: Emission Estimation Methods

##### **Theory:**

##### 1. Point Source

- Introduction to Point Source emissions
- Characteristics of Point Source Emissions
- Plotting of Point Source Emissions on map and its Life cycle.

##### 2. Non Point Source

- Introduction to Non Point Source emissions

- Characteristics of Non Point Source Emissions
  - Plotting of Non Point Source Emissions on map and its Life cycle.
3. Mobile Source
- Introduction to Mobile Source emissions
  - Characteristics of Non Point Mobile Source Emissions
  - Plotting of Mobile Source Emissions on map and its Life cycle.
4. Primary and Secondary data collection
- Types and differentiation of primary and secondary data of air emissions.
  - Characteristics and collection of primary data
  - Calculations, plotting and Interpretation of primary data.
  - Collection, compilation and validation of secondary data.
  - Calculations, plotting and Interpretation of secondary data

### **Practicals:**

Ex:1- Field visit at SAFAR Monitoring stations and different sectors to identify point and non-nonpoint sources of air emissions.

## **Unit III: Sources and Sectors**

1. Introduction to emission sources and sectors
  - Emission sources and sectors in urban and rural.
2. Industry & Power Sector
  - Classification of different industries and power sectors
  - Types of resources used in the industries and types of power plants. Technologies used, emissions emitted from them and its drawback.
  - Advantages and disadvantages of renewable and non-renewable energies used in industries and power sectors.
  - Air emissions (toxic and non-toxic) generated from the industrial wastes.
3. Transport
  - History of fuels used in transport sector and its present state.

- Types of vehicles used in urban and rural area also the current scenario
- Bharat Stage and its aspects towards air emissions, its brief study
- Counting of vehicles on road and the state of emissions on heavy traffic roads.
- Aspects of air emission from different mode of transports and its interaction with the atmosphere.

#### 4. Commercial

- Different area of commercial sectors in an urban area
- Types of power resources used in commercial areas
- Air emissions from wastes

#### 5. Street vendor

- Licensed and unlicensed street vendors
- Types of energy and fuels used by street vendors.

#### 6. Residential

- Types of energy and power supplies to different housing societies
- Cooking fuel used
- Methods used for household and garden waste disposal
- Indoor air pollution

#### 7. Slum and Other Sectors

- Types of fuels used in household slums
- Garbage dumping sites and open burning sites.

#### 8. Field Survey for inventory campaign

- Structuring an air emission inventory
- Aspects to cover in an inventory

### **Practicals:**

Ex:1- Emission Inventory and field visit of Industrial zone

Ex:2- Basics of transport survey and emission inventory in heavy and light traffic zone

Ex:3- Emission Inventory in a commercial zone and street survey

Ex:4- Communication with the street vendors and extracting the data needed through emission inventory.

Ex:5- Emission Inventory in a residential zone.

Ex:6- Emission Inventory and survey of a slum area and waste dumping sites.

Ex;7- Group Activity Emission Inventory of a city.

#### **Unit IV: Calculation of Emission and emission factors**

1. Compilation and screening the Questionnaire data, its interpretation.
2. Trends in emission, graphical presentation
3. Calculation of emissions for each major sectors

##### **Practicals:**

Ex:1- Data Entry procedure, screening of data and user friendly interpretation (8 hours)

Ex:2- Developing of a case study depicting a trend in emissions with graphical simplified presentation (10 hours)

Ex:3- Calculations for emissions in different sectors in excel and its graphical representation ( 5 hours)

#### **Unit V: GIS application to Emission Inventory**

1. Introduction to GIS for Emission Inventory
2. Development of GIS based statistical Modelling for emission
3. Geotagging and geo-referencing, Digitization
4. Spatial distribution of Emissions
5. Conversion of data
6. Labelling and legend.

**Practicals:**

Ex:1- Installation and demonstration and working of Arc GIS software

Ex:2- Introduction to Maps on GIS

Ex:3- statistical Modelling for emissions

Ex:4- Geotagging and geo-referencing, Digitization

Ex:5- Spatial distribution of Emissions, Conversion of data Labelling and legend

## REFERENCES

1. Air Pollution Meteorology and Dispersion. by S. Pal Arya
2. Smoke Dust and Haze, by S.K. Friedlander, Oxford Univ. Press, 2000.
3. First Principles of Meteorology and Air Pollution, by Mihalis Lazaridis
4. Atmospheric Diffusion. by F. Pasquill
5. Special Scientific Report- SAFAR Ahmedabad 2017 C- MOES, IITM. Pune.
6. Emissions Inventory of India, Garg, Amit; Shukla, P. R.
7. Emission Inventory of Air Pollutants and Trend Analysis Based on Various Regulatory Measures Over Megacity Delhi- By Manju Mohan, Shweta Bhati, Preeti Gunwani and Pallavi Marappu Submitted: December 21st 2011 Reviewed: April 8th 2012 Published: July 26th 2012 DOI: 10.5772/45874
8. Procedures Document For National Emission Inventory, Criteria Air Pollutants 1985-1999, United States Office of Air Quality Environmental Protection Planning and Standards EPA-454/R-01-006 Agency Research Triangle Park NC 27 71 1 March 2001
9. Emission Inventory Criteria And Guidelines For The Air Toxics "Hot Spots" Program, CALIFORNIA Environmental Protection Agency Air Resources Board, Planning And Technical Support Division
10. Remote Sensing and Image Interpretation, 2011 by Lillesand , Kiefer , Chipman.

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“ The environment  
is everything  
that isn't me ”

- *Albert Einstein*

