



**Course Number** : CE 558  
**Course Name** : Air pollution and its mitigation  
**Credits** : 3-0-0-3  
**Prerequisites** : IC 230 (Environmental Science) for B.Tech.  
**Intended for** : 3<sup>rd</sup> and 4<sup>th</sup> year B.Tech., Post-graduate  
**Distribution** : Elective

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## 1. Preamble:

The atmospheric system mediates phenomena ranging from local- and regional-scale air pollution to global-scale climate change, thereby affecting the environment, human health and the sustainability of the planet as a whole. A robust understanding of these processes and the complexities of the earth-atmosphere-climate system is critical to the ability to design effective mitigation technologies and policies. This course aims to foster this understanding by focusing on the fundamental physical and chemical processes that govern atmospheric behaviour, especially related to the residence, transformation, transport, and deposition of gaseous and aerosol species. This is followed by analyses of the natural and anthropogenic controls on various aspects of air pollution, and perspectives on their measurement, monitoring, risk assessment and mitigation.

**Learning outcomes:** The students would i) develop a thorough understanding of the interactive processes that lead to atmospheric pollution on varying spatial scales; ii) appreciate the links between air quality and health; iii) develop insights into the theoretical and practical aspects of air pollution control engineering; and v) draw lessons from the success stories and failures of local, regional and global policies to tackle air pollution.

## 2. Course Modules:

### **Module 1: The atmospheric system** [5 Hours]

Vertical profiles of pressure and temperature; atmospheric structure; hydrostatic equilibrium and scale height; stability and lapse rates; temperature inversions; atmospheric dispersion; general circulation and surface winds; timescales of atmospheric transport

### **Module 2: Basics of atmospheric chemistry** [2 Hours]

Photochemical and radical-assisted reactions; daytime vs nighttime and tropical vs polar chemistry; species lifetimes; atmospheric measurement units

### **Module 3: Stratospheric processes** [5 Hours]

Dynamics of stratospheric transport; formation and distribution (latitudinal, seasonal and vertical) of stratospheric O<sub>3</sub>; UV shielding and effect on climate; role of HO<sub>x</sub>, NO<sub>x</sub> and chlorofluorocarbons in catalyzing O<sub>3</sub> depletion – observational evidence, mitigation measures, recovery and challenges

### **Module 4: Tropospheric gas-phase species** [8 Hours]

Local, regional and global pollutants; the oxidizing capacity of the troposphere; constraints on CO and CH<sub>4</sub>; the CO-HO<sub>x</sub>-NO<sub>x</sub>-VOC-O<sub>3</sub> cycle; photochemical smog – case study of Los Angeles, USA; dry and wet removal of pollutants; acidic deposition – case study of the



Northeastern USA; current scenario in Asia and the Indian perspective; mitigation, challenges and opportunities

**Module 5: Aerosols**

**[7 Hours]**

Historical perspectives on air pollution; physical properties of aerosols – formation, growth, aging and size distribution; primary vs secondary and externally- vs internally-mixed aerosol; core-shell theory; major aerosol chemical components and their sources; tracers

**Module 6: Effects on climate**

**[4 Hours]**

Greenhouse effect and interaction of potential greenhouse gases; solar and terrestrial emission spectra; radiative transfer; planetary energy balance; aerosol-light interaction; radiative forcing and global warming potential

**Module 7: Air pollution control technologies**

**[6 Hours]**

Mitigation technologies in stationary systems – fluidized bed combustion, integrated gasification combined cycle, flue gas desulfurization, baghouses, scrubbers, cyclone collectors, and electrostatic precipitators; mitigation technologies in mobile systems – catalytic converters, diesel particulate filters, fuel modification and blending

**Module 8: Risk assessment and policy intervention on air pollution**

**[5 Hours]**

Link between air pollution and mortality/morbidity; risk assessment for carcinogenic and non-carcinogenic pollutants; air quality indices – case study of India; air pollution as an externality; ambient, emission and technology standards; policies for air pollution control

**3. Textbooks:**

- i) Atmospheric Chemistry and Physics: From Air Pollution to Climate Change; 3<sup>rd</sup> Edition, 2016; John H. Seinfeld and Spyros N. Pandis; Wiley.
- ii) Introduction to Atmospheric Chemistry; 1<sup>st</sup> Edition, 2000; Daniel J. Jacob; Princeton University Press.

**4. References:**

- i) Chemistry of the Upper and Lower Atmosphere; 2<sup>nd</sup> Edition, 2000; Barbara J. Finlayson-Pitts and James N. Pitts Jr; Academic Press.
- ii) Air Pollution Control Engineering, 2<sup>nd</sup> Edition, 2000; Noel De Nevers; McGraw-Hill.
- iii) Environmental Chemistry, 5<sup>th</sup> Edition, 2012; C. Bard and M. Cann; W.H. Freeman and Company.
- iv) Research articles will be advised as required.