Jawaharlal Nehru University

School of Environmental Sciences

Ph. D. Programme - Courses

Core Courses (Mandatory for all)		
Course code	**Course title**	**Credits**
ES601R	Research Methodology I (RM-I)	2
ES602R	Research Methodology II (RM-II)	2
ES603R	Research and Publication Ethics (RPE)	2
Optional Courses		
Area-I		
ES 653R	Atmospheric Processes	2
ES 690R	Urban Climate and Air Quality	2
ES 691R	Remote Sensing of Air Pollution	2
ES 637R	Air Pollution Meteorology	2
ES 694R	Climate Dynamics	2
ES 655R	Statistical Methods and Data Analysis in R	2
ES 692R	Aerosol and Cloud Physics	2
Area-II		
ES 652R	Earth Processes	2
ES 661R	Remote Sensing in Geosciences	2
ES 678R	Cryosphere Studies	2
ES 693R	Engineering Geology	2
ES 644R	Geochemical Cycles	2
Area-III		
ES 695R	Sustainable Environmental Management	2
ES 616R	Water Pollution	2
ES639R	Limnology	2
ES632R	Air Pollution	2
ES675R	Chemical Speciation in Environment	2
ES 689R	Bio-renewable Resources and Technology	2
Area-IV		
ES 651R	Ecosystem Processes	2
ES 621R	Environmental Toxicology	2
ES 691R	Environment and Carcinogenesis	2
ES 678R	Rehabilitation Ecology	2
ES 687R	Host-Pathogen Interaction and Environment	2
ES 624R	Man and Tropical Forest Ecosystem Function	2
ES 696R	Himalayan Ecology	2
ES 622R	Cell and Environment	2
ES 688R	Environmental Microbial Genomics	2
ES 643R	Climate Change, Air Quality and Plants	2
ES 636R	Radiation and molecular biophysics	2

The Optional Courses offered in either semester depending on the availability of faculty.

Ph. D. Programme - Course Content

Course Title: Research Methodology-I (Core course) Course Code: ES 601R

Course Instructor: KK/AKM

RM11: Basic Statistics
Introduction to Statistical Methods, Data sampling and handling, Measure of central tendencies, concept of percentage, percentile, quartile, dispersions and concepts of variation, Correlation and Regression

RM12: Time series analysis
Robustness and resistance, Homogeneity and stationarity, Discrete and Continuous data, Time vs frequency domain approaches, First-order of auto regression, Higher-order of auto regression

RM13: Plots
Stem and Leaf display, Box-plots, Schematic plots Histograms, Cumulative frequency distribution Two paired Scatterplots, Higher dimension Correlation Matrix

RM14: Multivariate Data analysis
Sampling Distributions, Concept of Hypothesis (Null and alternate hypothesis), Confidence interval and test of hypothesis (Parametric and Non-parametric), Interpretation and reporting (Highlight of data analysis)

RM15: Probability
Elements of probability, Meaning, Properties, Theoretical probability distributions: Discrete, Continuous

RM16: Basics of Computer
Introduction, Configuration Machine language(s), Computer clusters Software(s)

References
Statistics by M. R. Spiegel and L. J. Stephens (Schaum's Outlines)
Statistical Methods by G. Snedecor and W. Cochran

Course Title: Research Methodology-II (Core course) Course Code: ES 602R

Course Instructor: UCK/IG

RM21: Fundamentals of research
Philosophy and Hypothesis of research, Types of hypothesis, Methods of testing hypothesis.
Research methods- Experimental, survey, case study etc.

RM22: Research data collection methods
Laboratory experiment- Weighing, dilution, laboratory apparatus, Preparation of standards, calibration graphs, types of distributions, CRM and IRMs. Field sampling: sampling types, sampling protocols, sample

preservation and transport Sampling methods for different environmental samples e.g. aerosols, gas Sampling methods of water and soil etc. Geological and biological samples preparation Aerosol sample preparation for anions, cations Sample preparation for heavy metals.
Survey method-preparation of questionnaire, interview etc.
Miscellaneous methods- from online publications, library search, archives etc.

RM23: Preparation of manuscript in Environmental Sciences
Structuring the article-Title, authors, affiliations, contact details, abstract, Introduction, Methodology, Statistical analysis, results and discussion, interpretation of results Preparation of tables, drawing figures, conclusion, acknowledgement, referencing etc.

Communication needs before submission of manuscript- manuscript file, author details, reviewer's names, key words, abstract, graphical abstract, funding information, declaration of conflict of interests, cover letter, highlights,

RM24: Quantitative methods
Linearity, Lambert beer's law, basic principle of UV-vis spectroscopy, Basic principle of chromatography, resolution, stationary and mobile phases Chemiluminescence, NDIR, ion-exchange, detectors and their applications, Internal standard, interferences, standard addition method. Optimization of analytical method, validation of analytical method Detection limit, limit of quantification, Uncertainty, errors, standard error.

RM25: Review of literature
Scientific approach for literature survey for historical background of research, Data extraction, consulting baselines, policy influences etc.

RM 26: Field work preparations
Travel plan, logistics, check lists, seasonal clothing, sampling gazettes, safety gazettes, first aid, handy eatables, tracking kit, log book, camera, sample preservation tools, portable equipments**.**
Post-field precautions, reporting preparation, data download, sample storage, analysis records.

RM27: Importance of seminars/workshops/conferences
Objectives of academic meetings, difference between seminars/workshops/conferences terms, webinars and their usefulness.

RM28: Accreditation and ranking
Good laboratory practices (GLP) ISO and NABL
NIRH , NAAC, Times and QS rankings.

References:
Coen Louis, Lawrence Manion and Keith Morrison. 2011. Research Methods in Education. Seventh ed. Routledge Taylor, London.
Creswell, J W. 2014. Research Design. Qualitataive, Quantiative and Mixed Methods Approaches. Fourth ed. Sage Publication.
Donohue J C. 1990. Understanding Scientific Literature: A Bibliometric Approach. MIT press, London.
Egghe L., and Rousseau R. 1990. Introduction to Informetrics: QuantitativeMethods in Library, Documentation and Information Science. Elsevier, Amsterdam.

Course Title: Research and Publication Ethics (RPE) (Core course) **Code: ES 603R**

Course Instructor: PKJ/DM

Philosophy and Ethics

Introduction of Philosophy: Definition, nature and scope, concept, branches Ethics: Definition, moral philosophy, nature of moral judgments and reactions

Scientific conduct

Ethics with respect to science and research, Intellectual honestly and research integrity, Scientific misconducts: falsification, fabrication and Plagiarism, Reductant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data

Publication Ethics

Publication ethics: definition, introduction and importance, Best practices/standards setting initiatives and guidelines: COPE, WAME etc., Conflicts of interest, Publication misconduct: Definition, concept, problems that lead to unethical behaviors and vice versa, types, Violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals

Open Access Publishing

Open access publications and initiatives, SHERPA/RoMEO online resource to check publisher copyright and self-archiving policies, Software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestion tools viz., JANE, Elsevier, Journal Finder, Springer Journal Suggester, etc.

Publication Misconduct

Ground Discussions, Subject specific ethical issues, FFP, authorship, Conflict of interest, Complaints and appeals: examples and fraud from India and abroad, Software tools, Use of plagiarism software Like Turnitin, Urkund and other open source software tools.

Databases and Research Metrics

Databases Indexing, databases, Citation database: Web of Science, Scopus etc., Research Metric, Impact factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score, Metrics: h-index, g index, i10 index, altmetrics

Suggested Readings:

1. Bird, A. (2006). Philosophy of Science. Routledge. pp 324.
2. MacIntyre, A. (1967). A Short History of Ethic. Routledge & Kegan Paul PLC
3. Muralidhar, K., Ghosh, A., Singhvi, A.K. (2019). Ethics in Science Education, Research and Governance. Indian National Science Academy, New Delhi
4. Chaddah, P (2018). Ethics in Competitive Research. Self-Published. pp 128.
5. Fanelli D, (2009) How many scientists fabricate and falsify research? A systematic review and meta-analysis of survey data, PLoS ONE 4(5): e5738
6. Fang FC, Steen GR, Casadevall A, (2012). Misconduct accounts for the majority of retracted scientific publications, Proceedings of the National Academy of Sciences, doi: 10.1073/pnas.1212247109
7. Shamoo, A.E. and Resnik, D.B., (2003). Responsible Conduct of Research. Oxford University Press.
8. Todorovich, M., Kurtz, P., Hook. (1977). The Ethics of Teaching and Scientific Research. Prometheus Books.

Syllabus: Area I

Course Title: Atmospheric Processes — Course Code: ES 653R

Course In-charge: A. P. Dimri

AP 1: Basic
Structure and composition of the atmosphere, Weather elements and definitions, Moisture variables, Virtual/potential temperature

AP 2: Atmospheric Stability
Lapse rates, Stability in the atmosphere, Heat balance of the earth-atmosphere system, Mixing heights, Divergence and Convergence, Advection and Convection, Barotropic and baroclinic stability, Quasi geostrophic approximation, Hydrodynamic instability

AP 3: Fundamental Forces
Equations of motion on a rotating earth, Balanced flow, Winds, wind roses and wind profiles, Thermal wind and Vertical motion, Rossby, Richardson, Reynolds and Froude Numbers.
Turbulent diffusion equation – Eddy transport of heat, mass and momentum, Bjerknes' Circulation theorem and applications, General circulation

AP 4: Weather systems
Condensation and Precipitation, Clouds and their classification, Cumulus convection, Convective storms Fronts and frontogenesis, Monsoons, Jet streams, Extratropical and tropical cyclones

AP 5: Climate
General Circulation, Climate system, climate variability, Numerical Weather Prediction and climate models, Climate science and climate change

References

- An Introduction to Dynamics Meteorology by J. R. Holton
- Physics of Climate by Peixoto and Oort
- Contemporary Climatology by P. J. Robinson and A. H. Sellers
- Numerical Prediction and Dynamic Meteorology by G. J. Haltiner and R. T. Williams

Course Title: Urban Climate and Air Quality — Course Code: ES 690R

Course In-charge: Krishan Kumar

UC1: Introductory Concepts in Urban Climate
Urbanization and Urban Ecology, The Urban Surface, The Urban Atmosphere, Defining the Urban Climate, Methods for Measuring the Urban Climate

UC2: Urban Airflow
Basics of Wind and Turbulence Flow in the Roughness, Sub-layer Flow in the Inertial, Sub-layer Flow in the Mixed Layer

UC3: Radiation and Energy Balance in the Urban Environment
Basic Radiation Principles and Laws, Radiation in the Urban Canopy Layer, Radiation in the Urban Boundary Layer, Urban–Rural Differences of Net Radiation, Basics of Energy Transfer and Balance Anthropogenic Heat Flux, Heat Storage Change Turbulent Heat Fluxes

UC4: Moisture in the Urban Environment
Basics of Atmospheric Moisture, Urban Effects on Humidity, Urban Effects on Condensation, Hypotheses regarding

Urban Effects on Cloud and Precipitation Processes

UC5: Urban Heat Island
Urban Temperatures and Heat Island Magnitude Surface, Heat Island, Canopy Layer Heat Island, Boundary Layer Heat Island

UC6: Urban Climate – Air Quality Interaction
Basics of Air Pollution, Meteorological Controls on Air Quality in the Urban Boundary Layer, Smog and Solar Dimming, Urban Plumes

References

- Oke, T. R., Mills, G., Christen, A., &Voogt, J. A. (2017). Urban climates. Cambridge University Press.
- Landsberg, H. E. (1981). The urban climate. Academic press.
- Oke, T. R. (2002). Boundary layer climates. Routledge.
- Baklanov, A., Sue, G., Alexander, M., &Athanassiadou, M. (Eds.). (2009). Meteorological and air quality models for urban areas (Vol. 140). Berlin, Heidelberg: Springer.

Course title: Remote Sensing of Air Pollution Course Code: ES 691R

Course In-charge: Arun Srivastava Course

Aerosol Optical Depth, Lamber Bear Law and its application in AOD, Aerosol Vertical Distribution, Ground and Satellite based remote sensing, Active and Passive Remote Sensing Techniques for Retrieval of Aerosol Layer Height, Characterisation of Vertical Variables With Remote-Sensing Techniques, Sun Photometer and Spectroradiometer, Inversion principles, LIDAR and SODAR, Radiative Impacts of Aerosols, Aerosols Heterogeneity and Climatic Implications, Satellite Observations for Aerosol Monitoring, Satellite Aerosol Database, Aerosol Remote Sensing Over the Indo - Gangetic Plain, South Asia, Detection of Aerosol Episodes, Aerosol Retrieval Framework, Retrieval of Biomass Burning Episodes, Miscellaneous - Polarisation Remote Sensing.

Reading Materials:

S. No.	Name of then book	Authors	Publisher
1	Aerosol Remote Sensing	Jacqueline Lenoble, Lorraine Remer and Didier Tanre	Springer
2	An Introduction to Solar radiation	Muhammad Iqbal	Elsevier
3	Remote Sensing of Aerosols, Clouds, and Precipitation	Tanvir Islam, Yongxiang Hu, Alexander Kokhanovsky and Jun Wang	Elsevier

Course Title: Air Pollution Meteorology Course Code: ES-637R

Course In-charge: Ram Pravesh

1. **Fundamentals of Air pollution Meteorology**
   Meteorological Fundamentals and Adiabatic Diagram, Effects of Meteorological parameters on Transport and Diffusion, Pollutant Concentration Variation, Influence of Topography on Transport and Diffusion, Equation of state and conversion of concentrations and Meteorological roses

2. **Principles, Theory of Turbulence and Diffusion**
   Introduction to Turbulence and Diffusion, Types of circulation and atmospheric wind flow, The generalized Gaussian Diffusion Equation, Atmospheric Diffusion Computations, Effective Stack Height and Mixing height

3. **Meteorology and Climatology to Air Pollution**
   Introduction to Air Pollution Climatology and cloud, Atmospheric Stability and Effects of local climate on Air Pollution, Interrelationship between Meteorology and Air Pollution, Urban Effects upon Meteorological

Parameters, Atmospheric Turbidity

4. **Meteorology of an Urban Atmospheric Chemistry**
   Introduction of Atmospheric chemistry to Air Pollution, Role of Meteorology on an urban Photochemistry, Natural Removal Processes in the Atmosphere, Scavenging of tracer from the atmosphere, Analysis of Air Quality Cycles

5. **Meteorological Instruments and Their Exposure**
   Applications of Meteorology to Air pollution, Forecasting Air Pollution Potential and Air Pollution surveys, Site Selection for a Potential Source, Atmospheric Tracers and Urban Diffusion Experiments

6. **Models for Urban Atmospheric Environment**
   Introduction and Types of Meteorological models, Meteorological models used for Urban Areas, Modeling effects on climate change on Air Quality, Sources of Meteorological data and its computation

Reference:

- Arya, S. P. (1999). Air pollution meteorology and dispersion (Vol. 6). New York: Oxford University Press.
- Baklanov, A., Sue, G., Alexander, M., &Athanassiadou, M. (Eds.). (2009). Meteorological and air quality models for urban areas (Vol. 140). Berlin, Heidelberg: Springer.
- Bakunin, O. G. (2008). Turbulence and diffusion: scaling versus equations. Springer Science & Business Media.
- Blackadar, A. K. (2012). Turbulence and diffusion in the atmosphere: lectures in Environmental Sciences. Springer.
- Bradshaw, P. (2013). An introduction to turbulence and its measurement: thermodynamics and fluid mechanics series. Elsevier.
- Eagleman, J. R. (1991). Air pollution meteorology.
- Gyr, A., &Rys, F. S. (Eds.). (2013). Diffusion and transport of pollutants in atmospheric mesoscale flow fields (Vol. 1). Springer Science & Business Media.
- Harrison, R. M. (Ed.). (2012). Handbook of air pollution analysis. Springer Science &
- Business Media.
- Holzworth, G. C. (1972). Mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous United States. US Government Printing Office.
- Jacobson, M. Z., & Jacobson, M. Z. (2005). Fundamentals of atmospheric modeling.
- Cambridge university press.
- Lyons, T. J., & Scott, W. D. (1990). Principles of air pollution meteorology. Bellhaven Press.
- Scorer, R. S. (1990). Meteorology of air pollution: implications for the environment and its future. Ellis Horwood Limited.
- Seinfeld, J. H., &Pandis, S. N. (2016). Atmospheric chemistry and physics: from air pollution to climate change. John Wiley & Sons.
- Turner, D. B. (1973). Effects of meteorological parameters on transport and diffusion. EPA. Air Pollution Training Institute Control Programs Development Division Office of Air and Water Programs.
- Venkatram, A. (Ed.). (2015). Lectures on air pollution modeling. Spring

Course Title: Climate Dynamics Course Code: ES 694R

Course In-charge: A. P. Dimri

CD 1: Evolution of climate: different concepts
Evolution of Earth's atmosphere (composition of primitive atmosphere, energy balance) Earth's early climate, Paleo climate and paleo-climatic record. Ice Sheets & Climate

CD 2: Global circulation pattern
Basics of global circulation (Hadley, Ferrel, Polar cell and Walker circulation), Basics of Oceanic circulation (Thermohaline circulation, different ocean currents and heat transport), Concept of monsoon system (Large Scale Dynamics and features), Indian Monsoon, East Asian Monsoon, African Monsoon, Australian Monsoon and South American Monsoon

CD 3: Global Teleconnections
ENSO basics IOD, basics Climate Change & El Nino, The Atlantic Multidecadal Oscillation The Pacific Decadal Oscillation Quasi-biennial Oscillation

CD 4: Climate Change and Climate Modeling
Concept of climate change Natural climate change Anthropogenic Climate Change, Climate Sensitivity and Feedback Mechanisms, Basics of General Circulation Models (Numerical Modeling techniques), their evolution and Coupled Atmosphere-Ocean Processes, Introduction to the IPCC Climate Model Simulations

CD 5: Introduction to Mountain climate
Concept of mountain meteorology Interactions, with large scale circulation Mountain snow and regional climate

References

- Frederick K. Lutgens, Edward J. Tarbuck, Dennis G. Tasa: Atmosphere, The: An Introduction to Meteorology (13th Edition)
- Hartmann, D. L.: Global physical climatology (Vol. 103). Newnes
- Tom S. Garrison: Oceanography: An Invitation to Marine Science
- Barry, R. G.: Mountain weather and climate. Psychology Press

Course Title: Statistical Methods and Data Analysis in R Course Code: ES-655R

Course In-charge: Krishan Kumar

SM1: Introduction to R and preliminaries
Getting started with R Interface R Objects, Simple manipulations; numbers and vectors Arrays and Matrices, Lists and Dataframes

SM2: Working with data in R
Reading and writing data Reading data from files, Using textual and binary formats Interfaces with the external environment Subsetting R objects

SM3: Control Structures in R
Conditional execution: if statements for Loops, Repeat Loops While Loops, Writing your own functions

SM4: Recapitulation of Basic Statistics and Analysis in R
Summary Statistics in R, Concept of Random Variable and Probability fundamentals Joint Probability Distributions, Conditional and Marginal Probabilities Correlation Analysis in R

SM5: Regression Modeling
Concept of Population and Sample Regression Functions Principle of Ordinary Least Squares (OLS), Assumptions Underlying OLS Multiple Linear Regression Model Regression Modeling in R

SM6: Principles of Experimental Design and Analysis of Variance
Randomization, replication and local control, Completely randomized design (CRD) and One-Way Analysis of Variance Randomized Block Design (RBD) and Two-way Analysis of Variance ANOVA in R

References

An Introduction to R by W. N. Venables, D. M. Smith and the R Core Team. R Programming for Data Science by Roger D. Peng (2015)
R for beginners by Emmanuel Paradis (2005)

Daniel, W. W., & Cross, C. L. (2018). Biostatistics: a foundation for analysis in the health sciences. Wiley.
Johnson, R. A., Miller, I., & Freund, J. E. (2000). Probability and statistics for engineers. In Proc. Miller Freund's (pp. 546-554).
Gujarāti, D. N. (2009). Basic econometrics. Tata McGraw-Hill Education.

Course Title: Aerosol and Cloud Physics **Course Code: ES 692R**

Course In-charge: A. K. Mishra

1. **Importance of aerosols and clouds in earth system sciences**
   Role of aerosols and clouds in earth system; Aerosol radiative effects and Climate change: aerosol-radiation & aerosol-cloud interaction.
2. **Aerosol characterization and size distribution**
   Types of aerosol based on origin, shape & size; Aerodynamic and Stoke's diameter; Particle size distributions; Maxwell distribution of velocities.
3. **Fluid properties and particle motion**
   Viscosity, conductivity and diffusivity; Reynold's number; Viscous and Inertial Forces; Stoke's Law, Particle Kinetics.
4. **Cloud formation mechanisms**
   Cloud types; Mixing and convection; Cloud condensation nuclei; Cloud droplet formation: evaporation, homogeneous and heterogeneous condensation; Köhler theory: Kelvin (curvature) and solute effects; Droplet growth mechanisms (diffusion; collision-coalescence); Coagulation; Basics of warm and cold cloud processes.
5. **Aerosol & cloud optical properties**
   Extinction, Absorption and Scattering theories (Rayleigh and Mie); Single scattering albedo; Asymmetry parameter.
6. **Current status of aerosol-cloud interaction studies**
   Case studies based on regional and global studies on aerosol-cloud interaction and its impact on climate.

Reference Books:

1. Parker C. Reist (1984), Introduction to Aerosol Science, Macmillan Publishing Company, Inc.
2. R.R. Rogers & M.K. Yau, (1996), A short course in cloud physics, Butterworth- Heinemann, 3rd edition.
3. William C. Hinds, (1998), Aerosol Technology, John Wiley & Sons, Inc.
4. H. R. Pruppacher and J. D. Klett (2010), Microphysics of clouds and precipitation, Springer, 2nd Edition.
5. Recent research papers will be distributed as reading materials.

Syllabus: Area II

Course Title: Earth Processes **Course code: ES 652R**

Course In-charge: AKT

1. Earth environment

Primary differentiations of the earth and the formation of its core, Mantle, Crust, Atmosphere and hydrosphere, Plate tectonics and the formation of oceans, Continents and mountains

2. Soil environment

Weathering and soil formation, Erosion, Transport and deposition of sediments by rivers

3. Geological environment

Wind and glaciers, Geological processes and ocean margins, Land-ocean interaction, Biogeochemical cycling of elements

Course Title: Remote Sensing Applications in Geosciences **Course Code: ES-661R**

Course-In-charge: S. Mukherjee

- Principles of Satellite remote sensing: Types of remote sensing satellites, Sensor, Platform, Resolution.
- Passive and Active Remote Sensing. Visual, Near infra red, Thermal and Microwave Applications
- Data acquiring and Interpretation techniques for Visual and Digital Image processing with Ground Truthing.
- Applications: Hydrogeology: Groundwater investigation and Exploration. Mapping of Landforms, Lithology, Structure, Landuse, Soil drainage etc. and GIS integration with available Geophysical, hydrological and Hydrogeological data. Arsenic Mobilization in Groundwater study using satellite data. Use of LANDSAT, IRS, SPOT and RADARSAT data. Hydrogeomorphic Microzonation by using Satellite data.
- Applications: Engineering Geology: Lnaduse, Utility of Remote sensing data for selecting sites/areas for dams, bridges, buildings etc. Remote sensing data for alignment of Railway line, Roads, Tunnels, Pipelines, Power Grid Layout using IRS-1D and SPOT satellite data.
- Applications: Mineral/Oil Exploration: Identification and mapping of host rock, structure, anomalies (Structural, Topographical, Drainage, Landforms). GIS integration with Geophysical, Geochemical and Geobotanical data.
- Applications: Glacial advancement and Retreat by using Satellite data, PIXEL analysis
- Applications: Environmental Geology: Impact of Mining of Minerals , Overuse of Groundwater Quarrying, Reservoirs on Environment. Terrain slope study and its use in Forest fire detection.
- Applications: Natural Hazards: Global warming, Snowfall, Rainfall, Earthquake Tsunami and Landslides.
- Extra terrestrial remote sensing: Influence of Sunspot and Space weather on Environment of the Earth using SOHO satellite data for investigation of Sun-earth variables including Magnetic field and Electron Flux and Cosmic ray data. Rock types and structures of Mars and Moon by using Optical, Hyperspectral and Thermal sensors.

Books

1. Mukherjee, S. (2006). Earthquake Prediction. Published by Brill Academic Publishers Koninklijke Brill NV, Leiden (The Netherlands) & Boston (USA). ISBN-10: 90 6764 450 1 and ISBN-13 (i) 978 9067644 50
2. Mukherjee, S. (2004). Text Book of Environmental remote Sensing. Published by Macmillan India Limited New Delhi ISBN: 1403922357. INBK103842 http://www.macmillanindia.com
3. Mukherjee, S. (1999). Remote sensing Applications in Applied Geosciences. Published by Manak Publications. New Delhi. ISBN 81-86562-69-9
6. Mukherjee. S.(2011). Sun-Earth-Cosmic connection ISBN 978-3-8443-0731-3LAP Lambert Academic Publishing Germany
7. Mukherjee,S. (2013).Extraterrestrial Influence on Climate Change , ISBN 978-81-322- 07290Springer.
8. Remote Sensing Principles and Interpretation. F.F. Sabins 9. Remote sensing Applications for Mineral Exploration. William Smith

Course Title: Geochemical Cycles — Course Code: ES 644R

Course In-Charge: A. Tiwari

1: Water chemistry

Introduction of natural waters, Chemistry of dissolved materials in water, Eh and pH, Stability diagrams

2: Basic concept of cycles

Concept of cycling through time, Concept of reservoirs, Fluxes and transfer of materials, Global cycling of elements, Rates of erosion

3: Important biogeochemical cycles

Carbon cycle, Nitrogen cycle, Oxygen cycle, Phosphorus cycle, Sulfur cycle

4: Disturbance and distribution of materials

Human induced disturbances in the cycling, Hydrological systems and distribution of materials through various sub-systems, Nutrient elements, Toxic metals

5: Case studies

Geochemical cycles of selected toxic elements: Case study- Fluorine, Case study-Aluminum, Case study- Mercury, Case study-Lead

Reference books:

- Drever, James I. The geochemistry of natural waters. Vol. 437. Englewood Cliffs: prentice Hall, 1988.
- Patrick L. Brezonik, & William A. Arnold. Water Chemistry: An Introduction to the Chemistry of Natural and Engineered Aquatic Systems. Oxford university
- press, 2011
- Schlesinger, W. H., & Bernhardt, E. S. Biogeochemistry: an analysis of global change. Academic press., 2013
- Wolfe, Gordon V. Global biogeochemical cycles. Eds. Samuel S. Butcher, Robert J. Charlson, and Gordon H. Orians. Vol. 50. London: Academic Press, 1992.

Course Title: Cryosphere Studies — Course Code: ES 678R

Course In-charge: AL Ramanathan Course structure

1. **Components of the cryosphere and their time scales.**
   Cold-arid environment, Snow and Ice morphometric characteristics, Physics of snow and ice, Ice sheets, sea ice, permafrost, Distribution of snow, ice and glacier (past and present)

2. **Cryosphere changes, mass and energy balance**
   Glacier change controlling factors and formation, Mass balance, Energy Budget, Meteorological

factors/controls, Snow and ice melting process

3. **Glacier distribution, glaciation and recent changes**
   Past glaciation and paleo-climate studies, Glacial and inter-glacial cycles, Little Ice Age, Isostatic adjustment of glaciers, Landscape alteration by glaciation, Recent changes

4. **Glacier, water resources and natural disasters**
   Snow and Ice: role in regional hydrology, Subsurface hydrology, Mountain Glaciated river basins, Natural hazards by glacier and snow, e.g. GLOF, avalanche, cloudburst etc., Future water resources changes

5. **Glacier, Frozen ocean and future changes**
   Seas ice dynamics, Ice shelf, ice stream, sea ice, ocean currents and climate, Polar region cryosphere and their future perspectives, Nutrient cycling and life systems

6. **Case studies and seminars**
   Statistical and advance approaches applied in Cryosphere studies, Case study of mass and energy balance in a Himalayan glacier, Case study of disaster: e.g. GLOF and avalanche, Case study of paleoclimate studies, e.g. ice and lake core-based climate reconstruction, Case study of Polar glaciers, e.g. Arctic and Antarctica, Synthesis

Reference books:

The Cryosphere: Series: Princeton Primers in Climate(Pages: 304):https://press.princeton.edu/series/princeton-primers-in-climate:ISBN: 9780691145266(Shawn J. Marchall,2012)

Introduction to the Physics of the Cryosphere, Melody Sandells, University of Reading, UK, Daniela Flocco, University College London, UK,ISBN: 9781627053020 | PDF ISBN: 9781627053037, 2014 | 88 Pages

Glaciers and Glaciation. Arnold, London (Benn D and Evans D; 1998; 734 pp)

The physics of glaciers, 4th edn. Butterworth-Heinemann, Oxford (Cuffey KM and Paterson WSB; 2010)

Mountain Glaciers and Ice Caps (Ananichheva, M., Arendt, A., Hagen, J.O., Hock, R., Josberger, E.G., Moore, R.D., Pfeffer, W.T. and Wolken, G.J., 2011)

Glaciers and climate change. A.A Balkema Publ., Brookfield, VT (Oerlemans J; 2001) **Glossary of glacier mass balance and related terms**, IHP-VII technical documents in hydrology 86 (Cogley, J. Graham, et al.; 2011)

Other References:

- Qiu, J., 2010. Measuring the Meltdown. *Nature*, *468* (7321), 141-142.
- Vihma, T., 2014. Effects of Arctic sea ice decline on weather and climate: A review. *Surveys in Geophysics*, *35*(5), 1175-1214.
- Ross, D., 1995. Introduction to Oceanography. New York: HarperCollins College Publishers. pp. 199-226, 339-343.
- All About Glaciers. National Snow and Ice Data Center (NSIDC).https://nsidc.org/cryosphere/seaice/study/index.html. Web.
- How much water is there on, in, and above the Earth. USGS.. Web.
- NOAA: Web.
- The Intergovernmental Panel on Climate Change (IPCC), 2011. Climate Change 2011: Summary for Policymakers. Web.
- Riebeek, H., 2010. Global Warming. NASA Earth Observatory. Web.
- Poore, R.Z., Williams, R.S., Jr., and Tracey, Christopher, 2000. Sea level and climate:
- U.S. Geological Survey Web. https://serc.carleton.edu/eslabs/cryosphere/1c.html
- *A Tour of the Cryosphere 2009* is a high definition animation showing fluctuations in the cryosphere through observations collected from a variety of satellite-based sensors.. *Image/animation NASA.*

Course Title: Engineering Geology **Course Code: ES-693R**

Course In-charge: N J Raju

1. **Earth Sciences and Weathering Processes**
   The exterior and the interior of the earth, Mechanical, chemical and biological weathering processes
2. **Rock Forming Minerals and Petrology**
   Common rock forming minerals, Physical properties of minerals, Classification and formation of rocks, Types of rocks and forms of igneous rocks
3. **Structural Geology and Groundwater Occurrence**
   Formation of geological structures, Classification of folds, faults and joints, Effects of geological structures on engineering projects, Occurrence of groundwater and Types of aquifers, Potentiality of different rocks as aquifers
4. **Earth Movements and Importance of Geology**
   Classification of earth movements, Causes of landslides, Importance of geology in civil engineering
5. **Engineering Properties of Rocks and Construction Materials**
   Physical properties of rocks, Rocks as construction materials – building stones, concrete and aggregates
6. **Geology for the Selection of Dams, Tunnels and Reservoirs sites**
   Geological consideration in the selection of a Dam, Tunnel and Reservoirs sites, Importance of rock types, Importance of geological structures, Effects of groundwater, Site stabilization methods

Reference Books

- **Steve Hencher**– Practical Engineering Geology, 2012, Spon Press, London.
- **F.G. Bell** – Basic Environmental and Engineering Geology, 2007, Whittles Publishing Limited, UK
- **N CheenaKesavulu -** Text book of Engineering Geology, 1999, Macmillan India Limited, New Delhi.
- **FGH Blyth and MH de Freitas** – A geology for Engineers, 1990, ELBS, UK.
- **DP Krynine and WP Judd** – Engineering Geology and Geotechnics, 1957, Mc Graw-Hill Book Company, New York.
- **S. K. Garg -** Physical and Engineering Geology, 1999, Khanna Publishers, New Delhi.
- **Parbin Singh** – Engineering and General Geology, 2002, SK Kataria and sons, Delhi.

Syllabus: Area III

Course Title: Sustainable Environmental Management **Code: ES 695R**

Coordinator: PSK Course structure:

Fundamentals of Environmental Management

Interaction of Natural Environment and Human Society; Human Population growth; Concept of Carrying Capacity; Environmental Ethics; Understanding Environmental Changes at local, regional and global level.

Natural Resource Management and Conservation

Principles of Natural Resource Management. Understanding and planning for balanced utilization of Natural Resources with special reference to Water, Land and Forest Resources.

Water quality and quantity, rational distribution of water in Agriculture, Industry and Domestic sector. Land use planning and distribution at Local, Regional and National level. Forest conservation Act of India

Economic Development and Environmental Degradation

Concept of Environmental Economics; Natural Resource Scarcity; Theory of Supply and Demand; Environmental Costs and Benefits; Environmental Externalities. Methods of Sustainable Economic Growth.

Sustainable Development and Environmental Protection

The concept of sustainable development; Dimensions of Sustainable Development, Sustainable Development Goals (SDG), Policies of Sustainable Development at Global Regional and National Level; Implications of Sustainable Development for India.

Environmental Legislation Development and It's Implementation

Indian Constitution and Environment; History of Environmental Legislation in India, Development of Environmental policies and regulations; Important Environmental Acts in India.

Environmental Management Tools and Techniques

Voluntary Installation of Environmental Management System (EMS) and Life Cycle Analysis (LCA) in organizations. Environmental Impact Assessment (EIA) study for major development projects. Environmental Management Plan (EMP) and Environmental Clearance.

Nature of Global Environmental issues and their management.

United Nations and International Environmental Agreements and treaties such as Kyoto Protocol, Montreal protocol and Paris Agreement.

Bibiliography:

1) Introduction To Environment Management: M. M. Sulphey and M M Safeer,
2) Introduction to Environmental Management: I.V Murali Krishna Valli Manickam
3) Environmental Management: Vijay Kulkarni andT.V.Ramchandra
4) Environmental Management and Development: C.J Barrow

Course Title: Water Pollution **Course Code: ES 616R**

Course In-charge: DM

Water Quality and standards

Water Quality Standards, Potable and Palatable waters, liquid concentration units and conversions, water pollutants and their sources,

Measurement of Water Quality Parameters

Organoleptic and Physicochemical Parameters

Fundamentals of Sampling and Analysis

Water Sampling, Quality Control and Quality Assurance(QA/QC)

Water Treatment Technologies

Pre-treatment, Preliminary treatment, Primary treatment, Secondary treatment, Tertiary and/or advanced treatment, Principles and design of groundwater, surface water and Industrial wastewater treatment facilities

Water Softening Chemistry

Removal of hardness using Lime-Soda Ash Process, Base exchange process or Zeolite process, emineralization process

Coagulation and Flocculation

Colloidal suspensions, coagulation and flocculation processes, stability of colloids, Destabilization of colloids, Selection of coagulants, coagulant aids, rapid mixing, transport of colloidal particles, Flocculation – shear gradients, energy requirements, Camp no.; flocculation equipment,

Sedimentation

Sedimentation processes, discrete particle, flocculent particles, dilute suspension, concentrated suspension, Class-1 sedimentation, Class-II sedimentation, Zone settling, Compression, Stroke's law, Newton's law, Hazen and Camp relationship, settling tank design, types of settling tanks, examples

Filtration

Filtration processes, Different types of filtration used in water treatment, filtration media, grain size distribution (effective size and uniformity coefficient), rapid and slow sand filtration, filter head loss, backwashing, novel filtration designs, membrane Processes (Reverse Osmosis, Nanofiltration, Ultrafiltration, Microfiltration), advantages and disadvantages of reverse osmosis.

Adsorption and Ion exchange Processes

Adsorption and ion exchange processes, Adsorption equilibrium, Isotherms, Freundlich and Langmuir models, ion-exchnagers (anionic and cationic)

Disinfection

Different approaches to disinfection and disinfectant types, disinfection kinetics (Chick's law), Break-point Chlorination, formation of Trihalomethanes

Bibiliography:

1. Chemistry for Environmental Engineering By Clair N. Sawyer; Perry l. McCarty; G. F. Parkin, Fifth Edition, Publisher: Tata McGraw-Hill
2. Introduction to Environmental Engineering and Science By Gilbert M. Masters, Publisher: Prentice-Hall of India Private Limited, Third Edition
3. Environmental Chemistry By Stanley E. Manahan, Publisher: Lewis Publishers
4. Wastewater Engineering: Treatment and Reuse By Metcalf and Eddy, Publisher: Tata McGraw-Hill
5. Water Chemistry by Mark Benjamin Publisher: McGraw-Hill, Publishing Co.; International edition
6. Water Chemistry by Vernon L. Snoeyink and David Jenkins, Publisher: Wiley (April 17, 1980)
7. Aquatic Chemistry (Paperback) by Werner Stumm and James J. Morgan, Publisher: Tata McGraw Hill

8. Principles of Environmental Chemistry by James E. Girard, Publisher: Jones & Bartlett Publishers

Course Title: Limnology **Course Code: ES 639R**

Course In-charge: J.K. Tripathi Course

Limnology: Definition, scope, and history; Physicochemical properties of water; Hydrological cycle and global water balance.
Lentic and lotic ecosystems: Distribution, Origin and forms of rivers and lakes, Morphometry and lab practical.
Physicochemical parameters: Light, heat, major ions, oxygen, and dissolved gases in aquatic ecosystems; Heavy metals and organic compounds in water. Field demonstration and lab practicals.
Edaphic factors: Sediments, Clay Minerals, Textural analysis (lab practical), Sediment-water interface and redox potential; Biogeochemistry of nitrogen, phosphorus, sulphur, calcium and other nutrients.
Life in water: Phytoplankton, periphyton, zooplankton, fish, benthic organisms and macrophytes; Microbiology of freshwaters.
Aquatic Ecology: Primary and Secondary production, Production processes and factors influencing them; Food-chain dynamics and energetics, Trophic status; Detritus and the Carbon cycle.
Lake evolution and paleolimnology: Past productivity, the effect of climate change on rivers and lakes; Stratigraphy (Field demonstration), Carbon-14 and other dating methods, Geochemical and isotopic proxies of paleolimnology.
Use and misuse of lakes and rivers: Water Pollution, Water quality management, Water quality standards, River and lake management in India.
Field demonstrations and practical sessions: As shown in detailed syllabus sections 2, 3, 4 and 7 above. The fieldwork will be covered in the nearby areas.

Bibiliography:

1. Robert G. Wetzel, Limnology: Lake and River Ecosystems 2001, Academic Press.
2. Gerald A Cole and Paul E. Weihe, Textbook of Limnology, 2015, Waveland Press Inc.
3. James I. Drever, The Geochemistry of Natural Waters, 1997, Pearson
4. G. Nelson Eby, Principles of Environmental Geochemistry, 2004, Brooks Cole-Thomson Learning
5. Patrick L. Brezonik and William A. Arnold., Water Chemistry: An Introduction to the Chemistry of Natural and Engineered Aquatic Systems, 2011, Oxford University Press
6. Andrew S. Cohen, Paleolimnology: The History and Evolution of Lake Systems, 2003, Oxford University Press

Course Title: Air Pollution **Course Code: ES 632R**

Course In-charge: U. C. Kulshrestha

Air pollution and its sources
Definition of air pollution, atmospheric composition, natural sources, anthropogenic sources, atmospheric layers, primary pollutants, secondary pollutants.

Chemistry of air pollution
Chemistry of oxides of sulphur and nitrogen, acid rain, buffering action of crustal particles, coal chemistry, atmospheric mercury, petroleum chemistry,

Transport and deposition of chemical air pollutants
Trans-boundary pollution, long range transport of pollutants, trajectory analysis, scavenging ratios, Stock's law, eddy, sedimentation, impaction, diffusion, atmospheric brown clouds, inter- tropical conversance zone, land-atmosphere interactions.

Air pollution prevention and control methods
Air pollution control equipments for particle and gases, air pollution regulation acts, PUC, parking, congestion, catalytic converters.

Air quality & criteria and non-criteria pollutants
Criteria and non-criteria pollutants for ambient air, Air Quality Index, stack emission standards,

Air pollution chemistry and climate change
Ozone depletion, greenhouse effect, global change, reactive nitrogen, carbonaceous aerosols and radiative forcing.

Bibiliography:

Chemistry of the Upper and Lower Atmosphere Barbara, J Finlayson-Pitts & James N Pitts Jr. 978-0-12-257060-5, Elsevier (2000).
Air Pollution and Climate Change in South Asia: Issues, Impact and Initiatives. Umesh Kulshrestha (ed). 2017. Athena Academic, London, UK, ISBN 9781910390344.
Fundamentals of air pollution Daniel Vallero, Elsevier (2014).
Environmental Chemistry, A K De, New Age International Publishers (2016).
Environmental Chemistry, P S Sindhu, New Age International Publishers (2010).
The Indian Nitrogen Assessment. YP Abrol TK Adhya VP Aneja, N Raghuram, H Pathak, U Kulshrestha, C Sharma and B Singh (Eds). Elsevier, USA, ISBN: 9780128118368 (2017).
Sustainable Air Pollution Management` R Chandrappa and U C Kulshrestha. Springer ISBN_978-3-319-21595-2, e-ISBN_978-3-319-21596-9 (2015).
Air Pollution. Rao M N and Rao H V N, Tata McGraw Hill (2007).
Plant Responses to Air Pollution'. Umesh Kulshrestha and Pallavi Saxena (Eds). Springer ISBN 978-981-10-1201-3 (2016).

Course Title: Biorenewable Resources and Technology **Course Code: ES 689R**

Course In-charge: DM

Biomass as Energy Source

Units and conversion, Fundamental concepts in understanding bioenergy and biobased products, Identification of various biomass resources to be used for energy production, advantages and disadvantages in the use of biomass as energy resources

Biomass Conversion Processes
Biomass conversion processes, Difference among chemical, biological and thermal conversion processes, Biorefinery concept

Biomass Properties for Thermal Conversion and Biological Conversion
Biomass properties and characterization (heating value, proximate ultimate analyses) , equipment used for biomass characterization

Biomass thermal conversion processes

Torrefaction: Importance of torrefaction, torrefaction process, properties of torrefied biomass, energy and mass balances and yields during torrefaction processes **Combustion:** Fundamentals of biomass combustion, Mass Balances for Combustion Processes, Types of Direct Combustion Systems, Co-combustion of Biomass, **Pyrolysis:** Biomass fast pyrolysis process, Mass balance for fast pyrolysis process, Thermodynamic Requirements, biooil and biochar, Biooil properties, characterization and applications, Biomass fast pyrolysis technology

Gasification: Fundamentals of Gasification, Mass Balances for Combustion Processes , Types of Synthetic Gases, Common Types of Gasifiers

Biomass Biological conversion processes

Bioethanol: Methods for producing ethanol from biomass resources, advantages and disadvantages of bioethanol, Biogass: Methods for biogass production from various biomass resources particularly animal manure

Biodiesel Production

Properties of Fats and Oils Biodiesel Conversion Processes,

Sustainability and Economic Issues of Biomass

Software and programs for Life cycle Analysis (LCA) related to biofuel production

Bibiliography:

1. Biorenewable Resources: Engineering New Products from Agriculture, 2nd Edition By Robert C. Brown and Tristan R. Brown Wiley- Blackwell; 2nd Edition (2014)

2. Introduction to Chemicals from Biomass (Wiley Series in Renewable Resource) by James H. Clark (Editor), Fabien Deswarte (Editor) Wiley; New edition (2008)

3. Renewable Energy: Power for a Sustainable Future By Godfrey Boyle, Publisher: Oxford University Press

4. Biorefineries - Industrial Processes and Products: Status Quo and Future Directions (2 Volume Set) by Birgit Kamm (Editor), Patrick R. Gruber (Editor), Michael Kamm (Editor) Wiley-VCH (2006)

5. Beyond Oil and Gas: The Methanol Economy by George A. Olah, Alain Goeppert, and G. K. Surya Prakash) Wiley-VCH; 1 edition (March 23, 2006)

6. Biofuels Engineering Process Technology (Hardcover) by Caye Drapcho (Author), John Nghiem (Author), Terry Walker (Author) McGraw-Hill Professional; 1 edition (July 30, 2008) Elsevier Science; 1 edition (January 11, 2007)

Course Title: Chemical Speciation in the Environment **Course Code: ES 675R**

Course In-charge: S. Yadav

Introduction to chemical speciation: Importance, need and definitions

Chemical Concepts: Acids & Bases, pH; The Carbonate System; Concepts of Chemical Equilibrium and Thermodynamics processes; Metal Ions & Complexation Reactions; Dissolution & Precipitation; Oxidation & Reduction

Techniques for Chemical speciation: General strategies for speciation; Chemical extraction methods (single and multi-step); QA/QC of chemical methods; Instrumentation (Direct methods and hybrid)

Metal Speciation in aquatic environment, Metal Speciation in sediments and soils, Metal Speciation in

Atmosphere, Metal Speciation in biological systems

Case studies and discussion papers: Chemical speciation in soil, sediments and aquatic environment; Discussion on research papers

Bibiliography:

Ure A. M. Ure and Davidson C. M. Davidson (2001) Chemical Speciation in Environment. Wiley-Blackwell; 2 edition

Bernhard, M., Brinckman, F.E., Sadler, P.J. (Eds.)The Importance of Chemical "Speciation" in Environmental Processes Springer-Verlag Berlin Heidelberg

L. Ebdon, L. Pitts, R. Cornelis, H. Crews, Philippe Quevauviller, O. F. X. Donard Trace element speciation for environment, food and health. Royal Society of Chemistry

G. Nelson Eby (2004) Principles of Environmental Geochemistry Brooks/Cole

Patrick L. Brezonik& William A. Arnold (2011) Water Chemistry: An introduction to the Chemistry of Natural and Engineered Aquatic Systems. Oxford.

Supplemental Reading:

Inorganic Chemistry for Geochemistry and Environmental Sciences: Fundamentals and Applications George w. Luther, III (2016)

Dibyendu Sarkar, Rupali Datta, Robyn Hannigan Concepts and Applications in Environmental Geochemistry Elsvier

Syllabus: Area IV

Course Title: Ecosystem Processes Course Code: ES 651R

Course In-Charge: PKJ

Introduction to Ecosystem

Introduction to the term Levels of Organization Trophic Dynamics Ecosystem Model Ecological Pyramids Ecosystem Processes, Concept of Planetary Boundary, Ecosystem Organization, Design Homeostasis Gaia Hypothesis, CLAW Hypothesis Succession/Ecological Succession, Primary and Secondary Succession Theories of Ecological Succession
Ecological Stability and Diversity Theories of ecological stability Resistances, Resilience

Primary Production
Processes and Factors Ecosystem Production Whole Lake Experiments Trophic Cascade hypothesis, Disturbances including Climate Change Measuring Primary Production

Trophic Dynamics - I
Trophic Level, Autotrophic vs. heterotrophic systems Ecological Pyramids Food Chain/Web – Energy Transfer
Niche Models and Ecological efficiencies

Trophic Dynamics – II
Global Biogeochemical Cycles, (Carbon, Hydrogen, Oxygen, Nitrogen, Sulphur, Phosphorus) Disruption of Biogeochemical Cycles and its consequences International Programs on Ecosystem Processes, Ecological Restoration to Ecosystem Management Recovery (Ecosystem and Landscape approaches)

Suggested Readings:

1. Ecological Concepts and Applications by Manuel C Molles Jr.
2. Ecology Environment and Resource Conservation by J.S. Singh, S.P. Singh and S.R. Gupta
3. Ecology Environmental Sciences and Conservation by J.S. Singh, S.P. Singh and S.R. Gupta
4. Ecology from Individuals to Ecosystem by Michael Begon, Colin R Townsend, and John L Harper
5. Ecology Michael L Cain, William D Bowman and Sally D. Hacket
6. Fundamentals of Ecology by E.P. Odum and Gray W. Barrett

Course Title: Environmental Toxicology Course Code: ES 621R

Course In-charge: Ilora Ghosh

ET-1: Definition and scope of Toxicology
Toxicology and its history of evaluation as an important subject to understand, Basic principles of toxicology, Absorption and distribution of toxicants, The effects on changes of physical, chemical as well as biological components of our environment, Dose response relationship. Frequency response and cumulative response, Statistical concepts LD-50's -- potency versus toxicity, margin of safety-concepts

of hypersensitivity and hyposensitivity.

ET-2: Uptake. Biotransformation, Elimination and Accumulation of chemicals:

Toxicokinetic models, Fick's Law for diffusion, Uptake rate and route depend on K_{ow}, Saturation kinetics, Biotransformation and detoxification by Phase I and II enzymatic reaction, Biotransformation of inorganic pollutants. Rate constant based models of elimination

ET-3: Uses of exposure assessment in risk assessment:

Factors that influence toxicity and route of administration causing abnormal response to chemicals; basis of selective toxicity; Beyond the toxin frail is the grave deeper than we thought: Metabolism, Activation; Detoxification and Toxicity analysis of Xenobiotics.

ET-4: Biotransformation of environmental contaminants:

Degradation, cytochrome P450 monooxygenase, detoxification, enzymatic basis, conjugation and related systems, Cytochrome P450 and its multiple forms, differential gene expression of cytochrome P450, Cytochrome P450 induction, transcriptional and translational control at the diversity of pollutant biodegradation.

ET-5: Chemical mutagenesis and carcinogenesis:

Chemicals as caracinogens, metabolic activation, aryl hydroxylase, epoxide formation Chemicals as caracinogenic chemicals as promoters, DHA repair mechanism.

ET-6: Use of Exposure Assessment in Epidemiology:

Population based studies; Lifetime Average Daily Dose analysis for non-cancer risk to estimate Hazard index, Cancer risk estimating Hazard index and its biological monitoring.

ET-7: Genomic approaches to toxic mechanisms:

Genetic diversity, gene to ecosystem and population genetics with basic background of genetic polymorphism, To study of the response of a genome towards environmental stressors, Toxicants with molecular expression, dose-time and phenotype relationships.

ET-8: Toxicogenomics:

Introduction of Toxicogenomics and Human health, Introduction to microarray and its application in toxicology and human health, Case studies on clinical impact on polymorphisms in drug metabolizing enzymes: One, Case studies on clinical impact on polymorphisms in drug-metabolizing enzymes: Two, Application of toxcogenomicsand drug metabolism towards detoxification, Introduction to Pharmacogenomics, Case studies on clinical impact on polymorphisms towards pharmacogenomics, Towards precision on understanding genetic basis of response to detoxification, Integrating pharmacology, genetics with other technologies as transcriptomics, proteornics, metabonomics. imaging, i.e. combined approach to diagnosis.

References:

1. Texts books:

Casarett and Doull's Toxicology 6th Ed, Klaassen CD, McGrawHill 2001

Casarett and Doull's Essentials of Toxicology - the companion handbook to *Casarett and Doull*'s *Toxicology* by JB Watkins and CD Klaassen, McGraw-Hill 2003.

Ian Shaw & John Chadwick, Principles of Environmental ToxicologyTaylor & Francis, Padstow UK (1998).

Our Stolen Future by T Colborn, JP Myers, and D Dumanosky,

Goldberg, S., *Clinical Physiology Made Ridiculously Simple,* Med Master, Inc., Miami. 1997.

Goldberg, S., *Clinical Biochemistry Made Ridiculously Simple,* MedMaster, Inc., Miami. 2001.

The Common Sense Approach to Hazardous Materials, Fire, Frank. L., Fire Engineering, Penn Well Corp., 2009

2. Also recommended for background material, the need is:

a) A good biochemistry book e.g. Lehninger et al. or Stryer
b) A good cell biology book - *Molecular Biology of the cell* by Alberts et al.

The following web sites are helpful:
Haz-Map: http://hazmap.nlm.nih.gov
TOXNET: http://toxnetnlm.nih.gov
Also recommended for historical importance
Rachel Carson, Silent Spring, Published by Houghton MicHill 1962.
Demon in the Freezer: A True Story, Richard Preston, Random House Publishing Group, 2002

Course Title: Environment and Carcinogenesis **Course Code: ES691R**

Course In-Charge: PR

1. Concepts and knowledge of cancer
Introduction: Concepts and knowledge of cancer, Classification of cancer

2 Molecular Basis of Cancer
Mechanism of multi-stage carcinogenesis: Initiation, Promotion, Progression and Cell cycle regulation, Cellular metabolic pathways and cell proliferation

3 Environmental factors
Carcinogens; Metabolism of environmental carcinogens, Binding of carcinogen to DNA and covalent adduct - PAH, Interaction with Aromatic amines, Interaction with nitro- aromatic compounds 5 Interaction with halogenated compounds, *Physical agents*; Ionizing Radiation: Direct ionizing effects and effects mediated by various factors and Non-ionizing Radiation, *Chemical agents*; Diesel Emissions, Coke Oven Emissions, Coal Tar Emissions, Shale Oil, Particulate Matter, Tobacco Smoke, *Biological agents*: Viral oncogenes

4 Mutagenesis and cytogenetics
Mutagens, mutagenesis and cytogenetics, cell cycle, Chromosomal alterations, DNA damage, Cellular indicators of tumorigenicity, Regenerative Cell Proliferation, Cytotoxicity. Growth factors and Oncogenes, Tumor Suppressor Genes

5. Chemoprevention of cancer
Chemoprevention by natural products, Chemoprevention bysynthetic substances

6 Risk assessment of carcinogens; epidemiology
Exposure assessment of carcinogens, Risk assessment of carcinogens, Industrial chemicals and occupational exposure, Etiology of different cancer, Epidemiology

Reference books:

1. Cancer Biology (3rd Ed Roger) J.B. King and Mike W. Robin, Publisher, Prentice Hall and Pearson Education Ltd (2006)
2. Molecular carcinogenesis and the molecular biology of Human cancer (Ed) David Warshawsky and Joseph R Landolph Jr. Publisher: CRC Press (2006).
3. Carcinogens in Industry and the Environment (Ed) James M. Sontag. Publisher: Marcel Dekker (1981).
4. The Biology of Cancer, **Robert A. Weinberg,** Publisher: Garland Science (2006)

Course Title: Radiation and Molecular Biophysics Course Code: 636R

Course In-Charge: R. Meena

MRB 01: Overview on radiation biophysics

Atoms, nuclides, radionuclides, Structure of animal and plant cells and sub-cellular organelles, Biological macromolecules: nucleic acids, proteins, polysaccharides and lipids.

MRB 02: Radiation chemistry of free radical

Radiochemistry of water, Generation of free radicals, Macromolecular reactions of free radicals

MRB 03: Radiation detection and Dosimetry

Radiation units, detection and measurements, SAR measurements, Factors affected the SAR measurement, Exposure to biological systems

MRB 04: Biological effects of radiation at cellular and molecular level

Whole body effects, Thermal and non-thermal effects, Structural and functional changes, Oxidative stress markers, Cell signaling and apoptosis, Immunological and inflammatory markers

MRB 05: Effects on major organ systems

Immune system, Effects on Memory and behavioral pattern, Reproductive system, Cardiovascular system, liver and biliary system

MRB 06: Molecular mechanism of radiation carcinogenesis

Interaction with DNA, RNA and Nucleoproteins, Mutations and genetic instability, Micronuclei induction, Biomarkers of tumor promotion, Radical pair mechanism

MRB 07: Safety guidelines and biomedical applications

Exposure of body, Power density and radiation level, Safety criteria, New discovery of radiotherapy

References

1) Radiofrequency and Microwave Effects on Biological Tissues: Jitender Behari
2) Radiation Biology: Alison P Casarett
3) Understanding Radiation Biology: From DNA Damage to Cancer and Radiation Risk: Kenneth Chadwick
4) Biological Radiation Effects: Kiefer, Jurgen
5) Recent Reviews

Course Title: Rehabilitation Ecology Course Code: ES 678R

Course in-charge: KGS

1: Rehabilitation-conservation-development inter-linkages

Rehabilitation: the “acid test” of translating ecological concepts into on-the- ground sustainable practices, Typology, Global programmes, National programmes, Assessing effectiveness and efficiency

2: Ecological concepts: population level

Population and ecological genetics in rehabilitation ecology, Eco-physiological dimensions in rehabilitation setting, Implications of population dynamics and metapopulation theory in rehabilitation, Evolutionary restoration ecology, Rehabilitating/restoring populations

3: Ecological concepts: community level

Connecting community ecology theory with rehabilitation, Global, regional and local processes, Environmental conditions and habitat characteristics, Scalar dynamics, Food web approaches

4: Ecological concepts: ecosystem level

Resistance, resilience and ecosystem complex, Topographic heterogeneity and ecological rehabilitation, Multiple and alternative states of ecosystems, Multiple and alternative rehabilitation trajectories, Multi-functionality, Characterizing sustainable rehabilitation

5: Logical framework approach

Generic version of logical framework, Rehabilitation planning, Rehabilitation monitoring and evaluation

6: Case studies

Statistical issues and study designs in rehabilitation, Case study – rehabilitation of grasslands, Case study –rehabilitation of forests, Case study-rehabilitation of agricultural lands, Case study-rehabilitation of landscape and socio-ecological systems, Synthesis

Reference books:

Bradshaw, A.D. and Chadwick, M.J. 1980. The Restoration of Land: the Ecology and Reclamation of Derelict and Degraded Land. University of California Press, Los Angeles, California.

Falk, D.A., Palmer, M.A. and Zedler, J.B. (Eds.) 2006. Foundations of Restoration Ecology, Island Press, Washington D.C.

Ramakrishnan, P.S. 1992. Shifting Agriculture and Sustainable Development: An Interdisciplinary Study from North-Eastern India, UNESCO, Paris and The Parthenon Publishing Group, Carnforth.

Course Title: Host-Pathogen interaction and Environment Course Code: ES-687R

Course In-charge: KM

HPIE 01: Overview on Infectious Microbes

Types of microbes, Human diseases caused by virus and bacteria, Human disease caused by fungus and protozoa

HPIE 02: Pathogenicity of Microorganisms

Host pathogen relationship, Pathogenesis of viral diseases, Pathogenesis of bacterial diseases, Pathogenesis of fungal and protozoan diseases, Toxigenicity, Evasion of host defense

HPIE 03: The Epidemiology of Infectious Disease

Epidemiological terminology, Recognition of an infectious disease, Infectious disease cycle, Transmission of pathogen

HPIE 04: Overview on Host Immune System

Normal microbiota of the human body, Cells, tissues and organs of immune system, Physical and chemical barriers in nonspecific resistance, Inflammation and phagocytosis, The complement system, Cytokines and natural killer cells

HPIE 05: Antimicrobial Chemotherapy

General characteristics of antimicrobial drugs, Mechanisms of action of antimicrobial drugs, Factors influencing the effectiveness of antimicrobial drugs

HPIE 06: Environmental Factors Associated with Emergence of Diseases

Emerging and reemerging infectious diseases and pathogens, Mechanisms of antimicrobial resistance, Antibiotic misuse and drug resistance, The origin and transmission of drug resistance, Role of agriculture, animal husbandry in the transmission of antibiotic resistance

HPIE 07: Understanding the New Strategies to Control Infectious Diseases

Emerging tools and technology for countering antibiotic resistance, New discovery of antimicrobial agents

Course Title: Man and Tropical Forest Ecosystem Function Course Code: ES-624R

Course In-Charge: SCG

Unit I: Ecosystem concept-Temporal and spatial dimensions; Sustainable development concept-Spatial and temporal dimensions.

Unit II: Carbon fluxes: Carbon pools and fluxes, Decomposition and stabilization of organic matter, Net ecosystem production, Phenology as strategy to optimize carbon gains, Nutrient partitioning, Nutrient resorption

Forest hydrological processes, Perturbations and forest ecosystem properties.

Water fluxes: Water uptake by trees, Tree water relations: Water transport from soil to plants, Xylem water transport, Phloem water transport, Transpiration, Responses of plants to drought

Unit III: Forest ecosystem function: General characteristics; Primary productivity of forest ecosystems, litter production and decomposition, nutrient cycling and nutrient conservation strategies, plant water relations.

Unit IV: Forest ecosystem function: Global change and forest ecosystem, Climate change, - Biodiversity depletion, Biological invasion.

Unit V: Various facets of biodiversity, Biodiversity assembly rules and environment filters, Species identity and dominance effects on ecosystem processes, Biodiversity effect on biomass production, Biodiversity effects on ecosystem multifunctionality, Mechanisms underlying biodiversity-ecosystem functioning relationships, value of biodiversity-ecosystem functioning.

Unit VI: Natural versus Human managed ecosystems; Complex agroecosystems of traditional societies. Structure and organization, stability and resilience; forest ecosystem function as related to social economic and cultural perceptions of traditional societies; Indicators of sustainable development; Rural ecosystem rehabilitation; Value of traditional science and technology for sustainable management of natural resources; People's perception of environment and development and community participation; Why people's participation? Conceptual issues of Humans as part of ecosystem function.

Course Title: Himalayan Ecology Course Code: ES 696R

Course In-Charge: PKJ

Himalayan Environment and Development

Mountain ranges of the world, UN Agenda 2030, Mountain in SDGs2030 Mountain oriented policy – global perspective, Biological Diversity, Climate setting Physical setting, Socio-ecological settings Forests & forestry, Water Resources Cultural Diversity, Landscapes, communities and Livelihoods Traditional knowledge system Transhumant, pastoralism and collectors Urbanization, Tourism and Sustainability, Adventure tourists/eco-tourists/religious tourist and sightseers Conservation and

development issues, Sustainable Future, Environmental Issues Disasters and Climate Change Political and governance issues, Economic, Cultural and Environmental needs (SDGs vis-à-vis Himalaya)

Related Readings:
Forest vegetation of the Himalaya by J. S. Singh & S. P. Singh
Himalaya: A Human History by Ed Douglas
Life in the Himalaya by Maharaj K Pandit

Course Title: Cell and Environment (CE) Course Code: ES622R

Course In-Charge : Ilora Ghosh

CE-1: Introduction to cell and its micro-environment
Introduction to cell and environment on micro-environment, Cellular interaction with pollutants at the biomacromolecular level, Its reflection on the gene expression and cell behaviour, Its reflection on cellular signalling.

CE-2: Cell to cell signalling and effect of environmental factor
Extra-cellular signals, Cell surface receptors and xenobiotics, Receptor and non-receptor kinases on cellular signalling, Nuclear translocation protein and signal transduction, G-protein cascade and a case study

CE-3: The structural and functional properties of major classes of cell surface receptors
Regulation of receptors internalization, Turnover via stimulation of protein phosphorylation with specificity for serine and theonine residues

CE-4: Focuses on components important for cytoplasmic signal transduction coordinated with environment
Induction ofprotein phosphorylation due to xenobiotics exposure in cellular system, Signalling pathways involve in protein phosphorylation during abnormal signalling, Activities of cytoplasmic phosphatase and its importance for regulating the magnitude and duration of signalling cascade due to xenobiotics.

CE-5: Nuclear responses due to environmental pollutant and impacts:
Focus on cellular signalling delineated all the way from cell surface to the nucleus during xenobiotic interactions, Regulation of transcription factors by phosphorylation due to surface interaction of pollutant, Mechanism of control of cell cycle and structural and functional properties of tumor suppressor p53.

List of Books:
Signal Transduction Edited by Carl-Henrik Heldin and Mary Purton Published by Chapman and Hall, An imprint of Thomson Science, UK.
Recent reviews related to the course structure in Scientific Journals and Publications.

Course Title: Environmental Microbial Genomics Course Code: ES 688R

Course In-Charge: M. Dua

Exploiting a genomics approach to develop a terrestrial biomarker for heavy metal contamination: Genomics of thermophiles, The Genomes of pathogenic intracellular bacteria, Metagenomics: DNA sequencing of environmental samples, Genomics to study changes in gene expression in response to eutrophic & oligotrophic conditions, Genomics of Actinobacteria, the high G+C gram positive bacteria, A survey of plant pathogen genomes, Genome sequence of an extremely halophilic archaeon, Microbial

Population genomics and ecology, Application of genomics to biocatalysis and biodegradation, A genomic approach to vaccine development, Evolution of microbial nitrilase gene family: a comparative and environmental genomics study, Wastewater treatment: a model system (using genomics) for microbial ecology, Transcriptomics, proteomics and interactomics: unique approaches to track the insights of bioremediation

Suggested readings:

- Microbial genomes by CM Fraser, T Read and KE Nelson
- Internet browsing with combination of keywords like environment, genomics, microbes, ecology, pathogenesis, bioremediation, diversity, communities etc
- Pub Med papers on the above-mentioned keywords
- Molecular Microbial Ecology (Advanced methods) by A. M. Osborn
- Principles of gene manipulation and genomics by SB primrose and RM Twyman
- Introduction to Genomics by Arthur Lesk
- Genomes 3 by TA Brown

Course Title: Climate Change, Air Quality and Plants Course Code: ES 643R

Course In-Charge: U. Mina

1: Climate Change, Air Quality and Plant ecology inter-linkages, approaches

Global environment, climate change, air quality attributes and plants, interlinkages, Typology, Global programmes, National programmes, Assessing effectiveness and efficiency

2: Climate Change and Plant ecology

Climate and evolution and distribution of Plant Diversity, Plant ecology indicators of Climate Change, Plant functional Traits and Climate change Impact, Plant biodiversity and climate change

3: Air Pollution and Plant Ecology

Key phytotoxic air pollutants Deposition and Uptake by Vegetation, Air pollutants impacts at all levels of plant organisation from molecular, whole plant to community, Air pollutants role in altering plant response to common stresses, both abiotic and biotic

4: Plants and mitigation of climate change and air pollution

Plant role in adaptation and mitigation of climate change impacts, Plants as air pollution bioindicators, Plants efficiency in air pollution mitigation, Innovative approaches and plant based emerging technologies

5. Application and Logical framework approach

Statistical issues and experimental designs, Student participation: assignment and presentations of primary literature

6: Case studies

Case study – Climate change impact and plant diversity, Case study –Climate change and adaptation in plant diversity, Case study-Plant based climate change mitigation approach, Case study-Air pollution impact of plant diversity, Synthesis – Plant based air pollution mitigation approach

Reference books, Journals and online resources

1) J. N. B. Bell and M. Treshow(Eds.) 2002. Air Pollution and Plant Life, 2nd Edition, Wiley Publication.
2) EvgeniosAgathokleous, ElisaCarrari and Pierre Sicard(Eds.) 2019, Air Pollution and Plant Ecosystems. Climate (ISSN 2225-1154). Open Access Journal by MDPI

3) R. M. M. Crawford (2008). Plants at the Margin: Ecological Limits and Climate Change, Cambridge University Press
4) Journal – TREE (Trends in Ecology and Evolution)
5) Global Change Biology
6) Ecological Indicators
7) https://royalsocietypublishing.org
8) https://www.pnas.org
9) Botanical Information and Ecology Network. https://bien.nceas.ucsb.edu/bien/publications/