JAWAHARLAL NEHRU UNIVERSITY
SCHOOL OF ENVIRONMENTAL SCIENCES

Minutes of the 97th (A) Meeting of the Special Committee of the School convened by e-mail through circulation of Agenda

In the beginning by the email message to the Special Committee members, Prof. U. C. Kulshrestha, Dean and Chairperson of the Special Committee welcomed the new members (Prof K S Rao, Dr C Sharma and Dr M V Ramana) of the special committee and thanked the outgoing members (Prof R K Dixit, Prof R K Srivastava, and Prof A D Rao) for their constant support to the school. He also informed the committee members that due to the present Covid-19 pandemic, it was not conducive to hold the meeting physically, hence the 97th (A) Meeting of the Special Committee of the School was convened through circulation by e-mail. The Agenda items of both Part A and Part B of the 97th Special Committee were circulated among the following members vide e-mail dated 07.12.2020 and additional agenda of Part B on 09.12.2020.

1. Prof. U. C.Kulshrestha - Chairperson
2. Prof. K. S. Rao
3. Dr. Chhemendra Sharma
4. Dr. M. V. Ramana
5. Prof. M. Ravichandran
6. Prof. Sunil Kumar Singh
7. Prof. S. Balasundaram
8. Prof. D.P. Vidyarthi
9. Prof. K.G. Saxena
10. Prof. I.S. Thakur
11. Prof. S. Mukherjee
12. Prof. P.S. Khillare
13. Prof. A. L. Ramanathan
14. Prof. Krishan Kumar
15. Prof. A.P. Dimri
16. Prof. Kasturi Mukhopadhyay
17. Prof. Dinesh Mohan
18. Prof. S.C. Garkoti
19. Prof. N.J. Raju
20. Prof. P.K. Joshi
21. Prof. Jayant Kumar Tripathi
22. Prof. Paul Raj R.
23. Dr. Ilora Ghosh
24. Dr. Sudesh Yadav
25. Dr. Usha Mina
26. Dr. Meenakshi Dua
27. Dr. Arun Kr. Srivastava
28. Dr. Ramovatar Meena
29. Dr. Amit Kumar Mishra
30. Dr. Ram Pravesh Kumar
31. Dr. Ashwani Kumar Tiwari

It may be noted that the Agenda of the 97th (A) Meeting of the Special Committee was not circulated among student representatives of the School, since the University has not approved election of the JNUSU 2019-2020.

The members were requested to go through the Agenda and provide their comments by 10.12.2020 by 10:a.m (morning). Comments received from Committee members before 10 a.m. on 10.12.2020 were incorporated in the minutes. It was further stated that if, no comments/reply is received by 10 a.m on 10.12.2020, the agenda items will be considered as approved. Therefore, the following Agenda items of 97th (A) Meeting of the Special Committee of the School convened through circulation (by e-mail) are hence considered approved.

Item No. 1: The Committee noted that during Monsoon Semester 2020-21, a total of 162 students were registered which includes 33 students in MSc, 96 in Ph D, 17 in MPhil and 16 in 9(b).

Item No. 2: (*Item No. 3 in the circulated agenda may be read as Item No.2*) The Committee noted the names of the following M.Sc. and M.Phil/Ph.D students, whose names have been removed from the rolls of the University on the reasons mentioned against each:

Sl. No.	**Name of the Students/ Program of Study**	**Reg. No.**	**Date of the Admission**	**Date from which name removed**	**Reason**
1	Reema Tiwari	26365	29.07.2013	05.09.2020	Not Registered in Monsoon Semester 2020-21
2	Nischal Sharma	1201026857	16.07.2019	05.09.2020	Not Registered in Monsoon Semester 2020-21
3	Pooja Yadav	1321000195	02.08.2019	05.09.2020	Not Registered in Monsoon Semester 2020-21
4	Shreya Dubey	2091000959	05.08.2019	05.09.2020	Not Registered in Monsoon Semester 2020-21
5	Sonal Gaur	1201029364	17.07.2019	05.09.2020	Not Registered in Monsoon Semester 2020-21
6	Ashutosh Kumar Yadav	1911002860	10.07.2019	05.09.2020	Not Registered in Monsoon Semester 2020-21
7	Karma Sichoe	1201007402	11.07.2019	05.09.2020	Not Registered in Monsoon Semester 2020-21
8	Piyush Kumar Ojha	68425	27.07.2018	05.09.2020	Not Registered in Monsoon Semester 2020-21
9	Nguyen Van Linh	2018146	12.10.2018	05.09.2020	Not Registered in Monsoon Semester 2020-21

(U.C.Kulshrestha)
Dean & Chairperson, Special Committee, SES, JNU

JAWAHARLAL NEHRU UNIVERSITY
SCHOOL OF ENVIRONMENTAL SCIENCES

Minutes of the 97th (B) Meeting of the Special Committee of the School convened by e-mail through circulation of Agenda

In the beginning by the email message to the Special Committee members, Prof. U. C. Kulshrestha, Dean and Chairperson of the Special Committee welcomed the new members (Prof K S Rao, Dr C Sharma and Dr M V Ramana) of the special committee and thanked the outgoing members (Prof R K Dixit, Prof R K Srivastava, and Prof A D Rao) for their constant support to the school. He also informed the committee members that due to the present Covid-19 pandemic, it was not conducive to hold the meeting physically, hence the 97th (A) Meeting of the Special Committee of the School was convened through circulation by e-mail. The Agenda items of both Part A and Part B of the 97th Special Committee were circulated among the following members vide e-mail dated 07.12.2020 and additional agenda of Part B on 09.12.2020.

1. Prof. U. C.Kulshrestha - Chairperson
2. Prof. K. S. Rao
3. Dr. Chhemendra Sharma
4. Dr. M. V. Ramana
5. Prof. M. Ravichandran
6. Prof. Sunil Kumar Singh
7. Prof. S. Balasundaram
8. Prof. D.P. Vidyarthi
9. Prof. K.G. Saxena
10. Prof. I.S. Thakur
11. Prof. S. Mukherjee
12. Prof. P.S. Khillare
13. Prof. A. L. Ramanathan
14. Prof. Krishan Kumar
15. Prof. A.P. Dimri
16. Prof. Kasturi Mukhopadhyay
17. Prof. Dinesh Mohan
18. Prof. S.C. Garkoti
19. Prof. N.J. Raju
20. Prof. P.K. Joshi
21. Prof. Jayant Kumar Tripathi
22. Prof. Paul Raj R.
23. Dr. Ilora Ghosh
24. Dr. Sudesh Yadav
25. Dr. Usha Mina
26. Dr. Meenakshi Dua
27. Dr. Arun Kr. Srivastava
28. Dr. Ramovatar Meena
29. Dr. Amit Kumar Mishra
30. Dr. Ram Pravesh Kumar
31. Dr. Ashwani Kumar Tiwari

The members were requested to go through the Agenda and provide their comments by 10.12.2020 by 10:a.m (morning). Comments received from Committee members before 10 a.m. on 10.12.2020 were incorporated in the minutes. It was further stated that if, no comments/reply is received by 10 a.m on 10.12.2020, the agenda items will be considered as approved. Therefore, the following Agenda items of 97th (A) Meeting of the Special Committee of the School convened through circulation (by e-mail) are hence considered approved.

Item No. 1: The Committee approved the Ph.D. Synopsis in respect of the following student(s) as recommended and forwarded by the supervisor(s) after duly recommended by the Doctoral Committees:

SI. No.	Name of the Student	Title of Synopsis	Supervisor
1.	Mr. Ajith M P	**Removal of harmful chemical and microbial contaminants from Yamuna water using nano-composites.**	Prof. Paulraj R.
2.	Ms. Jayshree Das	**Characterizing impacts of fire on forested landscape of Odisha.**	Prof. P.K. Joshi
3.	Ms. Sonali Sharma	**Regulating ecosystem services in urbanising landscapes of Western Himalaya.**	Prof. P.K. Joshi
4.	Ms. Jyoti Kushawaha	**Evaluation of Groundwater Quality and Impact of Saline Water Intrusion in the Coastal Aquifers in Parts of Puri District, Odisha, India.**	Prof. N. Janardhana Raju
5.	Mr. Anand Kumar Yadav	**Lignocellulosic waste-derived biochars for sorptive dye removal from water.**	Prof. Dinesh Mohan
6.	Brahmacharimayum Preetiva	**Effect of Sustainable Biochars on Saline Soil Reclamation and Plant Growth.**	Prof. Dinesh Mohan
7.	Swastik Behera	**An Attempt to Resurrect the Abandoned Antibiotics against Resistant *Staphylococcus aureus* through Combination with Analogues of α-MSH.**	Prof. Kasturi Mukhopadhyay
8	Ms. Prachika	**Alpha-Melanocyte Stimulating Hormone Based Peptides as Potential Therapeutics against the Emerging Multi-drug Resistant Coagulase Negative Staphylococci**	Prof. Kasturi Mukhopadhyay
9	Ms. Sonali Rajput	**Prevalence, Antimicrobial Resistance and Virulence of Methicillin Resistant Staphylococci from Urban Waste Water in Delhi NCR**	Prof. Kasturi Mukhopadhyay
10	Mr. Ashim Chandra Roy	**The Role of Tetra-hydro Serpentine on Modulation of Oxidative Stress in Mammalian System**	Dr. Ilora Ghosh
11	Abdul Wahid Monib	**Chemical Characterisation of Surface Dust and Soil of Kandahar Region, Afghanistan and its Environmental Implications**	Dr. Sudesh Yadav

12	Mr. Mohammed Ahmed Musallam Al-Shali	**Assessment of Heavy Metal Contamination in Agricultural Farm System of Oman**	Dr. Ramovatar Meena Co-supervisor Dr. Ahmed Al-busaidi (SQU, Oman)

Item No. 2: The Committee noted the award of M.Phil./Ph.D. degrees of the University to the following students:

Doctor of Philosophy:

SI. No.	Name of the Student	Supervisor	Date of Viva-voce
1.	Ms. Prachi Singh	Prof. Dinesh Mohan	18.02.2020
2.	Mr. Naveen Kumar	Prof. AL. Ramanathan	02.03.2020
3.	Mr. Vineet Vimal	Prof. Dinesh Mohan	12.03.2020
4.	Mr. Namrata Priya	Prof. AL. Ramanathan	12.03.2020
5.	Mr. Hemant Kumar	Prof. Dinesh Mohan	16.06.2020
6.	Ms. Sana Mumtaz	Prof. K. Mukhopadhyay	08.07.2020
7.	Md. Maroof Azam	Prof. J.K. Tripathi	10.07.2020
8.	Mr. Prabhat Kashyap	Prof. Krishan Kumar	15.07.2020
9.	Mr. Thupstan Angchuk	Prof. AL. Ramanathan	15.07.2020
10.	Ms. Manisha Mishra	Prof. U.C. Kulshrestha	16.07.2020
11.	Ms. Madhavi Jain	Prof. A.P. Dimri	17.07.2020
12.	Mr. Praveen Kumar Rai	Prof. A.P. Dimri	22.07.2020
13.	Mr. Abhishek Verma	Prof. S.C. Garkoti	04.08.2020
14.	Mr. Mayank Krishna	Prof. S.C. Garkoti	06.08.2020
15.	Mr. Prince Kumar	Prof. K. Mukhopadhyay	12.08.2020
16.	Ms. Harshita Asthana	Prof. S. Mukherjee	19.09.2020

Master of Philosophy:

SI. No.	Name of the Student	Supervisor	Date of Viva-voce
1.	Mr. Kalyan Biswal	Prof. AL. Ramanathan	28.02.2020
2.	Mr. Sadan Kumar Sharma	Dr. Ilora Ghosh	28.07.2020

Item No. 3: Allotment of the PhD Supervisor in respect of the following student is approved as below:

SI.No.	Name of the Student	From	To
1.	Mr. Sadan Kumar Sharma	Dr. Ilora Ghosh	Dr. Ramovatar Meena

Item No.4. The Committee approved the request of the following students, on the recommendations of 3-Member Committee to re-register themselves under clause 9(b) of the M.Phil/Ph.D ordinance prevailing at the time of their admission in the University:

SI.No.	Name of the Student	Supervisor	w.e.f.
1.	Mr. Saurabh Kumar Singh	Prof. J.K. Tripathi	As per university guidelines
2.	Ms. Karuna Rao	Prof. AL. Ramanathan	-do-
3.	Ms. Arohi Dixit	Dr. Ashwani Kumar Tiwari and Dr. N. S. Siddaiah	-do-
4.	Ms. Akanksha Verma	Prof. Paulraj R.	-do-
5.	Ms. Anju	Dr. Sudesh Yadav	-do-
6.	Mr. Amarjeet	Dr. Sudesh Yadav	-do-
7.	Ms. Pinky Doley	Prof. K.G. Saxena	-do-
8.	Mr. Rajeshwar Pratap Singh	Dr. Meenakshi Dua	-do-
9.	Ms. Kundan	Prof. P.K. Joshi	-do-
10.	Ms. Sudesh	Prof. U.C. Kulshrestha	-do-
11.	Mr. Shailendra Kumar	Prof. S.C. Garkoti	-do-
12.	Mr. Kamal Kishor	Prof. Dinesh Mohan	-do-
13.	Ms. Aparna C R	Dr. Ilora Ghosh	-do-
14.	Ms. Nishi Sahu	Dr. Ilora Ghosh	-do-
15.	Moh Naseem	Prof. U.C. Kulshrestha	-do-
16.	Ms. Deepali Singh	Prof. S. Mukherjee	-do-
17.	Ms. Kanchan Tiwari	Prof. K. Mukhopadhyay	-do-
18.	Mr. Anurag Chaudhary	Prof. J.K. Tripathi	-do-
19.	Mr. Amit Kumar Yadav	Prof. P.S. Khillare	-do-
20.	Ms. Zainab Siddiqui	Prof. P.S. Khillare	-do-
21.	Ms. Midhuna T.M	Prof. A. P. Dimri	-do-
22.	Ms. Prerana Joshi	Prof. NJ Raju and Dr. N. S. Siddaiah	-do-

Item No. 5: **De-registration of the following candidates which was referred to the JNU administration has been decided as below-**

Sl. No.	Students Name	MPhil or Ph.D.	Supervisor	Decision
1.	Ms. Nina Nancy Murmu	Ph.D	Prof. Paul Raj	Approved
2	Mr. Dudun Mehta	Ph.D	Dr. A K Srivastava	Approved
3.	Ms. Prachika	Ph.D	Prof. K Mukhopadhyay	Not approved due to minimum residency period.

Item No. 6: **The Committee recommended Zero Semester of the following students as recommended and forwarded by their Supervisor.**

Sl. No.	Students Name	MPhil or Ph.D.	Semester	Supervisor
1.	Ms. Juhi Gupta	PhD	Winter semester 2019-20	Prof. I. S. Thakur
2.	Ms. Neha Chauhan	Ph.D	Winter Semester 2020-21	Prof. P. K. Joshi

Item No. 7. The Committee approved the following courses which are newly introduced:-

i. ES 690R Urban Climate and Air Quality.
ii. ES 691R Remote Sensing of Air Pollution.
iii. ES 696R Himalayan Ecology.

The course content of the courses is given in Annexure I.

Item No. 8. The Committee approved the modification in titles of the following courses:-

i. ES 643R `Climate Change and Air Pollution Implications on Plant Biodiversity' as `Climate Change, Air Quality and Plants.
ii. ES 655R ` Statistical Methods' to `Statistical Methods and Data Analysis in R'.
iii. ES 689R `Bio-renewable Resources' to ` Bio-renewable Resources' and Technology'.

Item No. 9: The Committee approved the course content of MPhil/PhD syllabus which has been revised by the Syllabus Revision Committee which had the following members:-

Prof U C Kulshrestha	Chairman
Prof A P Dimri	Member (Convener, Area I)
Prof N J Raju	Member (Convener, Area II)
Prof Dinesh Mohan	Member (Convener, Area III)
Prof P K Joshi	Member (Convener, Area IV)
Prof K. Mukhopadhyay	Member
Prof Paulraj R	Member

The Course content of the following courses is given in the **Annexure I.** The committee noted that the Syllabus Revision Committee had a number of rounds of online meetings and email exchanges for due deliberations. The course content has also been discussed among the area of concern for which Area Leaders had due deliberations. Then it was circulated to the faculty. The finalized content is approved.

Core Courses (Mandatory for all): total 6 credits (to be taught by multiple faculty)		
S.No.	**Course Nomenclature**	**Credits**
ES601R	Research Methodology I (RM-I)	2
ES602R	Research Methodology II (RM-I)	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 evaluation process for each of the course work would be as follows:

Activities	**Marks**
Tutorial/assignment/quiz/term paper before Mid Semester	10 Marks
Mid Semester Exam	30 Marks
Tutorial/assignment/quiz/term paper Before End Semester	10 Marks
End Semester	50 Marks
Total	100 Marks

Item No. 10: The Committee approved the panel of examiners as given in the Annexure II.

Item No. 11: The Committee approved revision of Title of PhD synopsis as recommended by DRC in respect of the following:

SI.No.	Student Name	Previous Title	Revised Title	Supervisor
1.	Mr. Arindan Mandal	Distributed modeling of mass and energy balance and boundary processes of Chhota Shigri glacier in northern India	"Modeling of Mass and Energy Balance and Boundary Processes of Chhota Shigri Glacier in Northern India"	Prof. AL. Ramanathan

(U. C. Kulshrestha)
Dean & Chairperson
Special Committee, SES, JNU

Course Content

Course Title: Research Methodology-I(Core course)

Course Code: ES 601R

Couse Coordinator: APD (to be taught by multiple faculty).

Course structure

The course comprises of five modules listed in table below. Each module has given hour units.

Modules	Unit Title	Teaching hours
RM11	Basics Statistics	6
RM22	Time series analysis	6
RM13	Plots	4
RM14	Multivariate Data analysis	6
RM15	Probability	4
RM16	Basics of Computer	4

Syllabus in detail

RM11: Basic Statistics (6 hrs) 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 (6 hrs)

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 (4 hrs)

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

RM14: Multivariate Data analysis (6 hrs)

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 (4 hrs)

Elements of probability
Meaning

Properties
Theoretical probability distributions: Discrete, Continuous

RM16: Basics of Computer (4 hrs)

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 Code: ES 602R
Couse Coordinator: UCK (to be taught by multiple faculty).

Course structure

The course comprises of 7 modules listed in table below. Each module has given hour units.

Modules	Unit Title	Teaching hours
RM21	Fundamentals of research	2
RM22	Research data collection methods	10
RM23	Preparation of manuscript in Environmental Sciences	3
RM24	Quantitative methods	7
RM25	Review of literature	2
RM26	Field work preparations	2
RM27	Importance of seminars/workshops/conferences.	1
RM28	Laboratory accreditation	3

Syllabus details:

RM21: Fundamentals of research (2).

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

RM22: Research data collection methods (10)

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 (3).

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 (7)

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 (2).

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

RM 26: Field work preparations (2).

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 (1).

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

RM28: Accreditation and ranking (3)

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)

Code: ES 603R

Course Coordinator: PKJ (to be taught by multiple faculty).

Course structure

The course comprises of six modules listed in table below. Each module has 4-5 units.

Modules	Unit Title	Teaching hours
1	Philosophy and Ethics	3
2	Scientific Conduct	4
3	Publication Ethics	7
4	Open Access Publishing	4
5	Publication Misconduct	4
6	Database and Research Metrics	7

Syllabus in detail

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 Likeke 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

Course structure

The course comprises of five modules listed in table below. Each module has given hour units.

Modules	**Unit Title**	**Teaching hours**
AP 1	Basic	4
AP 2	Atmospheric Stability	4
AP 3	Fundamental Forces	8
AP 4	Weather Systems	8
AP 5	Climate	6

Syllabus in detail AP

1: Basic (4 hrs)
Structure and composition of the atmosphere
Weather elements and definitions
Moisture variables, Virtual/potential temperature

AP 2: Atmospheric Stability (4 hrs)
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 (8 hrs)

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 (8 hrs)

Condensation and Precipitation
Clouds and their classification
Cumulus convection

Convective storms Fronts
and frontogenesis
Monsoons
Jet streams
Extratropical and tropical cyclones.

AP 5: Climate (6 hrs)

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 690 R (New)
Course In-charge: Krishan Kumar

Course structure

- The course comprises of six modules listed in table below. Each module has given hour units. Modules

Module title
UC1 Introductory Concepts in Urban Climate
UC2 Urban Airflow
UC3 Radiation and Energy Balance in the Urban
Environment
UC4 Moisture in the Urban Environment
UC5 Urban Heat Island
UC6 Urban Climate – Air Quality Interaction
Teaching hours 5

Syllabus in detail

UC1: Introductory Concepts in Urban Climate (5hrs)

- Urbanization and Urban Ecology
- The Urban Surface
- The Urban Atmosphere
- Defining the Urban Climate
- Methods for Measuring the Urban Climate

UC2: Urban Airflow (4 hrs) 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 (8 hrs)

- 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 (4 hrs)

- 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 (4 hrs)

- Urban Temperatures and Heat Island Magnitude Surface
- Heat Island
- Canopy Layer Heat Island
- Boundary Layer Heat Island

UC6: Urban Climate – Air Quality Interaction (4 hrs)

- 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 (New)

Course In-charge: Arun Srivastava

Course Details:

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-637(Revised)
Course In-charge: Ram Pravesh

Course structure

The course comprises of six modules listed in table below. Each module has 4-5 units.

Modules Title

1. Fundamentals of Air Pollution Meteorology
2. Principles, Theory of Turbulence and Diffusion
3. Meteorology and Climatology to Air Pollution
4. Meteorology of an Urban Atmospheric Chemistry
5. Meteorological Instruments and Their Exposure
6. Models for Urban Atmospheric Environment

Syllabus in detail

1. Fundamentals of Air pollution Meteorology (6 hours)

1) Meteorological Fundamentals and Adiabatic Diagram
2) Effects of Meteorological parameters on Transport and Diffusion
3) Pollutant Concentration Variation
4) Influence of Topography on Transport and Diffusion.
5) Equation of state and conversion of concentrations and Meteorological roses

2. Principles, Theory of Turbulence and Diffusion (5 hours)

1) Introduction to Turbulence and Diffusion
2) Types of circulation and atmospheric wind flow
3) The generalized Gaussian Diffusion Equation
4) AtmosphericDiffusionComputations
5) Effective Stack Height and Mixing height

3. Meteorology and Climatology to Air Pollution (5 hours)

1) Introduction to Air Pollution Climatology and cloud
2) Atmospheric Stability and Effects of local climate on Air Pollution
3) Interrelationship between Meteorology and Air Pollution
4) Urban Effects upon Meteorological Parameters
5) AtmosphericTurbidity

4. Meteorology of an Urban Atmospheric Chemistry (5 hours)

1) Introduction of Atmospheric chemistry to Air Pollution
2) Role of Meteorology on an urban Photochemistry
3) Natural Removal Processes in the Atmosphere
4) Scavenging of tracer from the atmosphere
5) Analysis of Air Quality Cycles

5. Meteorological Instruments and Their Exposure (5 hours)

1) Applications of Meteorology to Air pollution
2) Forecasting Air Pollution Potential and Air Pollution surveys
3) Site Selection for a Potential Source
4) AtmosphericTracersand
5) Urban Diffusion Experiments

6. Models for Urban Atmospheric Environment (4 hours)

1) Introduction and Types of Meteorological models
2) Meteorological models used for Urban Areas
3) Modeling effects on climate change on Air Quality
4) 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 (New)

Course In-charge: A. P. Dimri

Course structure

- The course comprises of five modules listed in table below. Each module has given hour units.

Modules	Unit Title	Teaching hours
CD 1	Evolution of Climate	4
CD 2	Global Circulation pattern	4
CD 3	Global Teleconnections	8
CD 4	Climate Change and Climate modeling	8
CD 5	Introduction to mountain climate	6

Syllabus in detail

CD 1: Evolution of climate: different concepts (4 hrs)

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 (4 hrs)
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 (8 hrs)
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 (8 hrs)
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 (6 hrs)
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-655 R

Course In-charge: Krishan Kumar

Course structure

The course comprises of six modules listed in table below. Each module has given hour units.

Modules Module title
SM1 Introduction to R and preliminaries
SM2 Working with Data in R
SM3 Control Structures in R
SM4 Recapitulation of Basic Statistics and Analysis in R
SM5 Regression Modeling
SM6 Principles of Experimental Design and Analysis of Variance
Teaching hours 5
Syllabus in detail

SM1: Introduction to R and preliminaries (5hrs)

- Getting started with R Interface R
- Objects
- Simple manipulations; numbers and vectors
- Arrays and Matrices
- Lists and Dataframes

SM2: Working with data in R (4 hrs)

- 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 (5 hrs)

- Conditional execution: if statements for
- Loops
-
- Repeat Loops
- While Loops

Writing your own functions

SM4: Recapitulation of Basic Statistics and Analysis in R (5 hrs)

- 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 (4 hrs)

- 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 (5 hrs)

- 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).
- Gujarati, D. N. (2009). Basic econometrics. Tata McGraw-Hill Education.

Course Title: Aerosol and Cloud Physics

Course Code: ES 692R (Revised)

Course In-charge: A. K. Mishra

Course structure

The course comprises of six modules listed in table below. Each module has 3-5 units.

Modules Unit Title

Teaching hours

1. Importance of aerosols and clouds in earth system sciences 4
2. Aerosol characterization and size distribution 3
3. Fluid properties and particle motion 7
4. Cloud formation mechanisms 8
5. Aerosol & cloud optical properties 4
6. Current status of aerosol-cloud-climate interaction studies 4

Syllabus in detail

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

(Revised) in-charge: AKT

Course structure

	Module title	Teaching (hours)
1	Earth environment	11
2	Soil environment	08
3	Geological environment	11

	Total	**30**

The course comprises of three modules listed in table below. Each module has 3-6 units.

Syllabus in detail

- 1: Earth environment (11 hours**)**

    1. Primary differentiations of the earth and the formation of its core
    2. Mantle,
    3. Crust,
    4. Atmosphere and hydrosphere
    5. Plate tectonics and the formation of oceans
    6. Continents and mountains

- 2: Soil environment (8 hours)

    1. Weathering and soil formation,
    2. Erosion
    3. Transport and deposition of sediments by rivers

- 3: Geological environment (11 hours)

    1. Wind and glaciers
    2. Geological processes and ocean margins
    3. Land-ocean interaction
    4. Biogeochemical cycling of elements

Course Title: Remote Sensing Applications in Geosciences

Course Code: ES-661 R (New)

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.HydrogeomorphicMicrozonation 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. INBK103842http://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 644 (Revised)
Course In-Charge: A. Tiwari

Course structure

The course comprises of five modules listed in table below. Each module has 4-5 units.

Module title	**Teaching (hours)**
1 Water chemistry	6
2 Basic concept of cycles	6
3 Important biogeochemical cycles	6
4 Disturbance and distribution of materials	6 5
Case studies	6
Total	30

Syllabus in detail

• 1: Water chemistry (6 hours)
1. Introduction of natural waters
2. Chemistry of dissolved materials in water
3. Eh and pH
4. Stability diagrams

• 2: Basic concept of cycles (6 hours)
1. Concept of cycling through time
2. Concept of reservoirs
3. Fluxes and transfer of materials
4. Global cycling of elements
5. Rates of erosion

• 3: Important biogeochemical cycles (6 hours)

1. Carbon cycle
2. Nitrogen cycle
3. Oxygen cycle
4. Phosphorus cycle
5. Sulfur cycle

• 4: Disturbance and distribution of materials (6 hours)

1. Human induced disturbances in the cycling
2. Hydrological systems and distribution of materials through various sub-systems
3. Nutrient elements
4. Toxic metals

• 5: Case studies (6 hours)

1. Geochemical cycles of selected toxic elements:
2. Case study- Fluorine
3. Case study-Aluminum
4. Case study- Mercury
5. 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 (Revised)

Course In-charge: AL Ramanathan

Course structure

The course comprises of six modules listed in table below. Each module has 4-5 units.

	Module title	Teaching hours
1	Components of the cryosphere and their time scales	5
2	Cryosphere changes, mass and energy balances	5
3	Glacier distribution, glaciation and recent changes	5
4	Glacier, water resources and natural disasters	5
5	Glacier, frozen ocean and future changes	4
6	Case studies	6

Syllabus in details (major and sub-topics to be covered)

1. Components of the cryosphere and their time scales. (5 hours)

- 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 (5 hours)

1. Glacier change controlling factors and formation
2. Mass balance
3. Energy Budget
4. Meteorological factors/controls
5. Snow and ice melting process

3. Glacier distribution, glaciation and recent changes (5 hours)

- 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 (5 hours)

- 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 (4 hours)

- 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 (6 hours)

1. Statistical and advance approaches applied in Cryosphere studies
2. Case study of mass and energy balance in a Himalayan glacier
3. Case study of disaster: e.g. GLOF and avalanche
4. Case study of paleoclimate studies, e.g. ice and lake core-based climate reconstruction
5. Case study of Polar glaciers, e.g. Arctic and Antarctica
6. 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 (Revised)

Course In-charge: N J Raju

Course structure

The course comprises of six modules list in table below. Each module has 4-5 units

S. NO	Module title	Teaching hours
1	Earth sciences and Weathering Processes	2
2	Rock Forming Minerals and Petrology	5
3	Structural Geology and Groundwater Occurrence	5
4	Earth Movements and Importance of Geology in Civil Engineering	4
5	Engineering Properties of Rocks and Construction Materials	5
6	Geology for the Selection of Dams, Tunnels and Reservoirs sites	9
	Total	**30**

Syllabus in detail

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 (Revised)

Coordinator: PSK

Course structure:

The course comprises of **SIX** modules listed in table below.

S.No	Module title	Teaching hours
1	Fundamentals of Environmental Management	5
2	Natural Resource Management and Conservation	5
3	Economic Development and Environmental Degradation	4
4	Sustainable Development and Environmental Protection	4
5	Environmental Legislation Development and it's Implementation	4
6	Environmental Management Tools and Techniques	8

Detailed Syllabus:

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

conomic 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

(Revised)

Course In-charge: DM

The course comprises of **SIX** modules listed in table below.

S. No	Module Title	Teaching hours
1	Water Quality and standards	02
2	Measurement of Water Quality Parameters	06
3	Fundamentals of Water Sampling and Analysis	02
4	Water Treatment Technologies	02
5	Water Softening Chemistry	02
6	Physicochemical processes for water and wastewater treatment	16

Syllabus details:

Water Quality and standards (02)

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

Measurement of Water Quality Parameters (06)
Organoleptic and Physicochemical Parameters

Fundamentals of Sampling and Analysis (02)
Water Sampling, Quality Control and Quality Assurance(QA/QC)

Water Treatment Technologies (02)
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 (02)

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

Coagulation and Flocculation (04)

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 (04)

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 (03)

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 (03)

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

Disinfection (02)

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 639 (Revised)

Course In-charge: J.K. Tripathi

Course structure:

The course comprises of **NINE** modules listed in table below.

S.No	Module title	Teaching hours
1	Limnology and water	3
2	Lentic and lotic ecosystems: Lakes and rivers	4
3	Physicochemical parameters	4
4	Edaphic factors	4
5	Life in water	2
6	Aquatic ecology	2
7	Lake evolution and paleolimnology	2
8	Use and misuse of lakes and rivers	3
9	Field demonstrations and practical sessions	6

Syllabus details:

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 632 R (Revised)

Course In-charge: U. C. Kulshrestha

Course structure:

The course comprises of SIX modules listed in table below.

S. No.	Module Title	Teaching hours
1	Air pollutionsources	5
2	Chemistry of air pollution	8
3	Transport and deposition of chemical air pollutants	5
4	Air pollution prevention and control methods	4
5	Air quality & criteria and non-criteria pollutants	2
6	Air pollution chemistry and climate change	6

Syllabus details:

Air pollution and its sources (5)

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

Chemistry of air pollution (8)

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 (5)

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 (4)

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

Air quality & criteria and non-criteria pollutants (2)

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

Air pollution chemistry and climate change (6)

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 (Revised)

Course In-charge: DM

Course Structure:

The course comprises of **seven** modules listed in table below.

S. No	Unit Title	Teaching hours
1	Biomass as Energy Source	2
2	Biomass Conversion Processes	2
3	Biomass Properties for Thermal Conversion and Biological Conversion	4
4	Biomass thermal conversion processes - Torrefaction - Combustion - Pyrolysis - Gasification	12
5	Biomass Biological conversion processes - Bioethanol - Biogass	5
6	Biodiesel Production	2
7	Sustainability and Economic Issues of Biomass Conversions	3

Syllabus details:

Biomass as Energy Source (2)

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 (2)

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

Biomass Properties for Thermal Conversion and Biological Conversion (4)

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

Biomass thermal conversion processes (12)

- **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 (5)

- 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 (2)

Properties of Fats and Oils Biodiesel Conversion Processes,

Sustainability and Economic Issues of Biomass (3)

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 (Revised)

Course In-charge: S. Yadav

Course Structure:

The course comprises of **EIGHT** modules listed in table below.

S.No	Module title	Teaching hours
1	Introduction to chemical speciation	2
2	Chemical Concepts	6
3	Techniques for Chemical speciation	6
4	Metal Speciation in aquatic environment	3
5	Metal Speciation in sediments and soils	4
6	Metal Speciation in Atmosphere	2
7	Metal Speciation in biological systems	2
8	Case studies and discussion papers	5

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 (Revised)

Course In-Charge: PKJ

Course structure

The course comprises of six modules listed in table below. Each module has 4-5 units.

Modules	Unit Title	Teaching hours
1	Introduction to Ecosystem	10
2	Primary Production	8
3	Trophic Dynamics – I	5
4	Trophic Dynamics - II	7

Syllabus in detail

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 621 (Revised)

Course In-charge: Ilora Ghosh

Course structure

The course comprises of eight modules listed in table below. Each module has different units.

Modules	Unit Title	Teaching hours
ET-1	Definition and scope of toxicology	5
ET-2	Uptake, biotransformation, elimination and accumulation of chemicals	3
ET-3	Uses of exposure assessment in risk assessment	3
ET-4	Biotransformation of environmental contaminants	3
ET-5	Chemical mutagenesis and carcinogenesis:	2
ET-6	Use of exposure assessment in epidemiology	2
ET-7	Genomic approaches to toxic mechanisms:	3
ET-8	Toxicogenomics	9

Syllabus in detail

- **ET-1: Definition and scope of Toxicology**

1. Toxicology and its history of evaluation as an important subject to understand
2. Basic principles of toxicology, Absorption and distribution of toxicants
3. The effects on changes of physical, chemical as well as biological components of our environment
4. Dose response relationship. Frequency response and cumulative response
5. 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:**

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

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

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

- **ET-4: Biotransformation of environmental contaminants:**

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

- **ET-5: Chemical mutagenesis and carcinogenesis:**

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

- **ET-6: Use of Exposure Assessment in Epidemiology:**

1. Population based studies; Lifetime Average Daily Dose analysis for non-cancer risk to estimate Hazard index

2. Cancer risk estimating Hazard index and its biological monitoring.

- **ET-7: Genomic approaches to toxic mechanisms:**

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

- **ET-8: Toxicogenomics:**

1. Introduction of Toxicogenomics and Human health
2. Introduction to microarray and its application in toxicology and human health
3. Case studies on clinical impact on polymorphisms in drug metabolizing enzymes: One
4. Case studies on clinical impact on polymorphisms in drug-metabolizing enzymes: Two
5. Application of toxcogenomicsand drug metabolism towards detoxification
6. Introduction to Pharmacogenomics
7. Case studies on clinical impact on polymorphisms towards phermacogenomics
8. Towards precision on understanding genetic basis of response to detoxification
9. 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 (Revised)

Course In-Charge: PR

Course structure

The course comprises of six modules listed in table below. Each module has different units.

Modules	**Unit Title**	**Teaching hours**
EC1	Concepts and knowledge of cancer,	2
EC2	Environmental agents: Carcinogens: Physical, Chemical and Biologicalagents.	10
EC3	Molecular basis of Carcinogenesis	6
EC4	Mutagenesis and cytogenetics	5
EC5	Chemoprevention of cancer	2
EC6	Risk assessment and epidemiology of environmental carcinogens	5
	Total	30

Syllabus in detail

1. Concepts and knowledge of cancer (2 Hrs)

1. Introduction: Concepts and knowledge of cancer

2. Classification of cancer

2 Molecular Basis of Cancer (5 Hrs)

1. Mechanism of multi-stage carcinogenesis:
2. Initiation
3. Promotion
4. Progression and Cell cycle regulation
5. Cellular metabolic pathways and cell proliferation

3 Environmental factors (10 Hrs)

1. Carcinogens; Metabolism of environmental carcinogens.
2. Binding of carcinogen to DNA and covalent adduct - PAH,
3. Interaction with Aromatic amines
4. Interaction with nitro- aromatic compounds 5
Interaction with halogenated compounds
6. *Physical agents*; Ionizing Radiation: Direct ionizing effects

   and effects mediated by various factors and Non-ionizing Radiation

7. *Chemical agents*; Diesel Emissions, Coke Oven Emissions, Coal Tar

   Emissions,

8. Shale Oil, Particulate Matter,

9. Tobacco Smoke

10. *Biological agents*: Viral oncogenes

4 Mutagenesis and cytogenetics (6 Hrs)

1. Mutagens, mutagenesis and cytogenetics, cell cycle

2. Chromosomal alterations, DNA damage,

3. Cellular indicators of tumorigenicity,

4. Regenerative Cell Proliferation,

5. Cytotoxicity. Growth factors and Oncogenes

6. Tumor Suppressor Genes

5. Chemoprevention of cancer: (2 Hrs)

1. Chemoprevention by natural products

2. Chemoprevention bysynthetic substances

6 Risk assessment of carcinogens; epidemiology (5 Hrs)

1. Exposure assessment of carcinogens
2. Risk assessment of carcinogens
3. Industrial chemicals and occupational exposure
4. Etiology of different cancer
5. 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 (Revised)

Course In-Charge: R. Meena

Course structure

The course comprises of seven modules listed in table below. Each module has variable units.

Modules	Unit Title	Teaching hours
MRB 01	Overview on radiation biophysics	3
MRB 02	Radiation chemistry of free radical	3
MRB 03	Radiation detection and Dosimetry	4
MRB 04	Biological effects of radiation at cellular and molecular level	6
MRB 05	Effects on major organ systems	5
MRB 06	Molecular mechanism of radiation carcinogenesis	6
MRB 07	Safety guidelines and biomedical applications	3
	Total	30

Syllabus in detail

- **MRB 01: Overview on radiation biophysics (3hrs)**

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

- **MRB 02: Radiation chemistry of free radical (3hrs)**

1. Radiochemistry of water
2. Generation of free radicals
3. Macromolecular reactions of free radicals

- **MRB 03: Radiation detection and Dosimetry (4 hrs)**

1. Radiation units, detection and measurements
2. SAR measurements
3. Factors affected the SAR measurement
4. Exposure to biological systems

- **MRB 04: Biological effects of radiation at cellular and molecular level (6 hrs)**

1. Whole body effects
2. Thermal and non-thermal effects
3. Structural and functional changes
4. Oxidative stress markers
5. Cell signaling and apoptosis
6. Immunological and inflammatory markers

- **MRB 05: Effects on major organ systems (5hrs)**

1. Immune system
2. Effects on Memory and behavioral pattern
3. Reproductive system
4. Cardiovascular system
5. liver and biliary system

- **MRB 06: Molecular mechanism of radiation carcinogenesis (5hrs)**

1. Interaction with DNA, RNA and Nucleoproteins
2. Mutations and genetic instability
3. Micronuclei induction
4. Biomarkers of tumor promotion
5. Radical pair mechanism

- **MRB 07: Safety guidelines and biomedical applications (3hrs)**

1. Exposure of body, Power density and radiation level
2. Safety criteria
3. 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 (Revised)

Course in-charge: KGS

Course structure

The course comprises of six modules listed in table below. Each module has 4-5 units.

	Module title	Teaching hours
1	Rehabilitation-conservation-development inter-linkages and integrated approaches	5
2	Ecological concepts: population level	5
3	Ecological concepts: community level	5
4	Ecological concepts: ecosystem level	6
5	Logical framework approach	3
6	Case studies	6

Syllabus in detail

- 1: Rehabilitation-conservation-development inter-linkages (5 hours**)**

1 Rehabilitation: the "acid test" of translating ecological concepts into on-the- ground sustainable practices
2 Typology
3 Global programmes
4. National programmes
5. Assessing effectiveness and efficiency

- 2: Ecological concepts: population level (5 hours)

1. Population and ecological genetics in rehabilitation ecology
2. Eco-physiological dimensions in rehabilitation setting
3. Implications of population dynamics and metapopulation theory in rehabilitation
4. Evolutionary restoration ecology
5. Rehabilitating/restoring populations

- 3: Ecological concepts: community level (5 hours)

1. Connecting community ecology theory with rehabilitation
2. Global, regional and local processes
3. Environmental conditions and habitat characteristics
4. Scalar dynamics
5. Food web approaches

- 4: Ecological concepts: ecosystem level (6 hours)

1. Resistance, resilience and ecosystem complex
2. Topographic heterogeneity and ecological rehabilitation
3. Multiple and alternative states of ecosystems
4. Multiple and alternative rehabilitation trajectories
5. Multi-functionality
6. Characterizing sustainable rehabilitation

- 5: Logical framework approach (3 hours)

1. Generic version of logical framework
2. Rehabilitation planning
3. Rehabilitation monitoring and evaluation

- 6: Case studies (6 hours)

1. Statistical issues and study designs in rehabilitation
2. Case study – rehabilitation of grasslands
3. Case study –rehabilitation of forests
4. Case study-rehabilitation of agricultural lands
5. Case study-rehabilitation of landscape and socio-ecological systems
6. 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-687

(Revised)

Course In-charge: KM

Course structure

The course comprises of seven modules listed in table below. Each module has variable units.

Modules	Unit Title	Teaching hours
HPIE 01	Overview on Infectious Microbes	3
HPIE 02	Pathogenicity of Microorganisms	6
HPIE 03	The Epidemiology of Infectious Disease	4
HPIE 04	Overview on Host Immune System	6
HPIE 05	Antimicrobial Chemotherapy	3
HPIE 06	Environmental Factors Associated with Emergence of Diseases	5
HPIE 07	Understanding the New Strategies to Control Infectious Diseases	3
	Total	30

Syllabus in detail

- **HPIE 01: Overview on Infectious Microbes (3 hrs)**

1. Types of microbes
2. Human diseases caused by virus and bacteria
3. Human disease caused by fungus and protozoa

- **HPIE 02: Pathogenicity of Microorganisms (6 hrs)**

1. Host pathogen relationship
2. Pathogenesis of viral diseases
3. Pathogenesis of bacterial diseases
4. Pathogenesis of fungal and protozoan diseases
5. Toxigenicity
6. Evasion of host defense

- **HPIE 03: The Epidemiology of Infectious Disease (4 hrs)**

1. Epidemiological terminology
2. Recognition of an infectious disease
3. Infectious disease cycle
4. Transmission of pathogen

- **HPIE 04: Overview on Host Immune System (6 hrs)**

1. Normal microbiota of the human body
2. Cells, tissues and organs of immune system
3. Physical and chemical barriers in nonspecific resistance
4. Inflammation and phagocytosis
5. The complement system
6. Cytokines and natural killer cells

- **HPIE 05: Antimicrobial Chemotherapy (3 hrs)**

1. General characteristics of antimicrobial drugs
2. Mechanisms of action of antimicrobial drugs
3. Factors influencing the effectiveness of antimicrobial drugs

- **HPIE 06: Environmental Factors Associated with Emergence of Diseases (5 hrs)**

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

- **HPIE 07: Understanding the New Strategies to Control Infectious Diseases (3 hrs)**

1. Emerging tools and technology for countering antibiotic resistance
2. New discovery of antimicrobial agents

Course Title: Man and Tropical Forest Ecosystem Function

Course Code: ES-624R (Revised)

Course In-Charge: SCG

Course structure

The course comprises of six modules listed in table below. Each module has 4-5 units.

Modules	Unit Title	Teaching hours
	Ecosystem structure	7.5
	Biogeochemical fluxes	7.5
	Forest ecosystem functions	7.5
	Global change and tropical forest ecosystems	7.5
	Biodiversity and ecosystem functions	7.5
	Natural versus human managed ecosystems	7.5

Syllabus in detail

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 (New)

Course In-Charge: PKJ

Course structure

The course comprises of six modules listed in table below. Each module has 4-5 units.

Modules	Unit Title	Teaching hours
1	Himalayan Environment and Development	6
2	Biological Diversity	6
3	Cultural Diversity	6
4	Tourism, and Sustainability	4
5	Sustainable Future	8

Syllabus in detail

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 (Revised)

Course In-Charge : Ilora Ghosh

Course structure

The course comprises of five modules listed in table below. Each module has different units.

Modules	Unit Title	Teaching hours
CE-1	Introduction to Cell and its micro-environment:	4
CE-2	Cell to cell signaling and effect of environmental factor	5x2=10
CE-3	The structural and functional properties of major classes of cell surface receptors	2x2=4
CE-4	Focuses on components important for cytoplasmic signal transduction coordinated with environment	3x2=6
CE-5	Nuclear responses due to environmental pollutant and impacts:	3x2=6

Syllabus in detail

- **CE-1: Introduction to cell and its micro-environment:**

1. Introduction to cell and environment on micro-environment
2. Cellular interaction with pollutants at the biomacromolecular level
3. Its reflection on the gene expression and cell behaviour
4. Its reflection on cellular signalling.

- **CE-2: Cell to cell signalling and effect of environmental factor:**

1. Extra-cellular signals.
2. Cell surface receptors and xenobiotics,
3. Receptor and non-receptor kinases on cellular signalling
4. Nuclear translocation protein and signal transduction.
5. G-protein cascade and a case study

- **CE-3: The structural and functional properties of major classes of cell surface receptors:**

1. Regulation of receptors internalization
2. 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:

1. Induction ofprotein phosphorylation due to xenobiotics exposure in cellular system
2. Signalling pathways involve in protein phosphorylation during abnormal signalling,
3. 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:

1. Focus on cellular signalling delineated all the way from cell surface to the nucleus during xenobiotic interactions
2. Regulation of transcription factors by phosphorylation due to surface interaction of pollutant
3. 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 (Revised)

Course In-Charge: M. Dua

Course structure:

 The course will begin with an orientation that introduces the necessary jargons in vocabulary of genomics viz. genomics, transcriptomics, proteomics, metabolomics, bioinformatics*, metagenomics etc. An overview of the techniques used in mapping and sequencing genomes will be discussed. Thereafter, published research and review papers will be taken up for discussion to understand how environmentalists are applying the tools of genomics and related high-throughput technologies to both cultured microbes and environmental samples in the study of bioremediation, pathogenesis, extremophiles, microbial ecology, metabolic diversity, microbial phylogeny and evolution.

 The course comprises of three modules listed in table below.

Modules	Unit Title	Teaching hours
1	Introduction to the vocabulary of microbial genomics and the tools of genomics	4
2	Case studies in the subject area with the help of publishes research and review articles	25
3	Student Presentation & In-class Quiz	1
		Total: 30

Syllabus in detail:

Peer reviewed research and review papers published in the recent decade will be taken up for discussion. The topics of discussion may include, but are not limited to the following:

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 (Revised)

Course In-Charge: U. Mina

Course structure

The course comprises of six modules selected to expose students to current research areas in the field. Each module has 4-5 units.

	Module title	Teaching hours
1	Climate Change, Air Quality and Plant ecology inter-linkages, approaches	5
2	Climate Change and Plant ecology	5
3	Air Pollution and Plant Ecology	5
4	Plants and mitigation of climate change and air pollution	6

5	Application and Logical framework approach	3
6	Case studies	6

Syllabus in detail

1: Climate Change, Air Quality and Plant ecology inter-linkages, approaches (5 hours)

1) Global environment, climate change, air quality attributes and plants, interlinkages
2) Typology
3) Global programmes
4) National programmes
5) Assessing effectiveness and efficiency

2: Climate Change and Plant ecology (5 hours)

1) Climate and evolution and distribution of Plant Diversity
2) Plant ecology indicators of Climate Change
3) Plant functional Traits and Climate change Impact
4) Plant biodiversity and climate change

3: Air Pollution and Plant Ecology (5 hours)

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

4: Plants and mitigation of climate change and air pollution (6 hours)

1) Plant role in adaptation and mitigation of climate change impacts
2) Plants as air pollution bioindicators
3) Plants efficiency in air pollution mitigation
4) Innovative approaches and plant based emerging technologies

5. Application and Logical framework approach (3)

1) Statistical issues and experimental designs
2) Student participation: assignment and presentations of primary literature

6: Case studies (6 hours)

1) Case study – Climate change impact and plant diversity
2) Case study –Climate change and adaptation in plant diversity
3) Case study-Plant based climate change mitigation approach
4) Case study-Air pollution impact of plant diversity
5) Synthesis – Plant based air pollution mitigation approach

Learning Outcomes

On Course completion, students will have the knowledge and skills to:

1) Understand and describe the ways in which climate change air pollution affects plant ecology
2) Find and interpret course related primary research literature and be able to analyse and critique the research results in written and oral formats.
3) Communicate science issues and ideas in both oral and written form

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/

Annexure II

List of the External Examiners to be considered by the Special Committee as proposed by the following faculty-

(i) Prof. S. C. Garkoti

1. Prof. S. B. Agrawal
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Specialization: Ecology & Environmental Science.

2. Prof. Y S Rawat
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Specialization: Ecology

3. Prof. Nandita Ghosal
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Specialization: Plant Ecology and Environmental Science.

4. Prof. Lalit M. Tewari Ecology and Environment, Department of botany, Kumaun University, Nainital **Phone no.**: 09412362085
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Specialization: Ecology

5. Prof. Laxman Singh Lodhiyal
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Specialization: Ecology

6. Prof. Kottapalli Sreenivasa Rao
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Specialization: Ecosystem analysis; Adaptation to climate change; Plant nutrition; Ecosystem redevelopment; Agroforestry system researches; Land use/cover analyses; Reserve people conflict mitigation, Soil and water conservation; Sustainable rural development models/approaches.

7. B K Dutta
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Specialization: Ecology

(ii) Prof. Paulraj R.

1. Prof. V. Samuel Raj
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Specialization: Drug discovery

(iii) Prof. Kasturi Mukhopadhyay

1. Prof. Bijay Ranjan Mirdha, M.D., Professor,
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Specialization: Molecular epidemiology of Infectious diseases with special reference to parasitic diseases (Malaria, Leishmanisis, Cystic Hydatidosis, Molecular epidemiology of Cryptosporidiosis and other coccidian, Molecular epidemiology of Pneumocystis jirovecii infection, Anti - microbial Resistance.

2. Prof. Amir Azam
Head and Professor of Medicinal Chemistry,
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110025
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Specialization: Entamoeba genome; Design, synthesis and evaluation of novel heterocyclic compounds against Amoebasis.

3. Dr. Shoma Paul Nandi, Professor &
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Specialization:Antimicrobial resistance against human pathogen, phytomedicine and endophytes.

4. Dr. Soumya Roy Choudhury Senior Principal
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Specialization: Molecular and Medical Microbiology: Organisms: V. cholerae, Yeast model and gut microbiota.

5. Prof. Ujjala Ghoshal

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6. Dr. Joydeep Mukherjee Associate
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2. Prof. R. Mohanraj Professor and Head
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(v) Prof. Umesh Kulshrestha

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(VI) Prof. A L Ramanathan

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