

CENTRAL UNIVERSITY OF GUJARAT



SCHOOL OF ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

Ph.D. IN ENVIRONMENT & SUSTAINABLE DEVELOPMENT

Effective from academic year 2021–2022

**Ph.D. IN ENVIRONMENT & SUSTAINABLE DEVELOPMENT
COURSE OUTLINE**

Semester-I				
Course Code	Paper No.	Paper Name	Credits	Hours/Week
Core Courses				
ESD-601	Paper-I	Research Methodology 1	02	02
ESD-602	Paper-II	Research Methodology 2 Research and Publication Ethics	02	02
ESD-603	Paper-III	Environment and Sustainability	02	02
ESD-604	Paper-IV	Analytical Process and Techniques in Environmental Sciences	02	02
Total Credits (Semester-I)			08	08
Semester-II				
Optional Courses (anyone) *				
ESD-651		Ecotoxicology	02	02
ESD-652		Crop Ecology	02	02
ESD-653		Soil biology and biochemistry	02	02
ESD-654		Remote Sensing and GIS	02	02
ESD-655		Instrumentation	02	02
ESD-656		Environmental Biotechnology & Environmental Nanotechnology	02	02
ESD-657		Groundwater Hydrology	02	02
ESD-658		Environmental Stresses in plants	02	02
ESD-659		Forestry and Remote sensing	02	02
ESD-660		Environmental Pollution	02	02
Core Course				
ESD-691		Project	06	12
Total Credits (Semester-II)			08	14
Total Credits			16	
Extra Credits				
ESD-692		Field work **/Specific Training **	04	08

*: Optional courses should be opted after recommendation of RAC

** : Field work/Industrial training should be specific for the research work to be carried out.

SEMESTER-I

CORE COURSES

ESD-601 RESEARCH METHODOLOGY-1 (CREDIT-2)

Unit-1: Research Design

Research meaning; motivation; concept and objectives of Research; Types of research; Research methods and Methodology; Research hypothesis: Types and formulation of hypothesis. Parameter and variables in research; Research design: Basic Principles; concepts; Prediction and explanation; Identification of research problem; Identification of research gaps; formulation of research objectives; Developing a research plan, Determining experimental designs; Formulation of the problem and hypothesis, Statistical Design, Sample size, protocol.

Unit-2: Data Collection

Literature review: Importance and purpose of literature review; sources of review; Methods of literature review; Sample and sampling procedure and Experimental design; Observation and collection of data; Methods of data collection; Source of data collection; Data Processing and Analysis; organization and presentation of data.

Unit-3: Statistics

Introduction to statistics: meaning; scope and limitations; Measures of Central tendency: concept; arithmetic mean, mode, median; Measures of dispersion-range, standard deviation Variance, Quartile Deviation, Coefficient of variability; Correlation analysis; Linear models and regression analysis, Analysis of Variance (ANOVA), Hypothesis testing; methods of hypothesis testing; F-test, t- test and chi square test, Introduction to statistical software

Unit-4: Report Writing

Components of thesis and dissertation (Synopsis, Title, Abstract, Introduction, Literature Review, Materials and methods, Tabulation of results, Plotting graphs, and interpretation and Bibliographic database.

Unit-5: Scientific Writing/Communication

A critical report about a scientific paper and discovery. Planning of and drafting of manuscript; writing of research proposals; research summary, research abstract and research paper. Writing abstract, determining questions, hypotheses, and objectives, writing an introduction to study, results, discussion, and conclusions; Referencing, Different styles of Bibliography; Submission of manuscript

Unit-6: Presentation

Introduction and application of Power point in presentations, basic features, and functions of Power Point, developing a good PowerPoint presentation, Advanced text editing operations, Adding graphical elements to presentation. Advantages and disadvantages of power point presentation, Research poster, making good research poster, software for making a poster

Suggested Readings:

- Gibaldi, Joseph. *MLA Handbook for Writers of Research Papers*. 7 th ed. New Delhi: East-West Press, 2009
- Kothari, C.R. *Research Methodology: Methods and Techniques*. New Delhi: New Age International Ltd, 1985.
- Faber J, Writing scientific manuscripts: most common mistakes, *Dental Press J Orthod*. 2017; 22(5): 113–117. doi: 10.1590/2177-6709.22.5.113-117.sar
- Gundogan, B., Koshy, K., Kurar, L., & Whitehurst, K. (2016). How to make an academic poster. *Annals of medicine and surgery (2012)*, 11, 69–71.
- Harolds, J.A., 2012. Tips for giving a memorable presentation, Part IV: Using and composing PowerPoint slides. *Clinical nuclear medicine*, 37(10), pp.977-980 <https://doi.org/10.1016/j.amsu.2016.09.001>
- Erren, T.C. and Bourne, P.E., 2007. Ten simple rules for a good poster presentation. *PLoS Comput Biol*, 3(5), p.e102. Topic 0019: writing your literature review,
- <https://snazlan.wordpress.com/2016/11/09/topic-0019-writing-your-literature-review/>
- <http://intra.tesaf.unipd.it/pettenella/Corsi/ReaserchMethodology/ResearchSynopsisWriting.pdf>
- <http://betterthesis.dk/literature-search/test-and-summary>
- [www.nitttrchd.ac.in › sitenew1 › comp_sc › pdf › PhD-Synopsis-template](http://www.nitttrchd.ac.in/sitenew1/comp_sc/pdf/PhD-Synopsis-template)
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5714380/>
- Crotty D, Journal Metrics, Article III; OtherMetrics: beyond the Impact Factor, *Cardiopulse*, doi:10.1093/eurheartj/ehx446
- Cross JO, Impact factors – The Basics, the e resource management Handbook, <https://www.uksg.org/sites/uksg.org/files/19-Cross-H76M463XL884HK78.pdf>

ESD-602 RESEARCH METHODOLOGY-2 (CREDIT-2)

Research and Publication Ethics (UGC Syllabus)

Course objectives: To create awareness about the publication ethics and publication misconducts.

Syllabus

Unit-1: Philosophy and Ethics

Introduction to philosophy: definition, nature and scope, concept, branches, Ethics: definition, moral philosophy, nature of moral judgements and reactions

Unit-2: Scientific Conduct

Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP), Redundant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data

Unit-3: 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 behavior and vice versa, types, Violation of publication ethics, authorship and contributorship, identification of publication misconduct, complaints and appeals, predatory publishers and journals

Unit-4: Open Access Publishing

Open access publications and initiatives, SHERPA/RoMEO online resource to check publisher copyright & 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.

Unit-5: Publication Misconduct

Group Discussions: Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad, Software tools (2 hrs.) Use of plagiarism software like Turnitin, Urkund and other open source software tools

Unit-6: Databases And Research Metrics

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

Course outcome: Students will understand the basics of philosophy of science and ethics, research integrity, publication ethics. Hands-on-sessions will identify research misconduct and predatory publications. Knowledge about indexing and citation databases, open access publications, research metrics (citations, h-index, Impact Factor, etc.) and plagiarism tools will enable students to choose right journal for publishing their plagiarism free work.

Suggested Readings:

- Bird, A. (2006). *Philosophy of science*. Routledge.
- MacIntyre, Alasdair (1967) *A Short History of Ethics*. London.
- P. Chaddah, (2018) *Ethics in Competitive Research: Do not get scooped; do not get plagiarized*, ISBN:978-9387480865
- National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). *On Being a Scientist. A Guide to Responsible Conduct in Research. Third Edition*. National Academies Press.
- Resnik, D. B. (2011). What is ethics in research & why is it important. *National Institute of Environmental Health Sciences*, 1 —10. Retrieved from <https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm>
- Beall, J. (2012). Predatory publishers are corrupting open access. *Nature*, 489(7415), 179—179. <https://doi.org/10.1038/489179a>
- Indian National Science Academy (INSA), *Ethics in Science Education, Research and Governance* (2019), ISBN:978-81-939482-1-7.

ESD-603 ENVIRONMENT AND SUSTAINABILITY (CREDIT-2)

Unit-1: Environment-Definition and Functions

Environment: Components, Functions of the Environment; Significance of the Environment
Depletion of Resources; Pollution impact on biotic and abiotic factors; Risk management of environmental pollution; Recent research in environment and pollution abatement.

Unit-II: Sustainable Development

Strategies for sustainable development; Use of Non-conventional Sources of Energy; Recycling/
Bioconversion; SD Goals; Solid waste management, Sustainability, environmental degradation
and economic growth; Environmental management
Climate change, mitigation and adaptation: research and case studies

Suggested Readings:

- An introduction to sustainable development / Jennifer A. Elliott. Elliott, Jennifer A, 2005 Abingdon, Oxon ; New York : Routledge, 2005
- Green business, green values, and sustainability / edited by Christos N. Pitelis, Jack Keenan and Vicky Pryce. Pitelis, Christos | Keenan, Jack, Routledge, 2011
- Environment and sustainable development in India edited by Raj Kumar Sen by Sen, Raj Kumar Mukherjee, Amit Pal, Pran Krishna Deep & Deep Publications Pvt. Ltd. New Delhi 2010

Library link, Central University of Gujarat: <http://14.139.122.35/drupal/node/19>

**ESD-604 ANALYTICAL PROCESS AND TECHNIQUES IN ENVIRONMENTAL SCIENCES
(CREDIT-2)**

Unit-I: Basics of Environmental Sampling

Introduction: sampling for analysis; methods of sampling; environmental sampling; plant, soil, water, air sampling procedures; development of a sampling plan; sampling strategies; processing of samples in the laboratory; preservation and storage of samples; importance of sampling. Pre-treatment and preparation of sample for analysis.

Basics of Remote sensing and GIS, GPS

Unit-II: Analytical Methods and Principles of Soil Land Plant Samples

Characterisation of soils and composts: Physical, chemical and biological characterisation. Study of problematic soils; Conversion of biodegradable wastes. Recording of experimental data. Analyses for primary and secondary metabolites in plant samples.

Unit-III: Analytical Methods and Principles Water and Air Samples

Surface water and Groundwater: Different sampling techniques of; Physico-chemical characterisation of surface water and groundwater; Air sample analysis

Unit-IV: Sustainability in sampling and analysis

Methodology and Quality Assurance/Quality Control of Environmental Analysis. Developing environmental sustainability criteria laboratories; green methodology in labs; Good laboratory practices for sustainability and safety.

Suggested readings:

- Statistical Methods for Environmental Pollution Monitoring; R. O. Gilbert, Van Nostrand Reinhold, New York 1987.
- Environmental Sampling and Analysis for Technicians; M. Csuros, Lewis Publishers, Boca Raton, 1994.
- Sampling for Environmental Data Generation; P. Grieco and R. Trattner, SciTech Publishers, Matawan, NJ 1990.
- Principles of Environmental Sampling, L. D. Keith, American Chemical Society, Washington, DC 1988.

Library link, Central University of Gujarat: <http://14.139.122.35/drupal/node/19>

SEMESTER-II

OPTIONAL COURSES

ESD-651 ECOTOXICOLOGY (CREDIT-2)

Unit-I: Basic concept

Introduction to ecotoxicology. Basics of environmental toxicology: Environmental persistence, Bioaccumulation, toxicity, Transport and fate of toxicants in environment. Ecotoxicity: determination of median lethal dose and concentration, protocol for testing, bioassay for measuring toxicity.

Natural Pollutants and natural cycles. Toxic effects at different organization level: Sequential effect of pollutants, effect on individual organism, population, community, and ecosystem. Development of resistance.

Unit II: Class of toxicants and processing

Exposure class toxicants in air, water, soil, domestic and occupational settings. Properties and effects of Use classes toxicants: Metals, Agricultural chemicals (Pesticides), food additives and contaminants, toxins. Absorption, distribution and elimination of toxic agents. Human health risk assessment: Risk assessment methods, Cancerous and non cancerous risk assessment. Environmental risk assessment.

Suggested Readings:

- Walker C. (2014). Ecotoxicology: Effects of pollutants on the natural environment. CRC Press, New York.
- Hodgson E. (2004). A textbook of modern toxicology (3rd Edition). John Wiley & Sons, Inc., Hoboken, New Jersey.
- Hoffman D.J., Rattner B.A., Burton G.A. Jr, Cairns J. Jr (2003). Handbook of ecotoxicology (2nd edition). Lewis Publisher
- Williams P.L., James R.C, Roberts S.M. (2000). Principles of Toxicology: Environmental and industrial application (2nd Edition). John Wiley & Sons, Inc.

ESD-652 CROP ECOLOGY (CREDIT-2)

Unit-I: Agricultural System and their component

Introduction to agricultural system, Trophic chain: Trophic system in agriculture, carrying capacity. Community concept of agro-ecosystem: Community change, biomass accumulation, crowding and competition, community response to limiting factor. Genetic resource: genetic diversity and changes in genetic structure, cultivar development. Development: Developmental time and switches, Quantifying phenological response, seed germination and dormancy.

Aerial Environment: Radiation concept, Radiation and Energy balance, Climate and Weather, Microclimate. Soil Resource: Plant nutrition, Management of soil fertility, fertilizer practice, tillage system

Unit II: Agricultural Process

Nitrogen Process: Nitrogen Cycle, Nitrogen fixation, decay and immobilization, Mineralization and nitrification, loss of nitrogen, Assimilation of mineral nitrogen by plant, use of organic nitrogen sources.

Water relation: Evapotranspiration, Water absorption by root, Crop water balance, water use efficiency

Photosynthesis: Photosynthetic system, Leaf and canopy photosynthesis, canopy structure for productivity and competitiveness.

Respiration and Partitioning: Carbon use in respiration, Growth respiration and growth yield, seasonal pattern of respiration, Morphological aspect of partitioning.

Suggested Readings:

- Connor D.J., Loomis R.S., Cassman K.G. (2011) Crop ecology: Productivity and Management in agricultural system. Cambridge University Press (2nd edition).
- Joy T. (1990) Agricultural Ecology. Routledge, New York, USA.
- Norman T.J., Pearson C.J., Searle P.G.E. (1995). The Ecology of tropical food system. Cambridge University Press (2nd edition).

ESD-653 SOIL BIOLOGY AND BIOCHEMISTRY (CREDIT-2)

Unit-1: Soil biology

Biotic factors in soil; Soil organisms - their role in organic matter decomposition and nutrient transformations, soil organic matter- its nature and constitution; soil-plant-microbial interactions. Soil organisms and pedogenesis. Soil characteristics influencing growth and activity of microbes and plants.

Microbes in Integrated nutrient management- its significance in modifying soil properties
Biochemical and Molecular approaches to study soil biota.

Unit 2 Soil biochemistry

Microbiology and biochemistry of root-soil interface; rhizosphere, Enzymes in microbial transformations of nutrients in soil; biochemical composition and biodegradation of soil organic matter and crop residues.

Soil related constraints in crop production in different parts of India. microbial toxins in the soil. sustainable agriculture and modification in soil constituents. Soil resource management Influence of Agronomic practices on soil

Case study: Saline soils; Acid soils; Agrochemicals and soil; Irrigation water quality and soil; organic farming and soil health.

Suggested Readings:

- *Anoop Singh, Shaili Srivastava, Dheeraj Rathore and Deepak Pant.2020. Environmental Microbiology and Biotechnology. Springer Publications. ISBN:978-981-15-6020-0*
- <https://doi.org/10.1016/B978-0-08-047514-1.50022-6>
- *Chhatarpal Singh,,Shashank Tiwari, Jay Shankar Singh, Ajar Nath Yadav .2020. Microbes in Agriculture and Environmental Development. Eds: CRC Press, Taylor and Francis Group ISBN 9780367524135*
- Soil biology and Biochemistry Journal, Elsevier
- Eileen J. Kladvko and M. Jill Clapperton.Soil Biology;Soil Management: Building a Stable Base for Agriculture. First published: 25 April 2011 Wiley online library
- L. Carpenter-Boggs and A. C. Kennedy.2011. Organic and Biodynamic Management Effects on Soil Biology

Library link, Central University of Gujarat: <http://14.139.122.35/drupal/node/19>

ESD-65 REMOTE SENSING AND GIS (CREDIT-2)

Unit-I: Remote Sensing and Digital Image Analysis

Basic Principles of Remote Sensing, Earth Observation Sensors and Platforms, Thermal Remote Sensing, Spectral Signatures of Different Land Cover Features and Visual Image interpretation, Digital Image Processing: Basic Concepts, Image Enhancement techniques, Image Classification Techniques and Accuracy Assessment. Microwave Remote Sensing, Hyperspectral Remote Sensing.

Unit-II: Geographical Information System & GNSS

Introduction to GPS and GNSS, GPS receivers, processing methods, errors and accuracy, GPS signal characteristics, Data formats (broadcast, precise ephemeris), Indian Regional Navigation Satellite System (IRNSS), DGPS demonstration. Introduction to GIS, Geographic Phenomena, Concepts and examples, Map Projection Concepts & Use in RS & GIS, Spatial Analysis-Introductory Concepts and Overview.

Unit-III: RS & GIS Applications

EO Applications for Natural Resources Management, RS and GIS Applications in Soil Resource Assessment, RS Applications in Agriculture- Crop Inventory & Yield Forecasting, RS & GIS Applications in Forestry and Ecology, RS & GIS Applications to Water Resources Management, RS & GIS for Coastal Zone Management, Remote Sensing Application to Atmospheric & Marine, Environment, RS & GIS Applications in Geology and Geomorphology.

Suggested Book

- Remote Sensing of the Environment: An Earth Resource Perspective John R. Jensen

ESD-655: INSTRUMENTATION (CREDIT -2)

Instrumental Methods for Analysis

Fundamentals of basic instruments: Concept, Electromagnetic spectrum, Quantum theory, Beer-lambert law.

Instrumentations: Theory, Principles, Working operation and application of Colourimetry, Spectrophotometry, Flame photometry, polarimetry, Atomic Absorption Spectroscopy, Gas Chromatography, High performance liquid chromatography, High Performance Thin layer chromatography,

Advance Instrumental Methods for Environmental Analysis

Fundamentals of Advance instrumentations: Theory, principles working operation and application of Liquid chromatography–mass spectrometry, Gas chromatography–Mass Spectrometer, Infra-Red Spectroscopy, Fourier Transform Infra-Red spectroscopy, Gamma Spectroscopy, Nuclear Magnetic Resonance, X-RAY Diffraction, *Scanning Electron Microscopy*, Transmission Electron Microscopy.

Bioinstrumentations: Biosensors, Electrophoresis, Gel electrophoresis, Polymerase chain reaction, conventional microscopy, Bioreactors.

Suggested reading

1. Roger Reeve (2002). Introduction to Environmental Analysis, John Wiley & Sons Ltd.
2. D.A.Skoog, D.M. West and F.J.Holler. (2001). Fundamentals of Analytical chemistry, 7th Edition. Harcourt Asia PTE.Ltd, New Delhi,
3. APHA standard methods for Water and Wastewater Examination, (1998). 20th Edition, Washington
4. Kim, Young, Platt, Ulrich. (2008). Advanced Environmental Monitoring. Springer
5. Janick Artiola, Ian L. Pepper, Mark L. Brusseau. (2004). Environmental Monitoring and Characterization. Elsevier.

**ESD 656 ENVIRONMENTAL BIOTECHNOLOGY & ENVIRONMENTAL
NANOTECHNOLOGY
(CREDIT-2)**

Unit-1: Environmental Biotechnology

Bioremediation: Definition, Types of bioremediation: In-situ and ex situ bioremediation; Bioremediation technologies; bioremediation monitoring; microbial metabolism, factors influencing metabolism, ground water and soil remediation - case studies

Phytoremediation: Definition, approaches, Phytoremediation processes, Mechanism of phytoremediation, Factors Influencing Phytoremediation, transgenic plants and its use for phytoremediation, Genetic engineering applications for phytoremediation; case studies.

Unit-2 Environmental Nanotechnology

Nanoscience for clean environment and sustainable development: Introduction, applications, and perspective in Environment; Nanotechnology for environmental sustainability; monitoring; Nano remediation; Nano remediation technologies: Research case studies.

Nanomaterials: Synthesis and characterization; Physical, Chemical, and Biological: (microbial and plant-based nanoparticle) synthesis; Natural Nanomaterial; Nanocomposite; Dendrimers; Nano polymers, Nano biopolymers, Nano biofilms, Nano catalyst, Nano semiconductors, carbon nanotubes, Nano clays; application of nanomaterial; Membrane Technology: Nano filtration; ultrafiltration; microfiltration; design and development of reactors; nano technological application for environment - Research case studies

Suggested Readings:

- Environmental Biotechnology: Concepts and Applications Editor(s): Priv.-Doz. Dr. Hans-Joachim Jördening, Prof. Dr. Josef Winter (2004) Print ISBN:9783527305858 |Online ISBN:9783527604289. DOI:10.1002/3527604286
- Textbook of Environmental Biotechnology (2006) P. K. Mohapatra. I K International Publishing House Pvt. Ltd; 1st Ed. edition (ISBN-10: 818823754X; ISBN-13: 978-8188237548
- Environmental Biotechnology (2010) M. H. Fulekar. ISBN 9781138097469 Published CRC Press.
- Environmental Biotechnology (2010) Wang, L.K., Ivanov, V., Tay, J.-H., Hung, Y.-T. (Eds.) eBook ISBN 978-1-60327-140-0; DOI 10.1007/978-1-60327-140-0
- Environmental Biotechnology Vol. 1 (2020) Gothandam, K., Ranjan, S., Dasgupta, N., Lichtfouse, E. (Eds.) ISBN 978-3-030-38191-2 DOI 10.1007/978-3-030-38192-9
- Environmental Biotechnology: Basic Concepts and Applications” by Indu Shekhar Thakur
- Bioremediation Technology: Hazardous Waste Management 1st Edition(2020) M H Fulekar (Editor), Bhawana Pathak (Editor) CRC Press

- Bioremediation- Applied Microbial Solutions for Real-World Environmental Cleanup- Ronald M. Atlas and Jim Philp: ASM Press, Washington
- Bioremediation Technology: Recent Advances- M.H.Fulekar: Springer Publishers
- Dictionary of Biotechnology- M.H.Fulekar: I.K. International Publishing House, New Delhi
- Environmental Biotechnology - M.H.Fulekar: Oxford & IBH Publishing House, New Delhi
- Environmental Biotechnology - Theory and Application – M.H.Fulekar: CRC Press and Science Publisher, USA
- Microbial Biotechnology- Fundamentals of applied Microbiology- Alexander N. Glazer and Hiroshi Nikaido, Cambridge University Press
- Microbial Methods for Environmental Biotechnology: Grainer, J.M. and Lynch, J.M. 1984. Academic Press.
- Microbiological Methods for Environmental Scientists and Engineers: Gaudy, A.F. and Gaudy, E.T. 1980, McGraw Hill.
- Nanotechnology –its Importance & Applications - M.H.Fulekar: IK International
- Environmental Nanotechnology (2017) By M. H. Fulekar, Bhawana Pathak ISBN 9781498726238 by CRC Press
- Environmental Nanotechnology Volume 1 (2018) Dasgupta, Nandita, Ranjan, Shivendu, Lichtfouse, Eric (Eds.) ISBN 978-3-319-76089-6; DOI 10.1007/978-3-319-76090-2
- Nanotechnology in Environmental Science (2018) Chaudhery Mustansar Hussain, Ajay Kumar Mishra ISBN:9783527342945 |Online ISBN:9783527808854 DOI:10.1002/ 9783527808854

ESD 657 Groundwater Hydrology (CREDIT-2)

UNIT-1:

Introduction to groundwater resources, occurrence and movement, Aquifers and their characteristics/classification, Darcy's law, Dupit's assumptions, Flow nets, Groundwater tracers, Well hydraulics – steady/unsteady, uniform/radial flow to a well in a confined/unconfined/leaky aquifer, Well flow near aquifer boundaries/for special conditions;

UNIT-2:

Quality of groundwater, Contaminant transport processes, Advection-dispersion equation, Treatment of contaminated groundwater, Climate change and groundwater; Introduction to Groundwater flow modelling, Governing equations, Artificial recharge, Saline water intrusion in aquifers - Ghyben-Herzberg relation, Remote sensing-based groundwater studies.

Suggested Readings:

- Groundwater Hydrology by Todd, D. K. and Mays, L. W., John Wiley & Sons, Inc.
- Ground and Surface Water Hydrology by Mays, L. W., John Wiley & Sons, Inc.
- Groundwater Modeling, in an Introduction to Water Quality Modelling by Mackay, R. & Riley, M., A. James, Wiley Publishers.
- Hydrogeology: Principles and Practice by Hiscock, K. M. and Bense, V. F., Wiley-Blackwell.

ESD 658 ENVIRONMENTAL STRESSES IN PLANTS (CREDIT-2)

Unit-1:

Impact of environmental stresses (abiotic and biotic) on growth, development, metabolism and yield of plants, Stress sensing and signalling in plants, Stress induced senescence in plants, Morphological, physiological, biochemical and molecular changes in plants in response to environmental stresses.

Unit-2:

General and stress specific tolerance mechanisms in plants, Types of reactive oxygen species (ROS), sites of ROS production in plants, ROS as signalling molecule, Oxidative stress, ROS induced oxidative damage in plants, antioxidative defense mechanisms in plants, Nonenzymatic and enzymatic components of antioxidative defense System in plants, Roles of osmolytes, polyamines, Late Embryogenesis Abundance (LEA) proteins, heat shock proteins (Hsps) in plant adaptation to different environmental stresses, Regulatory network underlying defense systems, Plant responses to concurrent environmental stresses

Unit-3:

Methods to study stress tolerance in plants, Strategies to develop stress tolerance in plants, Genetic engineering for developing stress tolerance, Genes implicated in stresses: genes encoding proteins that act directly and proteins that regulate stress responsive genes, Development of multiple stress tolerant plant.

Suggested Readings

- Mittler, R., 2006. Abiotic stress, the field environment and stress combination. *Trends in plant science*, 11(1), pp.15-19.
- Tuteja, N. and Gill, S.S., 2016. *Abiotic stress response in plants*. John Wiley & Sons. ISBN: 978-3-527-33918-1
- Hasanuzzaman, M., Fujita, M., Oku, H. and Islam, M.T. eds., 2019. *Plant tolerance to environmental stress: Role of phytoprotectants*. CRC Press. ISBN 9781032094014
- Jha, A.B., Misra, A.N. and Sharma, P. (2019) Regulation of osmolytes syntheses in plants and improvement of abiotic stress tolerance: Profiling and counteraction. In: *Approaches for Enhancing Abiotic Stress Tolerance in Plants* (pp. 311-318), Eds. Hasanuzzaman, M., Nahar, K., Fujita, M., Oku, H., Islam, T. 1st Edition, CRC Press, Taylor and Francis. DOI: 10.1201/9781351104722-17; ISBN 9780815346425
- Sharma, P., Jha, A.B., Dubey, R.S. and Pessarakli, M. (2012) Reactive oxygen species, oxidative damage and antioxidative defense mechanism in plants under stressful conditions. *Journal of Botany*, volume 2012, Article ID 217037, 26 pages, doi:10.1155/2012/217037.
- Sharma, P. and Dubey, R.S. (2011) Abiotic stress induced metabolic alterations in crop plants: Strategies for improving stress tolerance. In: Sinha, R.P., Sharma, N. K. and Rai, A.K. editors. *Botanical Research: The Current Scenario*, I K International Publishing House Pvt. Ltd., New Delhi, India, ISBN: 9789381141045, pp. 1-54.

- Kuila, A. ed., 2020. *Plant Stress Biology: Progress and Prospects of Genetic Engineering*. CRC Press. ISBN 9781771889254.

**ESD-659 FORESTRY AND REMOTE SENSING
(CREDIT-2)**

Unit-I: Forestry and Optical Remote Sensing

Forestry: Concepts Conventional/Recent Remote Sensing Classification and Forest Inventory, Climatic, Altitudinal and Topographical Zones and Vegetation Relation, Forest Types Classification and Retrieval of Biophysical Parameters, Sensor Requirements. Application of Optical Remote Sensing in Forestry. Remote Sensing application in forest cover change detection, Remote Sensing application in mapping of stressed vegetation.

UNIT-II: Forestry and Microwave Remote Sensing

Microwave remote sensing, Interaction with plant. Role of microwave remote sensing in forest studies-Interferometry and Polarimetry. Microwave techniques for Biomass estimation. Microwave techniques for forest cover classification. Interaction of microwave with forest.

Suggested Books:

- Nicolas Baghdadi and MehrezZribi (2016). Land Surface Remote Sensing in Agriculture and Forest, ISTE Press and Elsevier, UK.ISBN:978-1-78548-103-1 2.
- Roy, P.S., Dwivedi, and Vijayan, D. (2010). Remote Sensing Applications. NRSC, ISRO, Hyderabad. ISBN 978-81-909460-0-1. 3. NDMA (2010).
- Fortin, M.S. and Dale, M. (2005). Spatial Analysis for Ecologist, Cambridge University Press, Cambridge. ISBN- 9780521804345.

ESD-660 ENVIRONMENTAL POLLUTION (CREDIT-2)

Environmental pollution, Types of pollution; Water pollution, Air pollution, Soil pollution, Noise pollution, Radioactive pollution, Status of Environmental pollution in India

WATER POLLUTION

Water pollution: Types of pollution, causes of pollution, trends of pollution, effects of pollution on biotic life and environment; **Wastewater:** Characteristics of domestic, industrial agricultural wastes -their effects on water bodies; **Wastewater treatment technology:** Recycling and reuse of water, water audit-concern of zero discharge, safe land application of wastewater, Physico-chemical and biological methods, Industrial effluent treatments; **Legislations and Regulations:** Prevention and control of surface and ground water; Water (Prevention and Control of Pollution) Act, 1974

AIR POLLUTION

Sources and types of air pollution: Atmosphere and its functions, causes of air pollution, sources of air pollution, types of air pollution: **Pollution components:** Gaseous pollutants, particulate matter, photochemical smog, Air pollutants and their interaction in the atmosphere, hazardous air pollution; **Diffusion, Transport and dispersion:** Meteorological and topographical factors, lapse rate, atmospheric stability, mixing height, Monitoring air quality, air quality parameters, air quality index, air quality standards, Prevention and Control of air pollution technologies, modelling concepts, Gaussian plume model; Effect of air pollution on plants, animals, human and materials; **Legislations and regulations:** The Air (Prevention and Control of Pollution) Act, 1981

SOIL POLLUTION AND SOLID WASTE MANAGEMENT

Profile, texture and type: Soil in perspective: Soil profile, Soil texture and types, Sub soil and surface soil, Mineral constituent in soil; **ynamics:** Soil-water dynamics, soil-air changeable constituent, soil -water characteristics and behavior, effects of soil pollution; **Pollution and degradation:** Sources of soil degradation, soil erosion, Causes of soil pollution, Effects of soil pollution and plant productivity; **Treatment and Remediation:** Soil plant relationship. Control of soil pollution and treatment Technology, biotechnology for treatment of solid and biomedical waste; **Legislations and Regulations** for Solid waste, hazardous waste, biomedical waste, municipal waste, plastic waste, batteries waste and e-waste.

Suggested reading

1. Fundamental of Air pollution. 4th Edition, Daniel Vallero, Academic Press, Elsevier

2. Ambasht R.S.; Environment and Pollution: An Ecological Approach, CBS Publishers & Distributors; 1st Ed. edition 2014.
3. Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000
4. R.K. Khitoliya; Environmental Pollution, S Chand & Co Ltd; 1st Edn. 2004 edition (1 December 2006).
5. N. Kumar; Air pollution and Environmental Protection-Legislative policies, Mittal Publication.
6. Martin B. Hocking. (2005) Handbook of Chemical Technology and Pollution Control. Elsevier

Semester II

PROJECT 06 CREDITS

Course Code	Paper No.	Paper Name	Credits	Hours/Week
ESD 691		Project	06	12
Extra Credits				
ESD 692		Field work **/Specific Training **	4	8