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DEPARTMENT OF ENVIRONMENTAL STUDIES

SEMESTER - III

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COURSES OFFERED BY DEPARTMENT OF ENVIRONMENTAL SCIENCE

Category-I

Environmental Science Courses for Undergraduate Programme of study with Environmental Science as a Single Core Discipline

BSC (H) ENVIRONMENTAL SCIENCE

DISCIPLINE SPECIFIC CORE COURSE – 7 (DSC-EVS-7): ENVIRONMENTAL BIOTECHNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-7: ENVIRONMENTAL BIOTECHNOLOGY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Provide theoretical and practical biotechnological skills for environmental goals
- Evolve ecological foundations of using microorganisms in biodiversity assessment, ecosystems restoration, and environmental remediation
- Relate the microbial ecophysiology with biogeochemical cycles that govern the terrestrial ecosphere
- Emphasize the relevance of biotechnological processes in environmental applications and sustainable development

Learning outcomes

After this course, students will be able to learn the following skills.

- Apply the biotechnological methods to improve environmental management
- Perform comparative protein and DNA sequence analyses to elucidate the phylogenetic relationship
- Analyze non-culturable microbial diversity in the environment and classify microbes based on energy and carbon metabolism

- Plan methods for combined biological nutrient removal (BNR), treat wastewater, and remediate soils and water contaminated with organic and inorganic pollutants

SYLLABUS OF DSC-EVS-7

Theory (02 Credits: 30 lectures)

UNIT – I The Structure and Function of DNA, RNA and Protein (3½ Week) (7 lectures)

DNA: structural forms and their characteristics (B, A, C, D, T, Z); physical properties: UV absorption spectra, denaturation, and renaturation kinetics; biological significance of different forms; Synthesis.

RNA: structural forms and their characteristics (rRNA, mRNA, tRNA; SnRNA, Si RNA, miRNA, hnRNA); biological significance of different types of RNA; synthesis.

Protein: hierarchical structure (primary, secondary, tertiary, quaternary), types of amino acids; post-translational modifications and their significance; synthesis; types and their role: structural, functional (enzymes).

Central dogma of biology; genetic material prokaryotes, viruses, eukaryotes and organelles; mobile DNA; chromosomal organization (euchromatin, heterochromatin - constitutive and facultative heterochromatin).

UNIT – II Recombinant DNA Technology (3½ Week) (7 lectures)

Recombinant DNA: origin and current status; steps of preparation; toolkit of enzymes for manipulation of DNA: restriction enzymes, polymerases (DNA/RNA polymerases, transferase, reverse transcriptase), other DNA modifying enzymes (nucleases, ligase, phosphatases, polynucleotide kinase); genomic and cDNA libraries: construction, screening and uses; cloning and expression vectors (plasmids, bacteriophage, phagmids, cosmids, artificial chromosomes; nucleic acid microarrays

UNIT – III Ecological restoration and bioremediation (5 Week) (10 lectures)

Wastewater treatment: anaerobic, aerobic process, methanogenesis, bioreactors, cell and protein (enzyme) immobilization techniques; treatment schemes for wastewater: dairy, distillery, tannery, sugar, antibiotic industries; solid waste treatment: sources and management (composting, vermiculture and methane production, landfill. hazardous waste treatment); specific bioremediation technologies: land farming, prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, constructed wetlands, use of bioreactors for bioremediation; phytoremediation; remediation of degraded ecosystems; advantages and disadvantages; degradation of xenobiotics in the environment, decay behavior and degradative plasmids, hydrocarbons, substituted hydrocarbons, oil pollution, surfactants, pesticides, heavy metals degradative pathways.

UNIT – IV Ecologically safe products and processes (3 Week) (6 lectures)

PGPR bacteria: biofertilizers, microbial insecticides, and pesticides; bio-control of the plant

pathogen, Integrated pest management; development of stress-tolerant plants, biofuel; mining and metal biotechnology: microbial transformation, accumulation, and concentration of metals, metal leaching, extraction; exploitation of microbes in copper and uranium extraction.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Undertake comparative analyses of the ultrastructure of cells and cellular organelles of prokaryotes and eukaryotes.
2. Analyze UV absorption spectra of DNA, RNA and protein
3. Determine denaturation and renaturation of dsDNA
- 4-5. Estimate contents of DNA and protein in the given samples
6. Visit contaminated or degraded habitats and analyze their vegetation characteristics and compare them with pristine habitat
7. Characterize and analyze plants documented in practical 6 to identify species having the potential for phytoremediation
- 8-10. Isolate phosphate-solubilizing bacteria from different soils and assess morphological and functional variations in phosphate-solubilizing bacteria
11. Determine bacterial density in soils sampled from contaminated and pristine habitat
12. Visit and analyze various steps of Sewage/Wastewater treatment processes (STP/WTP).
- 13-15. Explore and use different molecular databases for application in environmental science

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Essential/recommended readings

- Furlong, J. and Evans, G.G., 2011. Environmental Biotechnology: Theory and Application. John Wiley & Sons.
- Jordening, H.J. & Winter J. 2005. Environmental Biotechnology: Concepts and Applications. John Wiley& Sons.
- Nelson, D.L. & Cox, M.M. 2013. Lehninger's Principles of Biochemistry. W.H. Freeman.
- Rittman, B.E. & McCarty, P.L. 2020. Environmental Biotechnology. Principles and Applications. McGraw-Hill, New York.
- Snustad, D.P. & Simmons, M.J. 2011. Principles of Genetics (6th edition). John Wiley& Sons.
- Vallero, D., 2015. Environmental Biotechnology: A Biosystems Approach. Academic Press.
- Wainwright, M., 2012. An introduction to Environmental Biotechnology. Springer Science & Business Media.

Suggestive readings

- Lodish, H., Berk, A., Kaiser, C.A., Kaiser, C., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H. and Matsudaira, P., 2008. Molecular Cell Biology. Macmillan.
- Moo-Young, M., Anderson, W.A. and Chakrabarty, A.M. eds., 2013. Environmental Biotechnology: Principles and Applications. Springer Science & Business Media.
- Petre, M. ed., 2013. Environmental Biotechnology: New Approaches and Prospective Applications. InTech, Croatia.
- Scagg, A.H. 2005. Environmental Biotechnology. Oxford University Press.
- Souvorov, A.V. 1999. *Marine Ecogonomics: The Ecology and Economics of Marine Natural Resource Management*. Elsevier Publications.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 8 (DSC-EVS-8): ATMOSPHERE & GLOBAL CLIMATE CHANGE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
ATMOSPHERE & GLOBAL CLIMATE CHANGE	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Analyze dynamics of atmospheric processes, which include their composition, meteorological phenomena, and atmospheric chemistry.
- Gain knowledge on the development of the Earth’s atmosphere, its dynamic nature, and variability in turns of the global energy balance.
- Describe air masses and formation and impacts fronts and how they affect local weather patterns,
- Develop a better understanding of the elements of the climate and climate change and human impacts on climate initiative policies.
- Train on different methods to understand the functioning of atmospheric processes and their importance in supporting life on Earth

Learning outcomes

After this course, students will be able to

- understand the underlying physical and chemical basis of the natural and anthropogenic greenhouse effect
- develop pathway analysis to develop linkages between various human-induced emissions of natural greenhouse gases and the formation of aerosols
- appreciate the variability in the Earth's climate and correlate the changing climate with different human activity
- critically evaluate the complexities and uncertainties about scientific evidence for climate change
- analyze Earth’s past and Anthropocene and global climate
- correlate effects of global climate changes on human communities and impacts of policy and technology initiatives taken at global and regional levels to combat the climate change

SYLLABUS OF DSC-EVS-8

Theory (02 Credits: 30 lectures)

UNIT – I Introduction and Global Energy Balance (2 Weeks) (4 lectures)

Evolution and development of Earth's atmosphere; atmospheric structure and composition; significance of atmosphere in making the Earth, the only biosphere; Milankovitch cycles. Earth's energy balance; energy transfers in the atmosphere; Earth's radiation budget; greenhouse gases (GHGs); greenhouse effect; global conveyor belt.

UNIT –II Atmospheric circulation (2½ Weeks) (5 lectures)

Movement of air masses; atmosphere and climate; air and sea interaction; southern oscillation; western disturbances; *El Nino* and *La Nina*; tropical cyclone; Indian monsoon and its development, changing monsoon in Holocene in the Indian subcontinent, its impact on agriculture and Indus valley civilization; effect of urbanization on microclimate; Asian brown clouds.

UNIT –III Meteorology and atmospheric stability (2 Weeks) (4 lectures)

Meteorological parameters (temperature, relative humidity, wind speed and direction, precipitation); atmospheric stability and mixing heights; temperature inversion; plume behavior; Gaussian plume model.

UNIT –IV Atmospheric chemistry (2 Weeks) (4 lectures)

Chemistry of atmospheric particles and gases; smog – types and processes; photochemical processes; ions and radicals in atmosphere; acid-base reactions in atmosphere; atmospheric water; roles of hydroxyl and hydroperoxyl radicals in atmosphere.

UNIT –V Global warming and climate change (2½ Weeks) (5 lectures)

Earth's climate through ages; trends of global warming and climate change; drivers of global warming and the potential of different greenhouse gases (GHGs) causing the climate change; atmospheric windows; impacts of climate change on atmosphere, weather patterns, sea level rise, agricultural productivity and biological responses - range shift of species, CO₂ fertilization and agriculture; impact on the economy and spread of human diseases.

UNIT –VI Ozone layer depletion (2½ Weeks) (5 lectures)

Ozone layer or ozone shield; Importance of ozone layer; Ozone layer depletion and causes; Chapman cycle; Orocess of springtime ozone depletion over Antarctica; Ozone-depleting substances (ODS); effects of ozone depletion; mitigation measures and international protocols.

UNIT –VII Climate change and policy (1½ Weeks) (3 lectures)

Environmental policy debate; International agreements; Montreal protocol 1987; Kyoto protocol 1997; Convention on Climate Change; carbon credit and carbon trading; Clean development mechanism.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Analyze the atmospheric chemistry of a given area with respect to target greenhouse gas(es) and its changes over time
2. Identify weather patterns and climate of the given region
3. Calculate the carbon footprint of the given institution (homes and/or college)
4. Evaluate the perception of climate change in developed and developing countries
5. Identify the critical factors governing global climate change and relate with the goals of different international governmental and non-governmental organizations
- 6-7. Compare the targets and achievements in global efforts to combat global climate change during the past three decades
- 8-9. Estimate the difference in carbon stock between soil and trees of a given area
10. Understand and correlate annual tree ring data with a historical account of climate
11. Identify the critical factors governing global climate change and relate them with the goals of different international governmental and non-governmental organizations
12. Compare climate change policies of selected developed and developing countries

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Barry, R. G. 2003. Atmosphere, Weather and Climate. Routledge Press, UK.
- Hardy, J.T. 2003. Climate Change: Causes, Effects and Solutions. John Wiley & Sons.
- Hoffman, S., Eriksen, T.H. and Mendes, P. eds., 2022. Cooling Down: Local

Responses to Global Climate Change. Berghahn Books.

- Manahan, S.E. 2010. Environmental Chemistry. CRC Press, Taylor and Francis Group.
- Maslin, M. 2014. Climate Change: A Very Short Introduction. Oxford Publications.
- Mathez, E.A. 2009. Climate Change: The Science of Global Warming and our Energy Future. Columbia University Press.
- Salby, M.L., 2012. Physics of the Atmosphere and Climate. Cambridge University Press.
- Speight, J.G., 2019. Global Climate Change Demystified. John Wiley & Sons.
- Wang, Y (2020). Atmosphere and Climate, 2nd Edition, Handbook of Natural Resources Vol VI, CRC Press.

Suggestive readings

- Crate, S.A. and Nuttall, M., 2016. Anthropology and Climate Change: From Actions to Transformations. Routledge.
- Gillespie, A. 2006. Climate Change, Ozone Depletion and Air Pollution: Legal Commentaries with Policy and Science Considerations. Martinus Nijhoff Publishers.
- Harvey, D. 2000. Climate and Global Climate Change. Prentice Hall.
- Hering, E., 2010. Atmosphere and Climate: Studies by Occultation Methods. Springer.
- Philander, S.G. 2012. Encyclopedia of Global Warming and Climate Change (2nd edition). Sage Publications.
- Sauer, T.J. and Norman, J.M. eds., 2011. Sustaining Soil Productivity in Response to Global Climate Change. Wiley-Blackwell.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 9 (DSC-EVS-9): MARINE ECOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MARINE ECOLOGY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into the dynamic processes that affect oceans, i.e., water, seafloor, and abundant life forms
- Identify the role being played by ocean-atmosphere interaction in the climate processes.
- Investigate the role of ocean processes in coastal and marine landform creation.

Learning outcomes

After this course, students will be able to

- Analyze the role of physical processes in the dynamic process of ocean circulation.
- Formulate solutions ailing the current state of the coastal and marine environment in terms of chemical and biological interactions.
- Implement the knowledge base to promote ocean awareness in light of human exploitation of its resources.
- Assess the impacts of environmental and anthropogenic variables on marine ecosystems and biodiversity with time and space
- Use ecological data to predict the impact of a given factor on marine biodiversity and ecology

SYLLABUS OF DSC-9

Theory (02 Credits: 30 lectures)

UNIT – I Introduction (2 Weeks) (4 lectures)

A short history of the oceans and continents, History of marine ecology, Morphologic and tectonic domains of the ocean floor; Ocean basins, Ocean sediments; Composition of seawater, carbon dioxide-carbonate system; Atmospheric circulation, Ocean circulation, Life in the ocean, Pelagic communities, Benthic communities, Uses and abuses of the ocean.

UNIT – II Geography and physical forcing of Marine Ecosystems: (2 Weeks) (4 lectures)

Climate and Circulation of the World Ocean, Geostrophic flow and the central ocean gyres, Convergence zones and fronts, Thermohaline circulation and the origins of deep-water coasts,

shallows, and their consequences; Global distribution of ocean productivity, Vertical structure of the pelagic water column, The spring bloom, High-nitrogen low-chlorophyll (HNLC) regions

UNIT – III Biodiversity and biogeography of Ocean (3 Weeks) (6 lectures)

Magnitude of Biodiversity; Biodiversity on Land and Sea, Phylogenetic Classification of Marine Biodiversity, Functional Organization of Pelagic and Benthic Life, Major Patterns in the Distribution of Marine Life (Spatial, latitudinal, longitudinal, depth, bottom type); Biogeography of Functional Traits, Evidence for Island Biogeography, Integrative Models of Marine Diversification, Biogeographic Classifications of the Ocean, Biogeography of the Anthropocene Ocean.

UNIT – IV Macro- and trait-based ecology of marine organisms (3 Weeks) (6 lectures)

Species Interactions, Functional groups of phytoplankton, benthic macrophytes, and grazers; Pelagic food webs, microbial loop, Metabolic scaling and life history, Abundance and the energetic equivalence rule, Macroecology of range size Specialization and resource partitioning, Nonequilibrium dynamics; Biological pump and the global carbon cycle, Trophic control in pelagic ecosystems.

UNIT – V Anthropocene Ocean (2½ Weeks) (5 lectures)

Marine populations in the Anthropocene, Marine defaunation and trophic skew, Empirical evidence for regime shifts in marine ecosystems, Mechanisms of marine regime shifts, Ocean Warming and its effects on community and sea level rise, Ocean Acidification and its effects on organisms and communities, Ecological stoichiometry, Climate change and redistribution of global marine fauna, Tropicalization, The Arctic opening

UNIT – VI Ocean Conservation and Management (2½Weeks) (5 lectures)

Maximum sustainable yield in fisheries, Strategic conservation of vulnerable life stages, Life history and the effectiveness of marine reserves, Organismal Fitness and Adaptation to the Environment, Dispersal, Recruitment, and Metapopulations, Tagging and tracking, Geochemical tags.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Construct microcosm for marine ecology studies
- 2-3. Determine environmental partitioning of target chemicals in the constructed microcosm
- 4-5. Determine physico-chemical properties of given sediment sample
- 6-7. Examine methods to analyze phytoplankton and zooplanktons in the given water samples and its application in analyzing marine ecology
8. Analyze relationships between soil particle characteristics and biological

- properties of sediment
9. Analyze oceanographic data by GIS and identify ecologically-relevant oceanographic data using remote sensing
 10. Isolate bacteria from the freshwater river and estimate their growth in seawater
 11. Determine microbial density in a given marine water sample
 12. Compare the biodiversity of freshwater bodies and marine ecosystems by examining a review/research paper
 13. Analyze plate tectonic theory and understand the variations in global marine ecosystems
 14. Evaluate merit and demerits of ocean acidification manipulation experiments conducted globally
 15. Compare and contrast the benefits of using a storage tank, mixing tank, header tank and experimental tank to understand marine ecology

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Arias, A.H. and Menendez, M.C. eds., 2013. Marine Ecology in a Changing World. CRC Press.
- Garrison, T.S., 2014. Essentials of Oceanography. Cengage Learning.
- Kennish, M.J., 2019. Practical Handbook of Marine Science. CRC Press.
- Kaiser, M.J., Jennings, S., Thomas, D.N. and Barnes, D.K., 2011. Marine Ecology: Processes, Systems, and Impacts. Oxford University Press.
- Mann, K.H. and Lazier, J.R., 2013. Dynamics of Marine Ecosystems: Biological-Physical Interactions in the Oceans. John Wiley & Sons.
- Speight, M.R. and Henderson, P.A., 2013. Marine Ecology: Concepts and Applications.
- Thrush, S., Hewitt, J., Pilditch, C. and Norkko, A., 2021. Ecology of Coastal Marine Sediments: Form, Function, and Change in the Anthropocene. Oxford University Press.

Suggestive readings

- Gray, J.S. and Elliott, M., 2009. Ecology of Marine Sediments: from Science to Management. Oxford University Press.
- Miller, C.B., 2009. Biological Oceanography. John Wiley & Sons.
- Pittman, S.J. ed., 2017. Seascape Ecology. John Wiley & Sons.
- Riley, J.P. and Chester, R. eds., 2016. Chemical Oceanography. Elsevier.
- Talley, L.D., 2011. Descriptive Physical Oceanography: An Introduction. Academic press.

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