# COURSE OF STUDY

## MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE

**(M.Sc. in Environmental Science)**

**Effective from Academic Year 2023 - 2024**
**&**
**For the Academic Batch 2023 - 2025**

# Department of Environmental Studies

# BERHAMPUR UNIVERSITY
## Bhanja Bihar – 760007
## Odisha, India

M.Sc. in Environmental Science Syllabus (course outline) as finalized by the Board of Studies (vide office notification dated 02 August 2023) in its 1st meeting held on 04 August 2023

# M.Sc. in Environmental Science

## Course Curriculum & Syllabi (Outline) - 2023

## Department of Environmental Studies, Berhampur University

### 1. About the Department

The history of the Department of Environmental Studies (DES) goes back to 2018 when its earlier avatar – the Department of Natural Resources Management and Geoinformatics (NRMG) was established in the erstwhile Khallikote University, Berhampur. Initially the department had an interdisciplinary focus offering Master (M.A./M.Sc.) and Ph.D. degrees in Khallikote University. After the amalgamation of Khallikote University with Berhampur University, a major academic restructuring exercise was carried out, and in Berhampur University while maintaining the interdisciplinary nature, the present Department of Environment Studies was created in the year 2021. Presently, this department offers Post Graduate Degree (M. Sc.) and Doctoral Degree in Environmental Science. The genesis for such a department was to produce quality manpower in the field of Environment and Sustainability both through teaching and R&D activities, to meet the aspirations of the state as well as the country. Presently, the Department has the following 04 faculty members:

- Dr B. Anjan Kumar Prusty, Associate Professor & Head
- Dr Kabita Baral, Assistant Professor
- Dr Santosh Kumar Beja, Assistant Professor
- Dr Rachna Panda, Assistant Professor (Contractual Faculty)

### 2. About the Post Graduate Programme

Presently, the Department of Environmental Studies offers M.Sc. and Ph.D. Environmental Science. Conducting the Post Graduate Programme is one of the approaches of disseminating the knowledge of environmental management and ecosystem conservation and helping in human resource development in the field is one of the major objectives of the Department of Environment Studies. The prime aim of this Post Graduate Program is to initiate a course which is different from the courses on Environmental Sciences being offered by many other universities. This course will address the need for better environmental management and sustainable development utilizing the expertise of the faculty members.

The Post Graduate Degree is offered as M.Sc. in Environmental Science. A prospective student to the Programme must have a BSc degree in Environmental Science /Physics / Chemistry / Botany/ Zoology/ Mathematics/ Agriculture Science/ Geography/ BE in Environmental Engineering) from any recognized University/institution with minimum of 45% marks in aggregate. The admission to 30 seats for this PG Programme is through the Common PG Entrance Test (CPET) as conducted by the Department of Higher Education, Government of Odisha. The Courses of Studies for M.Sc. in Environmental Science are under Choice Based Credit System (CBCS) effective from the academic session 2023-2024. The Syllabus has been designed covering practical/dissertations/field works/seminars, etc., wherever applicable. A

list of Text Books and Reference Books (as applicable) is provided against each paper for all the Semesters. However, students may also make use of authentic online sources for their benefit. A student is advised to deliver at least one seminar talk on a selected topic (research articles published in peer-reviewed journals) based on the syllabus during each semester (weekly-at least one Seminar by one of the students, to cover all students). During the course work, students are allowed to interact with the faculty to clarify their doubts, if any. The assessment pattern includes internal tests, end of semester examinations, field study reports, assignments, and major project works, as appropriate.

### 3. Programme Outcome

The M.Sc. in Environmental Science is a 02-year curriculum spanning over 04 semesters. The course is designed to equip the students with the ability to develop understanding on real-world environmental problems, and approaches to address such issues and challenges in environmental management. The course covers a good mix of both theoretical as well as practical components so that students can gain in-depth understanding of the tools and techniques widely used in environmental management in both industry, field and society, and at the same time develop good analytical, computational and geo-spatial skills in analyzing different environmental issues that the planet earth has been facing in this century. At the end of the course, the students shall have both theoretical and practical knowledge on the core issues of the Environment and Sustainability. They would also acquire general orientation and better understanding on all important aspects of Environment and sustainability, including (i) Ecosystem Ecology, (ii) Environmental Chemistry, (iii) Environmental Geosciences, (iv) Environmental Impact Assessment and Auditing, (v) Environmental Pollution, (vi) Forest and Wildlife Conservation, (vii) Hydrology and Water Resource Management, (viii) Disaster Management, (ix) Global Climate Change, and (x) Tools and Techniques of Environmental Monitoring (including analytical, computational, ecological, statistical, and geo-spatial tools).

## Snapshot of Credits (Semester wise)

| Semester | Courses | Credits | Marks |
|---|---|---|---|
| **1st Semester** | 06 core courses of 04 credits each (05 theory and 01 practical) | 24 | 600 |
| **2nd Semester** | 06 core courses of 04 credits each (05 theory and 01 practical) and 01 Value Added Course (Non-credit) | 24 | 600 |
| **3rd Semester** | 06 core courses of 04 credits each (02 core courses and 02 electives to be chosen from the 04 electives (stream specific), 01 Inter-departmental Elective (CBCT), 01 practical/field study/tutorial/assignments), and 01 Value Added Course (Non-credit) | 24 | 600 |
| **4th Semester** | 02 core courses of 04 credits each and 01 minor project (summer internship project) and major project work equivalent to 03 core courses)* | 24 | 600 |
| | **Total Credits** | **96** | **2400** |
| ** The dissertation / major project work shall be equivalent to 03 core courses (12 credits)* | | | |

## List of Courses (Papers)

| Sl No. | Paper Code | Title | Credits | Internal Marks | End Sem Marks | Total marks |
|---|---|---|---|---|---|---|
| **Semester - I** | | | | | | |
| 1 | ENVS C-101 | Fundamentals of Earth System Science | 04 | 20 | 80 | 100 |
| 2 | ENVS C-102 | Ecology and Ecosystems | 04 | 20 | 80 | 100 |
| 3 | ENVS C-103 | Basics of Remote Sensing and GIS | 04 | 20 | 80 | 100 |
| 4 | ENVS C-104 | Environment and Society | 04 | 20 | 80 | 100 |
| 5 | ENVS C-105 | Methods of Analysis of Environmental Samples | 04 | 20 | 80 | 100 |
| 6 | ENVS P-106 | Lab Practical – I: Based on the above papers (Environmental Monitoring Lab-I) | 04 | 0 | 100 | 100 |
| 7* | --- | Student Seminar (Departmental Journal Club)* | --- | --- | --- | |
| **Semester-I Total** | | | **24** | **100** | **500** | **600** |
| **Semester - II** | | | | | | |
| 8 | ENVS C-201 | Natural Resource Management and Governance | 04 | 20 | 80 | 100 |
| 9 | ENVS C-202 | EIA, Auditing & EMS: Tools and Techniques | 04 | 20 | 80 | 100 |
| 10 | ENVS C-203 | Basic Statistics and Computer Applications | 04 | 20 | 80 | 100 |
| 11 | ENVS C-204 | Aquatic Ecosystems and Water Resources Management | 04 | 20 | 80 | 100 |
| 12 | ENVS C-205 | Environmental Geosciences | 04 | 20 | 80 | 100 |

| Sl No. | Paper Code | Title | Credits | Internal Marks | End Sem Marks | Total marks |
|---|---|---|---|---|---|---|
| 13 | ENVS P-206 | Lab Practical – II: Based on the above papers (Environmental Monitoring and Computational Lab-II) | 04 | 0 | 100 | 100 |
| 14 | ENVS VAC-207# | Value Added Course | NC | 20 | 80 | 100 |
| 15* | --- | Student Seminar (Departmental Journal Club)* | --- | --- | --- | --- |
| 16$ | --- | Summer Internship (Industrial Visits or visit to different organizations/research institutions)$ | --- | --- | --- | --- |
| **Semester - II Total** | | | **24** | **100** | **500** | **600** |
| **Semester - III** | | | | | | |
| **Common Courses** | | | | | | |
| 17 | ENVS C-301 | Forest and Wildlife: Ecology and Conservation | 04 | 20 | 80 | 100 |
| 18 | ENVS C-302 | Energy & Environment | 04 | 20 | 80 | 100 |
| **Specialized (Elective) Courses** | | | | | | |
| 19 | ENVS E-303 | Elective - I | 04 | 20 | 80 | 100 |
| 20 | ENVS E-304 | Elective - II | 04 | 20 | 80 | 100 |
| 21 | ENVS P-305 | Lab Practical – III: Based on the above papers (Environmental Monitoring and Geological Lab-III) | 04 | 0 | 100 | 100 |
| **Common Courses** | | | | | | |
| 22 | ENVS CT-300** | CBCT course (Interdisciplinary Elective)** | 04 | 20 | 80 | 100 |
| 23 | ENVS VAC-307# | Value Added Course | NC | 20 | 80 | 100 |
| 24 | --- | Student Seminar (Departmental Journal Club) | --- | --- | --- | --- |
| **Semester - III Total** | | | **24** | **100** | **500** | **600** |
| **Semester - IV** | | | | | | |
| 25 | ENVS C-401 | Disaster Management | 04 | 20 | 80 | 100 |
| 26 | ENVS C-402 | Environmental Law (Acts, Notifications and Conventions) | 04 | 20 | 80 | 100 |
| 27* | --- | Student Seminar (Departmental Journal Club)* | --- | --- | --- | |
| 28$ | ENVS C-403$ | Minor Project Work (Summer Internship Report) and Journal Club (Seminar) Assessments | 04 | 20 | 80 | 100 |
| 29 | ENVS C-404**** | Major Project Work | 12 | 60 | 240 | 300 |
| 30 | ENVS AC-405## | Cultural Heritage of South Odisha | NC | 10 | 40 | 50 |
| **Semester - IV Total** | | | **24** | **100** | **500** | **600** |
| **Grand Total** | | | **96** | **---** | **---** | **2400** |

## Selection of Elective Courses

The Department offers a basket of Elective Papers offered during 3rdsemester to select students their own choice of specializations. The students can choose 01 elective paper from each elective cluster of 02 papers (total 02 elective papers) in 3rdsemester. Further, out of 05 CBCT papers (in the cluster), the students have to opt one paper offered by the Departments other than the Department of Environmental Science.

## Science Stream (M.Sc.)

**ENVS E-303: Elective – I**

A. Environmental Chemistry and Analytical Tools
B. Environmental Modeling

**ENVS E-304: Elective – II**

A. Environmental Pollution
B. Mining and Environment

## ** CBCT (Inter Disciplinary Elective) Papers (Students have to Choose one of the following courses except ENVS-CT-300)

- BIOT-CT-300: Biotechnology in Human Welfare (Offered by Dept. of Biotechnology)
- BOTA-CT-300: Economic Botany (Offered by Dept. of Botany)
- ENVS-CT-300: Population and Environmental Issues (Offered by Dept. of Environment Studies)
- MARB-CT-300: Environmental Impact Assessment (Offered by Dept. of Marine Science)
- ZOOL-CT-300: Conservation Biology (Offered by Dept. of Zoology)

## # Value Added Course (VAC): ENVS-VAC-207 and ENVS-VAC-307

**ENVS VAC-207: Value Added Course**

A. Mineral Beneficiation and Value Addition Process
**B.** Waste Management

**ENVS VAC-307: Value Added Course**

A. Bioresources for Livelihood Development
B. Environmental Ethics

**Guidelines for conducting value added courses (VAC)**

Value Added Course is not mandatory to qualify for any programme and shall be offered as non-credit course in the 2ndand 3rdsemester. It is a teacher assisted learning course open to students of the concerned department and the students shall register along with other courses in that semester. Classes for a VAC can be reflected in the timetable. The value-added courses may be also conducted during weekends / vacation period. A student will be permitted to register only one Value Added Course in a Semester. The course can be offered only if there are at least 10 students opting for it where the total strength is 50. In case of lower strength, it will be proportionate.

**Duration:** The duration of value-added course is 30 hours with a combination 18 hours (60%) of theory and 12 hours (40%) of practical. However, the combination of theory and practical shall be decided by the course teacher with the approval of the Head of the Department.

## ##Add On Course (AC):

**ENVS-AC-406:** Cultural Heritage of South Odisha

**Code Used**

**BIOT-** Biotechnology, **BOTA**- Botany, **ENVS**- Environmental Science, **MARB**- Marine Biology, **Zool**- Zoology **C-** Core, **E-** Elective, **S-**Seminar, **P-** Practical, **D-** Dissertation**, CT-** Interdisciplinary Elective (Choice Based Credit Transfer)**, VAC-** Value Added Course**, AC-** Add-On Course, **NC-** Non-Credit course

*** Student Seminar (Departmental Journal Club)**

Each student has to present a research article in the departmental journal club in all the four semesters. Further details on this are provided in the respective sections.

**$Summer Internship Programme**

All the students shall have to undergo a summer internship programme in (i) industries, (ii) research institutions and (ii) different organizations (NGOs or civil society organization working on environmental issues). Further details on this are provided in the respective sections.

***** Major Project Work**

All the students shall have to choose one supervisor (from among the faculty members of the department) and design a research work (in consultation with and under the supervision of the supervisor) to be carried out. Further details on this are provided in the respective sections.

**Mode of Course Delivery:**

Regular classroom teaching, Field/Lab Practical, Study tours, value addition through guest/invited lectures (physical lectures and webinars).

# SEMESTER- I

## 1. ENVS C-101: Fundamentals of Earth System Science (Core Course, 04 Credits)

**Course outcomes**:

- Understanding the earth formation and earth processes
- Understanding on the ocean system
- Learning about regional and global atmospheric conditions

| **ENVS C-101** | **Fundamentals of Earth System Science** | **Credits: 04** |
|---|---|---|
| **Unit 1:** introduction to Earth & Earth Processes **(12 Lectures)** | Evolution of solar system, Earth's orbital parameters, Kepler's laws of planetary motion; Geological Time Scale, Plate tectonics & plate boundary, seismology and internal structure of earth geomorphic processes and agents (fluvial and aeolian). | |
| **Unit 2:** Basics of Meteorology **(12 Lectures)** | Incoming solar radiation, Heat transfer in atmosphere, radiation of earth, Humidity, condensation, stability of atmosphere, inversion, and Atmospheric pressure, air masses and fronts, cyclones, global climate change issues | |
| **Unit 3:** Physical Oceanography **(12 Lectures)** | Morphology and tectonic domains of the ocean floor. Physical and chemical properties of seawater; Ocean currents, important current systems, Air-Sea interaction; Thermohaline circulation, El Nino and monsoon system. | |
| **Unit 4:** Biological and Chemical Oceanography **(12 Lectures)** | Classification of marine environment and organisms, physcio-chemical factors affecting marine life, ocean productivity, energy flow and biogeochemical cycles. Composition of sea water, classification of elements (major and minor), behavior and chemical exchanges, residence time | |

***Text Books***


1. McBride N and Gilmour I (Eds.) (2004). An Introduction to the Solar System. Cambridge, UK: Cambridge University Press.
2. Lal DS (1986). Climatology, Chaitanya Publication, Allahabad.
3. Trujjilo AP and Thurman HV (2011). Essentials of Oceanography (10$^{th}$Edition). Prentice Hall.
4. Condie, Kent. C. (1989). Plate Tectonics and Crustal Evolution. 3rd Edition. Butterworth-Heinemann Ltd.
5. Summerfield M.A (2011). Geomorphology and Global Tectonics, Wiley India Pvt Ltd.
6. Marshall. John, and R. Alan Plumb. Atmosphere, Ocean, and Climate Dynamics: An Introductory, Academic Press.
7. Randall DA (2005). An Introduction to the General Circulation of the Atmosphere, Colorado State University Press.
8. Wallace and Hobbs. Atmospheric Science (Latest Edition), An Introductory Survey, Elsevier


***Reference Books***


1. Siddhardha K (2016). The Earth's Dynamic Surface - A book of Geomorphology, Kitab Mahal.
2. Windlley B (1995). The Evolving Continents. 3rd Edition Wiley-Blackwell.

3. Davies, G.F. (1999). Dynamic Earth: Plates, Plumes and Mantle Convection. Cambridge University Press.
4. Barry and Chorley (1988). Atmosphere weather and climate, Routtledge, London,

## 2. ENVS C-102: Ecology and Ecosystems (Core Course, 04 Credits)

**Course outcomes**

- Understanding the ecological systems and organisms' adaptations
- Understanding the concepts of species, population and community in different habitats
- Understanding the community dynamics and succession in ecosystem
- Understanding the bio-geo-chemical cycling processes on earth

| **ENVS C-102** | **Ecology and Ecosystems** | **Credits: 04** |
|---|---|---|
| **Unit 1:** Fundamentals (Organism and Environment Interactions) **(12 Lectures)** | Ecology: Scope and Evolution, concepts and sub-divisions. Concept of stress and strain, adaptation and limiting factors; morphological, anatomical and physiological responses of organisms to light, temperature, water and salinity; soil-plant-atmosphere continuum. | |
| **Unit 2:** Ecosystem Ecology **(12 Lectures)** | Systems concept, ecosystem structure and functions, primary and secondary production, food chain and trophic levels, ecological energetic, material cycling, homeostasis and feedback. | |
| **Unit 3:** Population Ecology **(12 Lectures)** | Basic concepts, population characteristics, population dynamics, population growth, carrying capacity and environmental resistance, population regulation, life history strategies (r and K selection), population fluctuation, population interactions. | |
| **Unit 4:** Community Ecology and Dynamics **(12 Lectures)** | Definition, origin and development, characteristics, composition, structure, stratification, and factors. Ecological succession: Background, causes, trends, types, process, hydrosere, lithosere, heterotrophic succession, ecosystem development, climax concept and biome | |

***Text Books***

1. Dash MC (2001). Fundamentals of Ecology, 2nd Edition. Tata McGraw-Hill Publications.
2. Gotelli, Nicholas J. 2008. A Primer of Ecology, 4th Edition. Sinauer.
3. Mackenzie A, Ball AS and Virdee SR (2002). Instant Notes in Ecology. 2nd Edition. Viva Books Pvt. Ltd. New Delhi.
4. Odum EP and Barett GW (2017). Fundamentals of Ecology, 5th Edition. Cengage.
5. Sharma PD (2000). Ecology and Environment. 7th Edition. Rastogi Publications, Meerut, India.

***Reference Books***

1. Edwards AR, Andres R. 2005. The Sustainability Revolution: Portrait of a Paradigm Shift. New Society.
2. Primack, Richard B. 2010. Essentials of Conservation Biology, 5th Edition. Sinauer.
3. Sttiling, Peter. 2001. Ecology: Theories and Applications, 4th Edition. Prentice Hall.
4. Rogers, Peter P., Kazi F. Jalal, and John A. Boyd. 2007. An Introduction to Sustainable Development. Earthscan.

## 3. ENVS C-103: Basics of Remote Sensing and GIS (Core Course, 04 Credits)

**Course outcomes:**

- Understanding the basic concept of Remote Sensing and GIS
- Processing the remote sensing and GIS data
- Understanding on the approach for identifying and solving the geospatial problems

| **ENVS C-103** | **Basics of Remote Sensing and GIS** | **Credits: 04** |
|---|---|---|
| **Unit 1:** Introduction to Geoinformatics **(12 Lectures)** | Concept and Scope of Remote Sensing, Electromagnetic Radiation (EMR): Spectrum, Wavelength, Frequency, Energy, EMR wavelength regions and their applications, Interaction of EMR with matter, Spectral signatures. | |
| **Unit 2:** Fundamental of Remote Sensing **(12 Lectures)** | Sources of Energy, Radiation laws (Stefan-Boltzman; law, Wien's law, Kirchhoff's law), Black body and Real body, Radiant temperature & Kinetic temperature; Energy Interaction in the atmosphere (Scattering, absorption, transmission, atmospheric windows); Energy Interactions with Earth Surface Features (Spectral Reflectance Curve, Concept of signatures). | |
| **Unit 3:** Elements of GIS **(12 Lectures)** | Definition of GIS, Concept of Space and Time, Spatial data, Map Projection and Datum, Domains of Spatial information system, Components of GIS, GIS Functionalities for end user / system - Data Acquisition, Data Input, Data Management. | |
| **Unit 4:** GIS Data Analysis **(12 Lectures)** | Data Analysis, Data Modeling and Data Output; Geodata visualization and analysis - two – three – fourth dimension viewing – viewing by animation - Visualization by hyper map - virtual images – web GIS | |

***Text Books***


1. Godchild M. Fand Kemp K (1990). Developing a curriculum in GIS: The NCGIA Core curriculum project, University of California, Santa, Barbara.
2. Ian Haywood Cornelius and Steve Carver (2000). An introduction to GIS, Longman, New York.
3. Misra H.C. (1995). A Handbook on GIS, GSI India, Hyderabad.
4. Smith T.R. and Piquet (1985). GIS, London Press, London.


***Reference Books***


1. Taylor DRF (1991). GIS: The Micro-computer and Modern Cartography, Pergamon Press, Oxford.
2. Ian Heywood, Sarah Cornelius and Steve Carver (1998). An Introduction to Geographical Information System, Longman, New Delhi.
3. Lo CP and Young AKW (2006). Concepts and Techniques of Geographical Information System. 2nd Edition. Pearson.


## 4. ENVS C-104: Environment and Society (Core Course, 04 Credits)

**Course Outcomes**

- Understanding concepts, theories, debates, and empirical practices on the interaction between environment and society
- Understanding different issues of environmental issues
- Evaluates policies and practices concerning environmental governance and sustainable development.

| ENVS C-104 | Environment and Society | Credits: 04 |
|---|---|---|
| **Unit 1:** Population and Environment **(12 Lectures)** | Background, Demographic transition (India and World, Projections of population growth), Resource scarcity, Unsustainable lifestyle – increased consumerism; Theoretical Approaches (deep, social, political-economy, and feminist). | |
| **Unit 2:** Energy Crisis and Society **(12 Lectures)** | Classification of Energy Resources; Changing Nature of Demand for Energy; Energy crises: past and present, Alternatives sources of energy, energy geopolitics | |
| **Unit 3:** Environmental Degradation and Society **(12 Lectures)** | Environmental Degradation: Factors, Air Pollution, Water Pollution, Soil pollution, Waste management (Solid waste and Hazardous waste); Environmental degradation linkage with social dynamics (race, class, caste, gender and age groups) | |
| **Unit 4:** Environment and Sustainable Development **(12 Lectures)** | Evolution of Discourses on development and concept of sustainable development goals (SDG); emerging discourses (participatory governance, green economy and Radical Ecological democracy). | |

***Text Books***


1. Carolan M (2018). Society and Environment: Pragmatic Solution to Ecological Issues Routledge. New York.
2. Harris, P.G. and G. Lang (2015). Routledge Handbook of Environment and Society in India. Routledge. New York.
3. Maldondo, M (2015). Environment and Society. Socio-natural relations in the anthropocene. Springer.


***Reference Books***


1. Pretty, Jules, Andrew Ball (2007). "Introduction to Environment and Society." In: *The Sage Handbook of Environment and Society*. Sage Publications. ISBN: 9781412918435
2. Paskal, Cleo (2009). The Vulnerability of Energy Infrastructure to Environmental Change. Chatham House.
3. Pamela Chasek and David Downie (2016).*Global Environmental Politics, Seventh Edition*, Westview Press.
4. Baumol, W.J. and Oates W.E.(1988) : Theory of Environmental Policy, 2nd Edition, Cambridge University Pres
5. Cunningham WP and Cunningham MA (2002). Principles of Environmental Science: Inquiry and Applications. McGraw Hill Publications, New Delhi, 418 pp.
6. McKillop A and Newman S (2005). The Final Energy Crisis. Pluto Press, London. 325 pp.


## 5. ENVS C-105: Methods of Analysis of Environmental Samples (Core Course, 04 Credits)

**Objectives**: A student trained in Environmental science must understand the physico-chemical analysis of different compartments of the environment. The course aims to provide the students with an understanding on different analysis of water, soil, air, biological samples, Community analysis and geological survey tools.

**Course outcomes**

On completion of the course, the candidate will be able to understand

- Physico-chemical and Biological Parameters of water,
- Physico-chemical and Biochemical parameters of Soil,
- Air and Noise Intensity Analysis,
- Biological Sample and Community Analysis

| **ENVS C-105** | **Methods of Analysis of Environmental Samples** | **Credits: 04** |
|---|---|---|
| **Unit 1:** Physico-chemical and Bio-chemical parameters of water **(12 Lectures)** | pH, Conductivity, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Chloride, Alkalinity, Free $CO_2$, Nitrate, Phosphate, Sodium, Potassium, Primary Productivity, Phytoplankton, Zooplankton, Heterotrophic Bacteria, Total Coliform Bacteria and Faecal coliform. | |
| **Unit 2:** Physico-Chemical and Biochemical parameters of Soil **(12 Lectures)** | Nitrogen, Organic matter, Humus, Phosphate, Nitrate, $CO_2$ Evolution, Amylase, Invertase, Protease, Dehydrogenase, Bacteria and Fungi, Respiration and excretion study in animals, Extraction of soil meso-fauna | |
| **Unit 3:** Air and Noise Intensity Analysis **(12 Lectures)** | Sampling of $SO_x$, $NO_X$ and Suspended particulate matters from ambient air, Analysis of $SO_x$, $NO_x$ and Suspended particulate matters collected through Respirable Dust and Fine Particulate Matter Samplers<br>Measurement of ambient noise levels using Digital Sound Level Meters | |
| **Unit 4:** Biological Sample and Community Analysis **(12 Lectures)** | Amino-acid, Protein, Carbohydrate and Lipid Content in Plant and Animal samples, plant Pigment Content, Energy Content through Oxycalorific value, Density, Dominance, Abundance, Diversity and Population structure in grass land and forest | |

***Text Books***


1. APHA, AWWA and WEF (2017). Standard methods for examination of water and wastewater. 23rd Edition. American Public Health Association, American Water Works Association, Water Environment Federation.
2. Saxena MM (1990). Environmental Analysis: Water, Soil and Air. 2nd Edition. Agro Botanical Publishers, Bikaner, India.
3. Masters GM and Ela WP (2019). Introduction
4. Bibby CJ, Burgess ND, Hill DA and Mustoe S (2000). Bird Census Techniques. 2nd Edition. Academic Press.
5. Sutherland WJ (2006). Ecological Census Techniques: A Handbook. 2nd Edition. Cambridge University Press. 432 pp.


## 6. ENVS P-106: EVS Lab Practical – I: Based on the above papers (Practical: Core Course, 04 Credits)

**Course Outcomes**

- Hands on experience on titration and different basic instruments for environmental monitoring, *viz*., pH meter, TDS meter, nephelometer.
- Learning different basic analytical tools and techniques of environmental monitoring.
- Experiences different field measurements

| **ENVS P-106** | **Environmental Monitoring Lab - I** |
|---|---|
| **Section-I:** Water Quality Analysis | Determination of various basic parameters in surface water/ groundwater / marine water/ wastewater (pH, Electrical Conductivity, |

| | |
|---|---|
| **(24 Sessions)** | Alkalinity, Salinity, Turbidity, Hardness and Dissolved Oxygen, Chemical Oxygen Demand, Biochemical Oxygen Demand) |
| **Section-II:** Measurement of Ecological Attributes **(24 Sessions)** | Minimum size of the quadrat following Species-Area Curve method; Minimum number of quadrats to be laid down in the field; Vegetation Community Analysis, Frequency Classification, Animal Census Techniques (e.g. Birds); Identification and Sampling Methods for Plankton, Nekton and Benthos |
| *Note: The experiments should be conducted based on the availability of resources and infrastructure* | |

***Text Books***


1. APHA, AWWA and WEF (2017). Standard methods for examination of water and wastewater. 23rd Edition. American Public Health Association, American Water Works Association, Water Environment Federation.
2. Saxena MM (1990). Environmental Analysis: Water, Soil and Air. 2nd Edition. Agro Botanical Publishers, Bikaner, India.
3. Bibby CJ, Burgess ND, Hill DA and Mustoe S (2000). Bird Census Techniques. 2nd Edition. Academic Press.
4. Sutherland WJ (2006). Ecological Census Techniques: A Handbook. 2nd Edition. Cambridge University Press. 432 pp.


## 7. Student Seminar (Departmental Journal Club)

All the students shall be instructed to present a research article published in peer reviewed journals with necessary supervision and guidance from faculty members. The evaluation shall be out of 15 marks, and the said mark shall be reflected as one of the components in the course ENVS C-403 in 4th semester.

# SEMESTER-II

## 8. ENVS C-201: Natural Resource Management and Governance (Core Course, 04 Credits)

**Course Outcomes**

- Understanding the basic concepts and approaches
- Understanding emerging issues on environmental/resource management
- Assessing the challenges of past and present nature of developmental trajectory with limited supply of natural resources

| **ENVS C-201** | **Natural Resources Management and Governance** | **Credits: 04** |
|---|---|---|
| **Unit 1:** Concepts & Theories **(12 Lectures)** | Defining relevant concepts (natural resources, resistance, and natural stuffs); Theories of conceptualizing natural resources (classical and neo classical); Classification of Natural Resources; concept of renewability in a limited world. | |
| **Unit 2:** Natural Resource Scarcity **(12 Lectures)** | Conceptualizing Resource Scarcity (Traditional theories- and Political-economy perspective), Indicators of Resource Scarcity | |
| **Unit 3:** Resource Governance Theories and Practices **(12 Lectures)** | Key Philosophy and approaches (Evolution; Top-Down and Bottom-up approach; Bureaucratic Approach and Participatory Approach); State, resource, and citizens: Hardin's tragedy of Common, Community Based Natural Resource Management | |
| **Unit 4:** Uneven Development and Resource Conflicts **(12 Lectures)** | Regional Development; Resource abundance; Regional Disparity, Resource Curse Theory; Geo-politics: Resource War and resource conflict. | |

***Text Books***


1. Guha R (2004). Social ecology. New Delhi: Oxford University Press
2. Ostrom, E. (1990). Governing the commons: The evolution of institution for collective action. Cambridge: Cambridge University Press.
3. Rees J (1958). Natural Resources: Allocation, Economics, and Policy. Methuen. London and New York.
4. Malthus TR (1798). An essay on the principle of population. London. J. Johnson.


***Reference Books***


1. Ascher W(1999). Why Governments Waste Natural Resources: Policy Failures in Developing Countries. Baltimore: The John Hopkins Univ. Press.
2. Auty RM (2001). Resource Abundance and Economic Development. Oxford: Oxford University Press.
3. Bryant, R. & Bailey, S. (1997). Third world political ecology. London: Routledge.
4. Johnston, R. J. (1996). Nature, State, and Economy: A political economy of the environment. Chichester: John Wiley.
5. Pretty, J; Ball, A. S. (2007). The Sage handbook of environment and society. Sage Publication: NewDelhi
6. Robbins, Paul; Hintz, John and Sarah A. Moore (2014) Environment and Society: A Critical Introduction, Wiley-Blackwell

## 9. ENVS C-202: EIA, Auditing & EMS: Tools and Techniques (Core Course, 04 Credits)

**Course Outcomes**

- Understanding on the concept of EIA and Prior-environmental clearance process in India
- Understanding on the EIA and CRZ Notification vis-a-vis developmental projects
- Understanding on the next-generation EIA processes and their advantage over the classical techniques.
- Understanding on the Environmental Auditing process and management systems adopted in different industries.

| **ENVS C-202** | **EIA, Auditing & EMS: Tools and Techniques** | **Credits: 04** |
|---|---|---|
| **Unit 1:** EIA Overview **(12 Lectures)** | Concepts and evolution of EIA, types of EIAs, Procedures for undertaking EIAs (Data requirement, collection and acquisition, Public concerns, Strategies, Steps in EIA), Environmental Impact Statement and Environmental Management Plan (EMP) | |
| **Unit 2:** Legal Instruments and Notifications **(12 Lectures)** | Environmental Protection Act 1986, Environmental Impact Assessment (EIA) Notification (1994, 2006 and 2020); water act; Environmental Clearance Process in India, Post Environmental Clearance Monitoring, and Coastal Regulation Zone Notification (1991 and 2018). | |
| **Unit 3:** Next-Gen EIAs **(12 Lectures)** | Cumulative Impact Assessments, Strategic Impact Assessments (Concept, difference between SIA and EIA, Methods of SIA, Public Involvement, and Guidance and Good Practices), and Carrying Capacity Assessment (Concepts and Methods) | |
| **Unit 4:** Environmental Auditing and EMS **(12 Lectures)** | Background & definition, Goals, Types, Practice, Steps, Process and benefit of Environmental Audit, Benefits of Environmental Auditing Environmental Management System (EMS), ISO 14000, Benefits of ISO 14001 | |

***Text Books***


1. Canter, L. W., and L. G. Hill. 1981. Handbook of Variables for Environmental Impact Assessment. Ann Arbor, Michigan: Ann Arbor Science.
2. Pearce D and EB Barbier (2000) Blueprint for a sustainable economy. Earthscan.
3. Rau JG and Wooten DC (1980). Environmental Impact Analysis Handbook. McGraw-Hill Book Company. New York & New Delhi.
4. Treweek J 1999, Ecological impact assessment, Blackwell Science, Oxford
5. Wathern P (1990). Environmental Impact Assessment: Theory and Practice. Routledge, London and New York, 332 pp.


***Reference Books***


1. Ahmad YJ and GK Sammy (1985). Guide to Environmental assessment in developing Countries. London: Hodder and Stoughton (for the United Nations Environment programme).
2. Monnikhof RAH and Edelenbos J (2001). Into the Fog? Stakeholder Input in Participatory Impact Assessment. Impact Assessment and Project Appraisal 19 (1), 29-39.
3. Sengupta R (2001). Ecology and economics – an approach to sustainable development. Oxford University Press.
4. WCED (1987). Our common future: Report of the world commission on environment and development, Oxford University Press.

## 10. ENVS C-203: Basic Statistics and Computer Applications (Core Course, 04 Credits)

**Course outcomes**

- Understanding the concepts of environmental statistics
- Understanding the techniques in sampling and data analysis
- Ability to develop statistical models suitable for environmental modeling

| **ENVS C-203** | **Basic Statistics and Computer Applications** | **Credits: 04** |
|---|---|---|
| **Unit 1:** Descriptive Statistics **(12 Lectures)** | Background to Environmental Data Analysis, Measures of central tendency, measures of dispersion, skewness and kurtosis, Probability: definition, addition and multiplication laws, concept of random variable. Probability distributions: Binomial, Poisson and Normal distribution. | |
| **Unit 2** Hypothesis Testing **(12 Lectures)** | Concept of population and sample, Hypothesis testing and interval estimation for large samples; Chi-square test, t-test (Unpaired and Paired) and F test of significance, Analysis of variance (One-way and Two-way). | |
| **Unit 3:** Bivariate Analysis **(12 Lectures)** | Introduction to bivariate analysis, Covariance, Correlation analysis (One-tail and Two-tail), and Regression analysis (Linear and Polynomial). | |
| **Unit 4:** Computer Application **(12 Lectures)** | Demonstration of the above tests in Computer. | |

***Text Books***


1. Rangaswamy R (2010). Textbook of Agricultural Statistics. New Age International
1. Gupta SP (2014). Statistical Methods. Sultan Chand and Sons, 1426 pp.
2. Chapman SJ (1998). FORTRAN 90/95 for Scientists & Engineers, Mc-Graw Hill.
3. Ramakrishnan P (2019). Biostatistics, Saras Publication.
4. Rastogi VB (2019). Biostatistics, MEDTECH.


***Reference Books***


1. Snedecor GW and Cochran WG (1989) Statistical Methods. 8th Edition, Iowa State University Press, Ames.
2. Stell RG and Torrie JH (1997). Date Principles and Procedures of Statistics. McGraw-Hill.
3. Zar JH (2014). Biostatistical Analysis. 5th Edition. Pearson Education India. 760 pp.


## 11. ENVS C-204: Aquatic Ecosystems and Water Resources Management (Core Course, 04 Credits)

**Course outcomes**

- Understanding on the aquatic ecosystems and its associated concepts
- Understanding on the biological diversity and different habitats in wetlands, and the good and services of such ecosystems
- Understanding on the concepts of aquatic ecosystem restoration and management
- Understanding on water-stress zones and possible solutions to water scarcity

| ENVS C-204 | **Aquatic Ecosystems and Water Resources Management** | **Credits: 04** |
|---|---|---|
| **Unit 1:** Aquatic Ecosystems: Fundamentals **(12 Lectures)** | Aquatic ecosystems, typology, Wetlands: origin, extents, forms and distribution, Bio-geochemical issues (nutrient cycling) and Hydrology (water & sediment chemistry, Biomass and Productivity, Decomposition and Mineralization) | |
| **Unit 2:** Hydrogeology and Groundwater Dynamics **(12 Lectures)** | Introduction to groundwater hydrology, water-bearing properties of rocks and classification; Water table and piezometric surface; Geologic and geomorphic controls on groundwater; Darcy's law (applications and validation) | |
| **Unit 3:** Water Quality Monitoring **(12 Lectures)** | Physical and chemical properties of groundwater; Quality criteria for different uses; Groundwater contamination: geogenic and anthropogenic sources; sea-water intrusion; graphical representation of chemical data | |
| **Unit 4: Aquatic Ecosystem** Restoration & management (12 **Lectures)** | Ecosystem restoration: Tools and techniques, Species re-introduction, Seed-bank; constructed wetlands; ecosystem management and stakeholder participation.<br>Water stress regions, solution to water scarcity (rainwater harvesting, artificial recharge, desalination) | |

***Text Books***


1. Dodds WK (2002). Freshwater Ecology: Concepts and Environmental Applications. Academic Press, San Diego, California, USA.
2. Maltby E (1986). Waterlogged Wealth. Earthscan, London.
3. Mitsch WJ and Gosselink JG (2000). Wetlands. 3rd Edition. John Wiley & Sons, New York.
4. Prusty BAK, Chandra R and Azeez PA (2017). Wetland Science: Perspectives from South Asia. 1st Edition. Springer Publishers. ISBN 978-81-322-3715-0
5. Wetzel RG (2001). Limnology: Lake and River Ecosystems. Third Edition. Academic Press, San Diego, California, USA. 1006 pp.


***Suggested Readings***


1. Gopal B (Compiler) (1995). Handbook of Wetland Management, WWF-India, New Delhi, India. 305 pp.
2. Gopal B, Hillbricht-Iikowska A and Wetzel RG (1993). Wetlands and Ecotones: Studies on land-water interactions. National Institute of Ecology and International Scientific Publications, New Delhi, India.
3. Gopal B, Turner RE, Wetzel RG and Whigham DF (1982). Wetlands: Ecology and Management. International Scientific Publications and National Institute of Ecology, Jaipur, India.
4. Ramachandra TV, Ahalya N, Rajasekhara Murthy C (2005). Aquatic Ecosystems: Conservation, Restoration and Management. Capital Publishing Company, New Delhi.

## 12. ENVS C-205: Environmental Geosciences (Core Course, 04 Credits)

**Course Outcomes**

- Introduction to rock forming minerals
- To understand the different rock types and their formation
- Deals with emerging field like geochemistry and isotopic studies

| **ENVS C-205** | **Environmental Geosciences** | **Credits: 04** |
|---|---|---|
| **Unit 1:** Rock Forming Minerals and Igneous Rocks **(12 Lectures)** | Rock forming minerals, physical and chemical properties of minerals, Silicate mineral groups. Igneous rocks – classification, forms and textures; Bowen's reaction series, classification of igneous rock. | |
| **Unit 2:** Sedimentary and metamorphic rock with associate minerals **(12 Lectures)** | Sedimentary rocks – texture and structure; sedimentary processes and environments, sedimentary rock types. Metamorphic rock: Physico-chemical conditions, grade, P-T-t paths and tectonic significance, metamorphic rock types. | |
| **Unit 3:** Environmental Geochemistry and Radiogenic Isotope **(12 Lectures)** | Abundances of elements, Oddo-Harkin Law. Meteorites. Geochemical and Cosmochemical classification of elements and their basis. nuclides. Radioactive decay schemes. Decay constant, half-life, parent-daughter relations. U-Th systematics and their use in geochemistry. | |
| **Unit 4:** Stable isotopes in Environment studies **(12 Lectures)** | Stable isotopes: processes of isotope fractionation, δ-notation for H, C and O isotopes. O isotopes: fractionation in the hydrologic cycle. processes. Applications of isotopes in climate, hydrologic/hydrogeologic and biogeochemical studies. | |

***Text Books***


1. Brian Mason (1982). Principles of Geochemistry. J. Wiley & Sons.
2. Hoefs, J. (1997). Stable Isotope Geochemistry, 4th edition, Springer-Verlag, Berlin,
3. Krauskopf, K. B. (1979). Introduction to Geochemistry. McGraw Hill.
4. Winter, J.D. (2001). An introduction to Igneous and Metamorphic Petrology, Prentice Hall.


***Reference Books***


1. Pettijohn, F.J. (1975). Sedimentary Rocks. 3rdEdn. Harper and Row Publ., New Delhi.
2. Philpotts, A.R. (1994). Principles of Igneous and Metamorphic Petrology, Prentice Hall.
3. Tucker, M.E. (1981). Sedimentary Petrology: An Introduction, Wiley & Sons, New York.


## 13. ENVS P-206: Lab Practical – II: Based on the above papers (Practical: Core Course, 04 Credits)

**Course Outcomes**

- Determining different quality parameters in various environmental matrix., viz., soil, sludge, solid waste
- Hands-on experience on advanced programming techniques.

| **ENVS P-206** | **Environmental Monitoring, Computational and Geological Lab-II** |
|---|---|
| **Environmental Monitoring** | Determination of following parameters in soil/aquatic (freshwater/marine) sediment/industrial sludge |

| | |
|---|---|
| **(16 Sessions)** | ● Moisture<br>● Texture<br>● pH and Electrical Conductivity<br>● Total Organic Carbon<br>● Sodium, Potassium, Calcium and Magnesium<br>● $CO_2$ evolution from soil |
| **Data analysis**<br><br>**(16 Sessions)** | ● Hypothesis testing and interval estimation for large samples; Chi-square test, Student t-test (Unpaired and Paired) and F test of significance. Analysis of variance (One-way and Two-way). Correlation and regression. |
| **Geological Lab**<br><br>**(16 Sessions)** | ● Megascopic study of important rock forming and ore minerals<br>● Microscopic study of important rock forming minerals |
| *Note: The experiments should be conducted based on the availability of resources and infrastructure* | |

***Text Books***


1. Allen SE (1989). Chemical Analysis of Ecological Materials. 2nd Edition, Blackwell Scientific Publications, Oxford, London. 368 pp.
2. Cochran, W.G. and G.W. Snedecor. By K. Koehler, 2012 Statistical Methods, 8th edition. Iowa State University Press.
3. Gupta SP (2014). Statistical Methods. Sultan Chand and Sons, 1426 pp.
4. Saxena MM (1990). Environmental Analysis: Water, Soil and Air. 2nd Edition. Agro Botanical Publishers, Bikaner, India.
5. Stell, R.G. and J.H. Torrie. Date Principles and Procedures of Statistics. McGraw-Hill.
6. Tandon HLS (2005). Methods of analysis of soils, plants, waters, fertilizers & organic manures. 2nd Revised Edition. Fertilizer Development and Consultation Organization (FDCO). New Delhi. 201 pp.


## 14. ENVS VAC-207: Value Added Course (Non-Credit)

### a. Mineral Beneficiation and Value Addition Process

**Course Outcomes**

- Understanding on mineral deposits in India and their mining
- Understanding on mineral identification and beneficiation process
- Understanding on different analytical instruments used in mineral and chemical assay

| **ENVS VAC-207** | **Mineral Beneficiation and Value Addition Process** | **Credits: Nil** |
|---|---|---|
| **Unit 1:** Mineral Deposits **(06 Lectures)** | Introduction to various mineral deposits in India, Placer minerals and their importance, exploration, mining. | |
| **Unit 2:** Mineral Identification **(06 Lectures)** | Megascopic identification of ore forming minerals, microscopic identification of ore forming minerals, principles and mechanism of ore microscope | |
| **Unit 3:** Ore Beneficiation Processes **(10 Lectures)** | Ore dressing, comminution, physical concentration methods, Pretreatment Processes, Extraction via Flotation, bio-leaching & Bio-suction of metallic ore. | |

| | |
|---|---|
| **Unit 4:** Futuristic Perspectives **(08 Lectures)** | Future mineral consumption and world economy; energy demand and supply in future; marine mineral resources; developments in mineral exploration and exploitation. |

***Suggested reading***


1. Chatterjee, K.C. 2012. An introduction to mineral economics. New Age International Publishers, New Delhi.
2. Govett, G.J.S. & Govett, M.H. 1976. World mineral supplies. Elsevier, Amsterdam.
3. Sinha, R.K. & Sharma, N.L. Mineral economics. Oxford & IBH.


## b. Waste Management

**Course Outcomes**

- Understanding on characteristics and types of waste and their environmental impacts
- Understanding on solid and hazardous waste management (tools and techniques)
- Understanding on liquid waste management and treatment options

| **ENVS VAC 307** | **Waste Management** | **Credits: Nil** |
|---|---|---|
| **Unit 1:** Solid Wastes **(10 Lectures)** | Types, sources, characteristics, and impact on environmental health. Waste generation rates, Concepts of waste reduction, recycling and reuse. Collection, segregation and transport of solid wastes Handling and segregation of wastes at source. Collection and storage of municipal solid wastes. Solid waste processing technologies. Mechanical and thermal volume reduction. Biological and chemical techniques for energy and other resource recovery. Composting, Vermicomposting, Incineration of solid wastes. | |
| **Unit 2:** Solid Waste Disposal in Landfills **(08 Lectures)** | Site selection, design, and operation of sanitary landfills; secure landfills and landfill bioreactors; leachate and landfill gas management; landfill closure and post-closure environmental monitoring; landfill remediation. | |
| **Unit 3:** Hazardous Wastes **(06 Lectures)** | Definition, sources and characteristics: Hazardous waste categorization, generation, collection, transport, treatment and disposal. Legislation on management and handling of hazardous wastes | |
| **Unit 4:** Liquid Waste and Treatment Options **(06 Lectures)** | Waste water composition, waste water treatment plants (types of treatment, treatment technologies and design criteria (Preliminary treatment, primary treatment, secondary treatment, tertiary treatment), effluent discharge standards for various types of industries | |

***Text Books***


1. J. Glynn Henry and Gary. W. Heinke, “Environmental Science and Engineering”, Prentice Hall of India, 2004.
2. A. D.Bhide and B.B.Sundaresan, “Solid Waste Management – Collection, Processing and disposal” Mudrashilpa Offset Printers, Nagpur, 2001.


***Reference Books***


1. Biomedical Waste (Management and Handling) Rules, 1998

## 15. Student Seminar (Departmental Journal Club)

All the students shall be instructed to present a research article published in peer reviewed journals with necessary supervision and guidance from faculty members. The evaluation shall be out of 15 marks, and the said mark shall be reflected as one of the components in the course ENVS C-403 in 4$^{th}$ semester.

## 16.Summer Internship

All the students shall be instructed to undergo a summer internship programme in (i) industries, (ii) different organizations (NGOs or civil society organization working on environmental issues) and (iii) research institutions. The students shall also have to choose an internal supervisor (from amongst the faculty members of the Department) for the said exercise. The internal supervisor/ faculty shall make necessary coordination with different organizations for the desired internship programme of the respective students. Further, students shall also be encouraged to participate in the summer internship programme conducted by different Government of India agencies and Science Academies such as INSA-IASc-NASI. The students, who don't undertake summer internship programme shall be given different assignments or term papers and shall be required to submit reports for evaluation. The summer-internship report / assignment / term paper shall be evaluated by a board of internal examiners (comprising of all the faculty members of the Department). The said evaluation shall be out of 40 marks (20 marks for Report and 20 marks for presentation). This will be a part of the course ENVS C-403, and the evaluation shall be made accordingly in the 4$^{th}$ Semester.

# SEMESTER – III

## 17.ENVS C - 301: Forest and Wildlife: Ecology and Conservation (Core Course, 04 Credits)

**Course outcomes**

- Helps to learn basic of forest ecosystem and wildlife
- Equips students with tools of forest management and wildlife management
- Gives broader ideas of practices of forest and wildlife conservation

| **ENVS C - 301** | **Forest and Wildlife: Ecology and Conservation** | **Credits: 04** |
|---|---|---|
| **Unit 1:** Introduction to Forest Resource **(12 Lectures)** | Introduction to forest in India and World; Forest classification, Forest Conservation Practices: Concepts, and their emergence (Silviculture, Agroforestry, Social forestry, Community forestry, Sustainable forestry) | |
| **Unit 2:** Forest Ecology **(12 Lectures)** | Forest succession, Tree growth, Forest structure; Forest Inventory: Forest management (tools and approaches), Soil Conservation, Watershed and Hydrology Management. | |
| **Unit 3:** Fundamentals of Wildlife Biology / Conservation Biology **(12 Lectures)** | Introduction, extinctions (historical and recent), risks faced by small populations, Minimum Viable Population, Population Viability Analysis, reserve design in theory and practice<br>Habitat ecology: concept of habitats from microhabitat to biosphere, effects of habitat fragmentation, Biodiversity hot spots | |

| | |
|---|---|
| **Unit 4:** Wildlife Conservation and Management **(12 Lectures)** | In-situ and Ex-situ conservation approaches, captive breeding and propagation, rescue, rehabilitation and reintroduction, gene banks, Wildlife administration and legislation<br>Protected Area Network in India: Wildlife sanctuaries, national parks, biosphere reserves, etc. |

***Text Books***


1. Caughley G and Gunn A (1996). Conservation biology in theory and practice. Blackwell.
2. Davis, L.S., K.N. Johnson, P.S. Bettinger, and T.E. Howard. (2001). Forest management: to sustain ecological, economic and social values. 4th edition. McGraw Hill, New York.
3. Dwivedi AP (1993). Forests: the ecological ramifications. Natraj Publishers. Dehradun.
4. Giles R.II. (1994). Manual of Wildlife Management Techniques, Nataraj Publications, New Delhi.
5. Soule ME (1996). Conservation Biology. Sinauer Associates Inc. Sunderland Massachusetts.


***Reference Books***


1. Gadgil M. and Guha R. (1997). This Fissured Land. Oxford, New Delhi.
2. Gaston et al. (2000). Several papers. Special issue on biodiversity. Nature Vol. 405.
3. Myers et al. (2000). Biodiversity hotspots of the world. Conservation International.
4. Shiva V (1991). Ecology and the politics of survival: Conflicts over natural resources in India. United Nations University Press, Tokyo.
5. Singh C (1986). Common Property and Common Poverty, Oxford, New Delhi.


## 18. ENVS C-302: Energy and Environment (Core Course, 04 Credits)

**Course Outcomes**

- Understand energy scenarios, energy sources and their utilization.
- Acquire a comparative background in major social, political, ecological, and technological processes in the history of the global and national energy crises

| **ENVS C-302** | **Energy and Environment** | **Credits: 04** |
|---|---|---|
| **Unit 1:** Non-renewable Energy **(12 Lectures)** | Classification of Sources of Energy, types of non-renewable energy: Coal, Petroleum, History, Issues and Future Perspectives | |
| **Unit 2:** Renewable Energy **(12 Lectures)** | Types of renewable energy, history and importance; Tidal energy, hydrothermal energy, hydroelectric energy, geothermal energy, solar energy, wind energy | |
| **Unit 3:** Biomass Energy **(12 Lectures)** | Biofuels, bio-diesel, Gobar gas, fermentation technology, waste to energy | |
| **Unit 4:** Energy Policy **(12 Lectures)** | Current scenario in the energy demand, law and regulation on energy management, Possible Measures: Containment of population growth, Promoting public/mass transport systems, Clean energy development, Using waste heat, Saving Energy in industry. | |

***Text Books***


1. McKillop A and Newman S (2005). The Final Energy Crisis. Pluto Press, London. 325 pp.

2. J. Glynn Henry and Gary. W. Heinke (2004). "Environmental Science and Engineering", Prentice Hall of India.
3. Howard PH, Boethling RS and Jarvis WF (2020). Handbook of Environmental Degradation Rates. 1st Edition. CRC Press. 776 pp.

***Reference Books***

1. McKinney ML and Schoch RM (1998). Environmental Science: Systems and Solutions. Jones and Bartlett Publishers, Boston. 639 pp.
2. Miller GT Jr. (1996). Living in The Environment: Principles, Connections, and Solutions. 9th Edition. Wadsworth Publishing Company, New York. 727 pp.
3. Park C. (2001). The Environment: Principles and Applications. Routledge Publishers, London and New York, 598 pp.

## Specialized/Elective Courses

### 19. ENVS E-303: Elective – I

### A. Environmental Chemistry and Analytical Tools (Elective Course, 04 Credits)

**Course outcomes**

- students will understand the chemistry of all spheres.
- understand the formation and properties of different spheres.
- understand the mechanism and principles of different instruments.

| **ENVS E-303** | **Environmental Chemistry and Analytical Tools** | **Credits: 04** |
|---|---|---|
| **Unit 1:** Atmospheric Chemistry **(12 Lectures)** | Composition, structure and functions of atmosphere, atmospheric chemistry, classification of elements, earth's energy budget, reactions in the lower and upper atmosphere, radioactivity in the atmosphere, atmospheric stability, inversions and mixing height, wind rose. | |
| **Unit 2:** Hydrosphere Chemistry **(12 Lectures)** | Hydrosphere: structure and properties of water and their environmental significance, distribution of water in earth, freshwater and its chemistry, solubility of gases in water, role of water in environment.<br>Marine Chemistry: seawater properties and its constituents, nutrients and salts, metallic and non-metallic mineral resources such as Manganese nodules. | |
| **Unit 3:** Lithosphere Chemistry **(12 Lectures)** | Introduction to lithosphere, weathering (types and processes), pedogenesis (types, factors and process of soil development), soil types and their formation, soil profiles, soil properties (physical and Chemical). | |
| **Unit 4:** Analytical Tools **(12 Lectures)** | Principles and brief on analytical methods: Titrimetry, gravimetry, Centrifugation, colourimetry, spectrophotometry, flame photometry, atomic absorption spectrometry, chromatography | |

***Text books***

1. Rao, C. S. (1991). Environmental pollution control engineering. Wiley Watson Limited, New Delhi.
2. De AK (2003). Environmental Chemistry. Fifth Edition. New Age International (P) Limited, Publishers, Kolkata. 406 pp.
3. Sharma BK. Instrumental Methods. Goel Publishing House, Meerut.

***Reference Books***


1. Sharma BK. Environmental Chemistry. Goel Publishing House, Meerut.
2. Chatwal G and Anand S. Instrumental Methods of Chemical Analysis (Analytical Chemistry). S. Chand & Sons Publishers, New Delhi.
3. Kealey D and Haines PJ. Analytical Chemistry. Viva Books Private Limited, Mumbai.
4. Christian GD. Analytical Chemistry. John Willey & Sons.


## B. Environmental Modeling (Elective Course, 04 Credits)

**Course outcomes**

- To understand the environmental system.
- To understand different statistical and mathematical models suitable for environmental systems
- To able to develop different environmental models

| **ENVS E-303** | **Environmental Modeling** | **Credits: 04** |
|---|---|---|
| **Unit1:** Background **(12 Lectures)** | Environmental System and its components, Modeling, Model Classification - Deterministic Models, Stochastic Models, Dynamic Models, Steady State Models. General Steps Involved in Modeling, Mass Balancing, Energy Balancing | |
| **Unit 2:** Population Growth Modelling **(12 Lectures)** | Growth Kinetics: Exponential Growth Model, Logistic Growth Model; Monod Equation, Two Species Population Growth Model of Competition, Lotka-Volterra Prey-Predator Model | |
| **Unit 3:** Water Quality Modelling **(12 Lectures)** | Dissolved Oxygen (DO), DO Sag Curve, biochemical oxygen demand (BOD), Streeter Phelps equations for point and distributed sources, eutrophication in flowing water, contamination transport and Ground water pollution modelling | |
| **Unit 4:** Air quality Modeling **(12 Lectures)** | Point source modeling, Line source modeling, Area source modeling, Gaussian Plume models, Long-Range Atmospheric Transport (LRAT) and Dispersion Models | |

***Text Books***


1. Hipel, K.W and A.I. McLeod. (1994). Time Series Modeling of Water Resources and Environmental Systems. Elsevier Science.
2. Zanneti, P. (1990). Air Pollution Modeling Theories, Computational Methods and Available Software. Van Nostrand Reinhold, New York.


***Reference Books***


1. Thomann, R.V. and J.A. Mueller. (1987). Principles of Surface Water Quality Modeling and Control, Harper and Row.
2. Chapra, S.C. (1997). Surface Water Quality Modeling, McGraw-Hill. 3. Benaarie, M.M. 1980. Urban Air Pollution Modeling. MIT Press.


# 20. ENVS E-304: Elective – II

## A. Environmental Pollution (Elective Course, 04 Credits)

**Course Outcomes**

- Helps students to understand different types of environmental pollution in details, their sources and impact
- Creates skill to analyze present status of environmental contamination

- Critically analyze policies and programs implemented to combat environmental pollution

| ENVS E-304 | Environmental Pollution | Credits: 04 |
|---|---|---|
| **Unit 1:** Background, Air and Noise Pollution **(12 Lectures)** | Air Pollutants (sources and types), impacts of air pollution on ecosystem and human health, and control measures; National Ambient Air Quality Standard, air quality index, indoor air pollution (sources and impacts). Noise pollution: sources, permissible levels, impacts (on communication, life forms and human health) and control measures | |
| **Unit 2:** Water Pollution (Surface water, groundwater and marine pollution) **(12 Lectures)** | Sources, water pollutants (inorganic and organic) and impacts (ecosystem and human health), eutrophication, water quality standards and Water Quality Index, wastewater treatment (concept, types and processes). Marine Pollution: sources, impacts and control measures; oil spills, thermal pollution and their impacts | |
| **Unit 3:** Soil Pollution **(12 Lectures)** | Physico-chemical and biological properties of soil (texture, structure, inorganic and organic components), causes of soil pollution and degradation, soil pollutioncontrol measures; Industrial effluents and their interactions with soil components, acid mine drainage; Soilmicro-organisms and their functions - degradation of pesticides andsynthetic fertilizers. | |
| **Unit 4:** Solid and Hazardous Waste Pollution **(12 Lectures)** | Solid waste: composition, classification, sources and characteristics, waste generation, Concept of 4R (Refuse, Reduce, Recycle and Reuse), solid waste management (collection, segregation, transportation, processing: volume reduction), biological and chemical techniques for energy and other resource recovery; composting and vermicomposting. Hazardous Waste: sources, characteristics, categorization, generation, collection, transport, treatment and disposal. Legislation on management and handling of hazardous wastes. | |

***Text Books***


1. De AK (2003). Environmental Chemistry. Fifth Edition. New Age International (P) Limited, Publishers, Kolkata. 406 pp.
2. Holgate ST, Koren HS, Samet JM and Maynard RL. Eds. (1999). Air pollution and health. Elsevier.
3. Khopkar SM (2018). Environmental Pollution Monitoring And Control. 2nd Edition. New Age International Private Limited, India.
4. Rao, C. S. (1991). Environmental pollution control engineering. Wiley Watson Limited, New Delhi.
5. Sharma BK. Environmental Chemistry. Goel Publishing House, Meerut.


***Reference Books***


1. Cunningham WP and Cunningham MA (2002). Principles of Environmental Science: Inquiry and Applications. McGraw-Hill Publications, New Delhi. 418 pp.
2. Johri R (2009). E-Waste: Implications, regulations, and management in India and current global best practices. TERI Press, New Delhi. 330 pp.
3. McKinney ML and Schoch RM (1998). Environmental Science: Systems and Solutions. Jones and Bartlett Publishers, Boston. 639 pp.

4. Miller GT Jr. (1996). Living in The Environment: Principles, Connections, and Solutions. 9th Edition. Wadsworth Publishing Company, New York. 727 pp.
5. Park C. The Environment: Principles and Applications. Routledge Publishers, London and New York, 598 pp.
6. Sengupta B (2000). Environmental standards for ambient air, automobiles, fuels, industries and noise. Central Pollution Control Board, New Delhi, India. 78 pp.

## B. Mining and Environment (Elective Course, 04 Credits)

**Course Outcomes**

- Understanding on different mineral deposits and reserves (including fossil fuels) in India and world
- Understanding on different mining practices and their environmental impacts.
- Helps to understand the case studies on different mining processes and mineral beneficiation.

| **ENVS E-304** | **Mining and Environment** | **Credits: 04** |
|---|---|---|
| **Unit 1:** Mineral Resources **(12 Lectures)** | Economic mineral deposits: metal and non-metal deposit, processing of mineral, extraction of metals. Uses of common metal and their recycling, radioactive minerals. | |
| **Unit 2:** Fossil Fuels **(12 Lectures)** | Non-renewable energy resources, fossil fuels, their classification, Coal, Petroleum, Natural Gas and Other Gaseous fuels, Preliminary idea about geothermal energy and nuclear energy and their management | |
| **Unit3:** Environmental Impacts of Mining **(12 Lectures)** | Environmental impact of mining and processing of minerals, Environmental effect on mining dump and byproducts, resources conservation of mineral resources, Environmental impacts of uses of fossil fuels | |
| **Unit 4:** Case Studies **(12 Lectures)** | Case studies on mining operation and environmental impacts (Coal, Iron Ore, Bauxite, Chromite, Radioactive minerals, Phosphate, Lead-Zinc, Gold) | |

***Text Books***

1. Tiwari SK (2021). Mining and Environmental Science. Atlantic Publishers, New Delhi. 376 pp.
2. Dhar BB and Thakur DN (1996). Mining Environment. 1st Edition. CRC Press. 416 pp.
3. Spitz K and Trudinger J (2019). Mining and the Environment: From Ore to Metal. CRC Press. 812 PP.

***Reference Books***

1. McKinney ML and Schoch RM (1998). Environmental Science: Systems and Solutions. Jones and Bartlett Publishers, Boston. 639 pp.
2. Miller GT Jr. (1996). Living in The Environment: Principles, Connections, and Solutions. 9th Edition. Wadsworth Publishing Company, New York. 727 pp.
3. Eggert RG and Olin JM (Ed.) (2016). Mining and the Environment: International Perspectives on Public Policy. 1st Edition. Taylor & Francis Ltd. 180 pp.

4. Marcus JJ (Ed.) (1997). Mining Environmental Handbook: Effects of Mining on the Environment and American Environmental Controls on Mining. Imperial College Press. 816 pp.

## 21. ENVS P-305: Lab Practical – III (Based on the papers opted in Semester-III) (Core Course, 04 Credits)

**Course Outcomes**

- Hands-on experience on megascopic identification of rock forming minerals and rock types.
- Hands on experiences on different microscope to identify rock forming minerals, ore forming minerals and different rock types.
- Measure using different correction using different geoinformatics techniques
- Measuring the quality parameter of air and soil using different instruments

| **ENVS P-305** | **Lab Practical – III (Environmental Monitoring and Geological Lab-III)** | **Credits: 04** |
|---|---|---|
| **Environmental - Analytical Lab**<br><br>**(16 Sessions)** | ● Measurement of ambient air quality parameters<br>● $PM_{10}$<br>● $PM_{2.5}$<br>● $NO_x$<br>● $SO_2$<br>● Determination various water and soil quality parameters<br>● Base cations<br>● Nutrients | |
| **Geological Lab**<br><br>**(16 Sessions)** | ● Megascopic study of important rocks.<br>● Microscopic study of important rocks.<br>● Field visits | |
| *Note: The experiments should be conducted based on the availability of resources and infrastructure* | | |

***Text Books***

1. A.E. Adams, W.K. Mackenzie and C. Guillford: Atlas of sedimentary rocks under thin section.
2. Jensen R. John, Remote Sensing of the Environment: An Earth Resource Perspective, Pearson Education Pvt. Ltd., Delhi, 2006.
3. W.K. Mackenzie and C. Guillford: Atlas of rock forming mineral in thin section.

***Reference Books***

1. Digital Image Processing (3rd Edition) Rafael c.Gonzolez, Richard E.Woods Prentice Hall, 2007
2. Gibson, Paul. J. and Clare H. Power, Introductory Remote Sensing: Digital Image Processing and Applications, Routledge, London, 2000.
3. John A. Richards, Springer-Verlag, Remote Sensing Digital Image Analysis, 1999.
4. Milman S. Andrew, Mathematical Principles of Remote Sensing making Inferences from Noisy Data, Ann Arbor Press, Noida, 1999.
5. Paul J. Curran, Principles of Remote Sensing, English Language Book Society, Longman, 1985.

## 22. Recommended CBCT Courses (Inter Disciplinary Electives for Semester III)

### (i) BIOT CT-300: Biotechnology in Human Welfare (Department of Biotechnology)

**Course Outcomes:**

- Understanding on the inter disciplinary overview of the concepts and their applications in the field of Agriculture, Environment, Health and industry etc.
- Understanding on various concepts of Biotechnology, methods and applications in welfare of Mankind.
- Learning of comparative advantages and disadvantages of several basic technique of Biotechnology.

| **BIOT CT - 300** | **Biotechnology in Human Welfare (04 Credits)** |
|---|---|
| **Unit I:** Basic Concepts Biotechnology **(10 lectures)** | Basic Concepts of Biotechnology and its applications**,** Recombinant DNA technology**;** gene cloning, human genome project, Tools of Bioinformatics. |
| **Unit II:** Agricultural and Environmental Biotechnology **(10 lectures)** | **Agricultural and Environmental Biotechnology:** Application in Breeding, Nitrogen fixation, Transfer of pest resistance genes to plants, Interaction between plants and microbes, Qualitative improvement of livestock. Crop plant genome project Chlorinated and non-chlorinated organ pollutant degradation; degradation of hydrocarbons and agricultural wastes, stress management, development of biodegradable polymers. |
| **Unit III:** Medical and Pharmaceutical Biotechnology **(10 lectures)** | Development of therapeutic agents, recombinant live vaccines, gene therapy, Diagnostics; Principle of DNA fingerprinting, Stem cell Biology, Ethical issues in Biotechnology research |
| **Unit IV:** Industrial Biotechnology **(10 lectures)** | Introduction to bioprocess technology. Range of bioprocess technology and its chronological development. Basic principle of fermentation technology. Types of microbial culture and its growth kinetics– Batch, Fed batch and Continuous culture. |

***Recommended Textbooks and References:***


1. John E. Smith. Biotechnology (2009) 5th Edition, Cambridge University Press
2. S. Ignacimuthu Biotechnology: An Introduction (2012) 2nd Edition, Narosa Publishing House Ltd., India


### (ii) BOTA CT-300: Economic Botany (Department of Botany)

**Course Outcomes:**

- Understanding on different plants and crops of commercial importance
- Understanding on agro-forestry practice and plant species of significance
- Understanding on medicinal aromatic plants and their utilization

| BOTA CT-300 | Economic Botany | Credits - 04 |
|---|---|---|
| **Unit- I** | Origin, history, domestication, botany, cultivation, production and use of: Cereals: Wheat, rice, maize, sorghum, pearl millet and minor millets. Pulses: Pigeon pea, chickpea, black gram, green gram, cowpea, soyabean, pea, lentil, horsegram, lab-lab bean. | |
| **Unit- II** | Origin, distribution, cultivation, production and utilization of economic plants of following groups such as Plant of agro-forestry importance: Teak, Sal Acacia, Sesbania, Neem etc. Fibres: cotton, silk cotton, jute, sunnhemp.<br>Oilseeds: Groundnut, sesame, castor, rape seed, mustard, sunflower, safflower, niger, oil palm, coconut and linseed. | |
| **Unit- III** | Origin, distribution, classification, production and utilization of Fruits: mango, banana, citrus, guava, grapes and other indigenous fruits; apple, plum, pear, peach, cashewnut and walnut; Vegetables: tomato, brinjal, okra, cucumber, cole crops, gourds etc. | |
| **Unit- IV** | Important medicinal and aromatic plants: Sarpagandha, Belladonna, Cinchona, Nux-Vomica, Vinca, Mentha And Glycirrhiza, Plantago etc.; Narcotics: Cannabis, Datura, *Gloriosa*, Pyrethrum and opium. Important Spices and condiments Ginger, Garlic, Cinnamon, Cardamom, Cumin, Foeniculum, etc. | |

***Recommended Textbooks and References:***


1. Economic Botany: S. L. Kochhar, Cambridge University Press.
2. Economic Botany- Principle & Practices: G.E. Wickens, Kluwer Academic Publishers.
3. Economic Botany & Ethnobotany: Afroz Alam, Willey.


## (iii) ENVS CT-300: Population and Environmental Issues (Department of Environment Studies)

**Course Outcomes**

- Understanding the human population growth pattern and its associated environmental impacts
- Understanding the energy scenarios and different issues pertaining to environmental degradation
- Understanding the ecological footprints and resource depletion

| ENVS CT-300 | Population and Environmental Issues | Credits: 04 |
|---|---|---|
| **Unit 1:** Demographic Overview **(12 Lectures)** | Introduction, History of human population growth, The demographic transition: India and World; Projections of population growth, Effects of human population growth, Unsustainable lifestyle – increased consumerism. | |
| **Unit 2:** Energy Crisis **(12 Lectures)** | Energy Crisis: Background, Possible causes (Energy demand and consumption, Production capacity and dependence on imports); Ecologically friendly alternatives and Possible Measures | |
| **Unit 3:** Environmental Contamination **(12 Lectures)** | Ambient Air pollution, Indoor air pollution and Health Impacts<br>Surface water pollution, Ground water pollution and Health Impacts | |

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| | Solid Waste Pollution and Sustainable Solid Waste Management; Hazardous waste pollution, Radioactive waste, Electronic waste and Biomedical waste |
| **Unit 4:** Ecological Footprints and Carrying Capacity **(12 Lectures)** | Ecological footprints: Concepts, perspectives, carbon footprint, water footprint, Overshoot of ecological footprint and biocapacity of planet Earth, Resources Depletion. |

***Text Books***


1. Cunningham WP and Cunningham MA (2002). Principles of Environmental Science: Inquiry and Applications. McGrawHill Publications, New Delhi, 418 pp.
2. Johri R (2009). E-Waste: Implications, regulations, and management in India and current global best practices. TERI Press, New Delhi. 330 pp.
3. McKillop A and Newman S (2005). The Final Energy Crisis. Pluto Press, London. 325 pp.
4. Miller GT Jr. (1996). Living in The Environment: Principles, Connections, and Solutions. 9th Edition. Wadsworth Publishing Company, New York. 727 pp.
5. Park C (2001). The Environment: Principles and Applications. 2nd Edition, Routledge Publishers, London and New York, 598 pp.


***Reference Books***


1. Galli A (2010). Stomping on biodiversity: humanity's growing Ecological Footprint. In: Commonwealth Ministers Reference Book. Pp. 156-159.
2. McKinney ML and Schoch RM (1998). Environmental Science: Systems and Solutions. Jones and Bartlett Publishers, Boston. 639 pp.
3. MoEF (2009). State of Environment Report, India – 2009. Ministry of Environment and Forests, New Delhi
4. Sengupta B (2000). Environmental standards for ambient air, automobiles, fuels, industries and noise. Central Pollution Control Board, New Delhi, India. 78 pp.
5. WHO (2006). World Health Report 2006, World Health Organization, Geneva.


## (iv) MARB CT-300: Environmental Impact Assessment and Management Plans (Department of Marine Science)

**Course Outcomes**

- Understanding on the concept of EIA, the associated processes and notifications
- Understanding on the EIA methodology, prior environmental clearance process and EMP
- Understanding on the restoration and rehabilitation procedures and policies.

| **MARB CT-300** | **Environmental Impact Assessment and Management Plans** | **Credits: 04** |
|---|---|---|
| **Unit – 1**<br><br>**(20 Hours)** | Introduction to Environmental Impact Assessment. Environmental impact Statement and Environmental Management Plan. EIA notifications of Government of India from time to time. Guidelines for Environmental audit. | |
| **Unit – 2**<br><br>**(20 Hours)** | Environmental Impact Assessment (EIA) Methodologies. Generalized approach to impact Assessment. EIA processes, Scoping EIA methodologies, Procedure for reviewing Environmental impact analysis and statement. Environmental Management Plan and its monitoring, Evaluation of proposed actions. | |

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| **Unit – 3**<br><br>**(20 Hours)** | Nexus between development and environment, Socio-economic impacts, Aid to decision making, Formulation of development actions, Sustainable development, categorization of projects under EIA, project planning and implementation, Impact prediction, Mitigation measures. |
| **Unit – 4**<br><br>**(20 Hours)** | Introduction to. Selection of appropriate procedures, Restoration and rehabilitation technologies. Landuse policy for India. Urban planning for India. Rural planning and landuse pattern. Environmental priorities in India and sustainable development.<br>CRZ notifications and Environmental Impact Assessment in coastal zone. Coastal zone management plans of India. |

***Text Books***


1. W.P. Cunningham, 2010: Principles of Environmental Science.
2. Satsangi and A. Sharma 2015: Environmental Impact Assessment and Disaster Management.
3. R.R.Barthwal 2002: Environmental Impact Assessment.
4. C.H.Ecceleston, 2004: Environmental Impact Assessment.
5. J. Glassion, 2011: Introduction to Environmental Impact Assessment.
6. Glasson J., Therivel R., Chadwick A, (2005): Introduction to environmental impact assessment Taylor & Francis Group, London and New York.
7. Morris P., Therivel R., (2009): Methods of Environmental Impact Assessment 2009, 3rdedition, Routledge, Taylor & Francis Group, London and New York.
8. Morris P., Therivel R., (2001): Methods of Environmental Impact Assessment 2001, 2nd edition, Spon Press, Taylor & Francis Group, London and New York.
9. Eccleston C. H., (2011): Environmental Impact Assessment 2011, CRC Press, Taylor & Francis Group.


***Reference Books***


1. J. Hou, 2015: New Urbanism: The future City is Here.
2. James R. Craig, 2010: Earth Resources and the Environment.
3. R.Paliwal and L. Srivastava, 2014: Policy Intervention Analysis- Environmental Impact Assessment.


## (v) ZOOL CT-300: Conservation Biology (Department of Zoology)

**Course Outcomes**

- Understanding on fundamentals of Biodiversity, measuring biodiversity, international and national efforts
- Understanding on molecular phylogeny and different conservation measures to conserve biodiversity.
- Understanding on values of bio-resources and develop compassion toward bio-resources.

| **ZOOL CT - 300** | **Conservation Biology** | **Credits: 04** |
|---|---|---|
| **Unit I**<br>Basic Concepts<br>**(16 Lectures)** | Biodiversity (genetic diversity, species diversity, ecosystem diversity) and its use, Causes of biodiversity losses, IUCN red list of threatened | |

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| | species, Invasive species, Alien species, Indicator species, Keystone species, Umbrella species, Flagship species, Charismatic species |
| **Unit II** Measuring Biodiversity **(16 Lectures)** | Alpha, Beta and Gamma diversity, Species Richness(S), Evenness(E), Simpson index(D), Shannon-Weiner Index (H'), idea on biodiversity calculator software |
| **Unit III** International and National efforts for conserving biodiversity **(16 Lectures)** | National Act and International Act related to Biodiversity Conservation: Biological diversity Act 2002, National Biodiversity Authority, People Biodiversity Registrar, Convention on Biological diversity, Cartagena Protocol and Nagoya Protocol, Sustainable Development Goal and Biodiversity, Aichi Biodiversity Targets, CITES, WWF |
| **Unit IV** Conservation Measures and Molecular Phylogeny **(16 Lectures)** | In-situ conservation (Indian context) (Sanctuaries, National and Biosphere reserves) and Ex-situ conservation (Indian context) (Botanical gardens, zoos, cryopreservation, gene bank)<br>NCBI data base, basic idea on phylogenetic tree, Construction and interpretation of molecular phylogeny tree based on COI and 16s rRNA gene sequences using MEGA and other tools |

## 23. ENVS VAC 307: Value Added Course (Non-Credit)

## A. Bioresources for Livelihood Development

**Course Outcomes**

- Understanding on the potential of bio resources as livelihood support systems
- Understanding on sustainable indigenous farming practices and alternative livelihood options
- Basic working knowledge on extraction of products from bio resources (e.g. vermi-compost, honey, silk loom, sea food, mahua extract, medicinal extracts from flora and fauna).
- Understanding on prospects of eco-tourism through bioresources.

| **ENVS VAC 307** | **Bioresources and Livelihood Development** | **Credits: Nil** |
|---|---|---|
| **Unit 1:** Bioresources **(06 Lectures)** | Concept, classification, sources, potential of bioresources for sustainable livelihood, best practices, bioresources management policies (IBIN network) | |
| **Unit 2:**Agro-Bioresources &Sustainable Practices **(09 Lectures)** | Sustainable agro-practices (concepts & techniques), Community Managed agriculture, Organic Farming (Concept, status: local & global, principles and practices: good health & zero hunger, Indigenous Technical Knowledge (ITK), organic certification), Organic Inputs (composting, nutrient enrichment, green manuring), other practices (e.g. fungi-culture, apiculture, dairy, poultry). | |
| **Unit 3:** Blue Bio-Resources **(09 Lectures)** | Principles and best practices of aquaculture, mariculture, algal culture, aquaponics (freshwater and marine), therapeutics from the Sea, sustainable fisheries (craft and gears, cage culture, lobster fattening), fish processing technology and quality | |

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| | control, fish and shellfish breeding techniques (ornamental and edible), and scope of eco-tourism. |
| **Unit 4:** Livelihood Development Strategies<br><br>**(06 Lectures)** | Threats to traditional livelihood, food insecurity, impact of globalization and urbanization, livelihood adaptation planning, technology &knowledge management, development of bio resource-based livelihood skills, bio entrepreneurship, resource conservation, community-based initiatives and case studies |

***Text Books***


1. Dahama AK (2009). Organic farming for sustainable agriculture, Agrobios Publishers.
2. Palaniappan SP and Annadurai K (2018). Organic farming - Theory and Practice, Scientific Publishers (India).
3. Reddy SR (2017). Principles of organic farming. Kalyani Publisher, Ludhiana.
4. Pillai TVR and Kutty MN (2005). Aquaculture: Principles and Practices, Wiley-Blackwell.
5. Stickney RR (2009). Aquaculture: An Introductory Text, CAB International Publishers.
6. Srivastava CBL (1999). Fish Biology, Narendra Publishing House (India).


***Reference Books***


1. Ayyappan S, Jena JK, Gopalakrishnan A and Pandey AK (2006). Handbook of fisheries and aquaculture, 1st edition. Directorate of Information and Publications of Agriculture, Indian Council of Agricultural Research.
2. APHA, AWWA, WPCF (1998). Standard Methods for the Examination of Water and Wastewater, 20th Ed. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, D. C.
3. Santhanam R, Sukumaran N and Natarajan P (1987). A Manual of Freshwater Aquaculture. Oxford & IBH Publishing Co. Pvt. Ltd.


## B. Environmental Ethics

**Course Outcomes**

- Understanding on conceptual tools for thinking through, and participating in, complex ethical discussions about nature, the environment, and ecosystems.
- Understanding on a variety of new perspectives, principles, and frameworks that may be different from their own.
- Familiarizing with classical and current concepts, topics and debates in environmental ethics.

| **ENVS VAC - 207** | **Environmental Ethics** | **Credits: Nil** |
|---|---|---|
| **Unit 1:** Introduction to Environmental Ethics<br>**(08 Lectures)** | Background: Concept, Scope, and Significance; Land Ethics (Aldo Leopold); Ethics and Animals; Human and Other Animals; Contemporary Moral Problems | |
| **Unit 2:** Environmental Philosophy<br>**(06 Lectures)** | Philosophical Roots of Anthropocentricism (René Descartes, John Locke, The Western tradition, John Stuart Mill) Bio Centrism; Ecological Animalism; Eco-centrism | |

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|---|---|
| **Unit 3:** The Human Place in Nature<br>**(08 Lectures)** | Nature: Conception of a wild nature; Romanticism; The action of man upon nature; Political Ecology; Ecofeminsm; Deep ecology; Cultural Ecology; postmodernism |
| **Unit 4:** Concept of Sustainability<br>**(08 Lectures)** | Sustainable development: the conventional definition; Achieving a sustainable economy: Some Perspectives; Human Restoration of Nature; philosophy of climate change |

***Text Books***


1. Sandler, R. 2018. Environmental Ethics: Theory and Practice. Oxford University Press.
2. Gardiner and Thompson, 2017. The Oxford Handbook of Environmental Ethics. Oxford University Press
3. Attifield R (2018). Environmental Ethics: A Very Short Introduction, Oxford University Press.


***Reference Books***


1. Leopold. A. 1968. A sand County Almanac. Oxford University Press.
2. Boddice, R. 2011. Anthropocentrism: Humans, Animals, Environment. Brill.
3. Soper, 1995. What is Nature? Blackwell
4. Shiva, V. 2015. Earth Democracy: Justice, Sustainability and Peace. North Atlantic Books. Berkeley.
5. Shiva, V. 2010. Staying Alive: Women, Ecology, and Development.


## 24.Student Seminar (Departmental Journal Club)

All the students shall be instructed to present a research article published in peer reviewed journals with necessary supervision and guidance from faculty members. The evaluation shall be out of 15 marks, and the said mark shall be reflected as one of the components in the course ENVS C-403 in 4$^{th}$ semester.

# SEMESTER-IV

## 25.ENVS C-401: Disaster Management (Core Course, 04 Credits)

**Course Outcomes**

- Understanding general concepts in the dimensions of natural and human induced disasters
- Learning about practices of disaster preparedness, response and recovery processes.
- Understanding and analyzing approaches of Disaster Management
- Building skills to respond to disaster

| **ENVS C-401** | **Disaster Management** | **Credits: 04** |
|---|---|---|
| **Unit 1:** Introduction to Disasters<br><br>**(12 Lectures)** | Background and Types (Geological: earthquakes, landslides, tsunami, mining; Hydro-Meteorological: floods, cyclones, lightning, thunder-storms, hail storms, avalanches, droughts, cold and heat waves; Biological: epidemics, pest attacks, forest fire; Technological: chemical, industrial, radiological, nuclear) | |
| **Unit 2:** Risk Assessment and | Disaster Risk: Concepts, types, Acceptable risk and Risk assessment.<br>Vulnerability: Concept, Observation, Identification, types and dimensions; Systematic management and Strategic planning for vulnerability reduction | |

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|---|---|
| Vulnerability Analysis **(12 Lectures)** | |
| **Unit 3:** Disaster Management (Preparedness and Response) **(12 Lectures)** | Nature, Importance, Dimensions and Scope of Disaster Management. Disaster Preparedness: concept, significance, measures, Disaster Preparedness Plan (Concept, significance, prediction, early warnings and safety measures) Role of science and technology in Disaster Risk Reduction |
| **Unit 4:** Disaster Management in Practice **(12 Lectures)** | Disaster Profile of India – Mega Disasters of India and Lessons Learnt, Disaster Management Act 2005, National Policy, Guidelines and Plans on Disaster Management; Role of Government (local, state and national), Non-Government and Inter Governmental Agencies |

***Text Books***


1. Smith, K. (1992). Environmental Hazards, London.
2. Bell, F.G (1999). Geological Hazards.Routledge, London.


***Reference books***


1. Krynine, D.S. and Judd, W.R. (1998). Principles of Engineering Geology by, CBS, New Delhi.
2. Bryant, E. (1985). Natural Hazards by, Cambridge University Press. London.
3. Nagarajan, R. (2001). Landslide Disaster – Assessment and Monitoring, Anmol Publications, New Delhi.
4. Cutter, Susan L (1999). Environmental risks and hazards, Prentice Hall of India, New Delhi.
5. Bill Mc Juire, Ian Mason and C. Killburn (2002). Natural hazards and Environmental change, Oxford University Press, New York.
6. Gupta, Harsh K. (2003). Disaster Management, Universities Press (India) Pvt. Ltd
7. Coppola, Damon P. (2006). Introduction to International Disaster Management.


## 26. ENVS C-402: Environmental Law: Acts, Notifications and Conventions (Core Course, 04 Credits)

**Course Outcomes**

- Understanding on various relevant acts and notifications for protection of environment and conservation of natural resources
- Understanding on different international conventions and treaties for on protection environmental and conservation natural resources

| **ENVS C - 402** | **Environmental Law: Acts, Notifications and Conventions** | **Credits: 04** |
|---|---|---|
| **Unit 1:** Acts for Environmental Protection **(12 Lectures)** | Articles in Indian Constitution, and different Acts for Environmental Protection and their provisions (Forest (Conservation) Act 1980, Wildlife (Protection) Act 1972, 2006, Biological Diversity Act 2002, The Mines and Minerals Act 2016, The Water Act 1974, The Air Act 1981, Environmental Protection Act 1986) | |
| **Unit 2:** Notifications for Environmental Protection | EIA Notification and its provisions, CRZ Notification & its provisions, RRZ Notification and its provisions, ESZ notification and its provisions | |

| ENVS C - 402 | Environmental Law: Acts, Notifications and Conventions | Credits: 04 |
|---|---|---|
| **(12 Lectures)** | | |
| **Unit 3:** International Conventions (Physico-chemical Aspects) **(12 Lectures)** | Stockholm Convention on Persistent Organic Pollutants (POPs), Sofia Protocol, Montreal Protocol, United Nations Framework Convention on Climate Change (UNFCC), United National Convention for Combating Desertification (UNCCD), | |
| **Unit 4:** International Conventions (Biological Aspects) **(12 Lectures)** | Convention on Biological Diversity (CBD), Ramsar Convention, Convention on Conservation of Migratory Species of Wild Animals (CMS), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, Washington Convention), United Nations Convention on Law of the Sea (UNCLOS) | |

***Text Books***


1. Doabia TS (2017). Environmental & Pollution Laws in India (Set of 2 Vol). 3rd Edition. LexisNexis. 3496 pp.
2. Ghosh S (2019). Indian Environmental Law: Key Concepts and Principles. 1st Edition. The Orient Blackswan. 360 pp.


***Reference Books***


1. Upadhyay S and Upadhyay V (2002). Handbook on Environmental Law - Forest Laws, Wildlife Laws and the Environment. Vols. I, II and III. Lexis Nexis- Butterworths-India, New Delhi.


## 27. Student Seminar (Departmental Journal Club)

All the students shall be instructed to present a research article published in peer reviewed journals with necessary supervision and guidance from faculty members. The evaluation shall be out of 15 marks, and the said mark shall be reflected as one of the components in the course ENVS C-403 in 4$^{th}$ semester.

## 28. ENVS C-403: Minor Project Work (Dissertation Work: Practical / Field Study; 04 Credits)

This course shall include the evaluation of Minor Project work (Summer internship) carried out by the students and the evaluation of journal club presentations (Dept. seminar presentations). The students shall have to submit the summer internship report in the department for evaluation and assessment. This minor project work and seminar presentations shall be equivalent to one core papers (04 Credits). The evaluation shall be out of 15 marks each for journal club presentation in each semester (totaling 60 marks), and 40 marks for the summer internship (20 marks for report and 20 marks for presentation). Of this, 20 marks for the presentation shall be considered as “internal mark”, and 20 marks for report and 60 marks of journal club presentation (04 semesters) shall be considered as “end-term marks”. The whole evaluation shall be carried out by a board of internal examiners (comprising of all the faculty members of the Department).

## 29. ENVS C-404: Major Project Work (Dissertation Work: Practical / Field Study; 12 Credits)

In this paper, all the students must opt for one supervisor (from among the faculty members of the department) and choose one research work (in consultation with and under the supervision of the supervisor), and carry out the major project work. The students shall have to submit the major project work report in the department for evaluation and assessment. This project work shall be equivalent to 03 core papers (12 Credits).

## 30. ENVS AC-405: Cultural Heritage of South Odisha

**Aim of the Course (ପାଠ୍ୟକ୍ରମରଲକ୍ଷ୍ୟ)**

Kabi Samrat Upendra Bhanja is the master-spirit of Odia Language and Culture during Medieval period. The campus of Berhampur University has been rightly named after Kabi Samrat Upendra Bhanja as 'BHANJA BIHAR'. South Odisha is the adorable storehouse of literary and cultural wealth of ancient and medieval Odisha which has elicited remarkable national acclaim. This course has been introduced with a view to familiarizing all the P.G. Students of Berhampur University with the excellent craftsmanship exemplified by the literary stalwarts including Kabi Samrat Upendra Bhanja along with the Arts, Culture and Folk Tradition of South Odisha. (ମଧ୍ୟଯୁଗୀୟ ଓଡିଆ ସାହିତ୍ୟ ଓ ସଂସ୍କୃତିର ମହାନାୟକ କବି ସମ୍ରାଟ ଉପେନ୍ଦ୍ର ଭଞ୍ଜ । ବ୍ରହ୍ମପୁର ବିଶ୍ୱବିଦ୍ୟାଳୟ ତାଙ୍କ ନାମରେ 'ଭଞ୍ଜବିହାର' ଭାବରେ ନାମିତ । ଗଞ୍ଜାମ ସମେତ ଦକ୍ଷିଣ ଓଡ଼ିଶା ସମଗ୍ର ରାଜ୍ୟର ବୁଧହଂସ କେଳିସର । ଏହାର କଳା-ସାହିତ୍ୟ-ସଂସ୍କୃତି-ଲୋକପରମ୍ପରା ସର୍ବଭାରତୀୟ ସ୍ୱୀକୃତିପ୍ରାପ୍ତ । ଏହାକୁ ଦୃଷ୍ଟିରେ ରଖି ବ୍ରହ୍ମପୁର ବିଶ୍ୱବିଦ୍ୟାଳରେ ସ୍ନାତକୋତ୍ତର ଶ୍ରେଣୀର ସମସ୍ତ ଛାତ୍ରଛାତ୍ରୀଙ୍କୁ କବି ସମ୍ରାଟ ଉପେନ୍ଦ୍ର ଭଞ୍ଜଙ୍କ ସମେତ ଦକ୍ଷିଣ ଓଡ଼ିଶାର ଅନ୍ୟାନ୍ୟ ସାହିତ୍ୟିକ ପ୍ରତିଭା ଏବଂ ଏହି ଅଞ୍ଚଳର କଳା, ସଂସ୍କୃତି, ଲୋକ ପରମ୍ପରା ସମ୍ପର୍କରେ ସାଧାରଣ ଧାରଣ ପ୍ରଦାନ କରିବା ପାଇଁ ଏପରି ଅଧ୍ୟୟନ ବ୍ୟବସ୍ଥା କରାଯାଇଛି ।)

***Details of the Course***

**This Paper consists of 50 marks with following 4 Units.**

- Unit - I: Literary works of Kabi Samrat Upendra Bhanja
- Unit - II: Other Litterateurs of South Odisha
- Unit - III: Cultural Heritage of South Odisha
- Unit - IV: Folk and Tribal Traditions of South Odisha

- ୟୁନିଟ-୧: କବିସମ୍ରାଟ ଉପେନ୍ଦ୍ର ଭଞ୍ଜଙ୍କ କୃତି ଓ କୃତିତ୍ୱ
- ୟୁନିଟ-୨: ଦକ୍ଷିଣ ଓଡ଼ିଶାର ଅନ୍ୟାନ୍ୟ ସାରସ୍ୱତ ସାଧକ
- ୟୁନିଟ-୩: ଦକ୍ଷିଣ ଓଡ଼ିଶାର ସାସ୍କୃତିକ ବିଭବ
- ୟୁନିଟ-୪: ଦକ୍ଷିଣ ଓଡ଼ିଶାର ଆଦିବାସୀ ଓ ଲୋକ ପରମ୍ପରା

**Course Outcome (ପାଠ୍ୟକ୍ରମର ନିଷ୍କର୍ଷ)**

The teaching imparted to the P.G. students of Berhampur University on the various dimensions of the literary and cultural heritage of South Odisha will help them to acquire a valuable understanding of the same. They will be inspired adequately to take the positives learnt from the course and use them in future in their personal literary and cultural pursuits and thereby promote the literature and culture of Odisha on a global scale. (ଓଡ଼ିଆ ସାହିତ୍ୟ ଓ

ସଂସ୍କୃତିର ଏହିପରି ଏକ ଗୁରୁତ୍ୱପୂର୍ଣ୍ଣ ଦିଗରେ ପାଠଦାନ କରିବା ଦ୍ୱାରା କେବଳ ଯେ କବିସମ୍ରାଟ ଉପେନ୍ଦ୍ରଭଞ୍ଜ ଓ ଦକ୍ଷିଣ ଓଡ଼ିଶାର କଳା-ସାହିତ୍ୟ-ସଂସ୍କୃତି-ଆଦିବାସୀ ଲୋକ ଜୀବନ ଓ ଲୋକ ପରମ୍ପରା ସମ୍ପର୍କରେ ବିଶ୍ୱବିଦ୍ୟାଳର ଛାତ୍ରଛାତ୍ରୀ ସଚେତନ ହୋଇପାରିବେ; ତାହା ନୁହେଁ, କବିସମ୍ରାଟ ଉପେନ୍ଦ୍ରଭଞ୍ଜଙ୍କ ସହିତ ଦକ୍ଷିଣ ଓଡ଼ିଶାର ସାହିତ୍ୟିକ ପରିମଣ୍ଡଳ ଏବଂ ଏହି ଅଞ୍ଚଳର ସାଂସ୍କୃତିକ ବିଭବ ଓ ଲୋକପରମ୍ପରା ସମ୍ପର୍କରେ ବିଶ୍ୱବିଦ୍ୟାଳୟର ଛାତ୍ରଛାତ୍ରୀମାନେ ମଧ୍ୟ ସମ୍ୟକ ଜ୍ଞାନ ଆହରଣରେ ବ୍ରତୀ ହୋଇପାରିବେ ।)