Savitribai Phule Pune University

M. Sc. Biodiversity – Monitoring and Utilization

Credit and Semester System Syllabus

M.Sc. Part II(2019 Pattern)

Degree: Master of Science

Subject: Biodiversity-Monitoring and Utilization

Faculty: Science & Technology

Dr. Ankur Patwardhan

Chairman, BOS in Biodiversity

General Information

M. Sc. Biodiversity - Monitoring and Utilization (credit and Semester System) is a twoyear postgraduate course, comprising four semesters. The curriculum gives holistic coverageto the extremely valuable field of Biodiversity. Biodiversity is the largest source of potentialwealth for the country, which remains grossly under explored. One of the reasons for theunder utilization is the dearth of trained manpower. The current generation of biologists islargely divided into field-oriented taxonomists and ecologists on the one hand and the laboriented functional and molecular biologists on the other. This divide has become a limitingfactor in the study of Biodiversity. The present program intends to bridge the gap byinculcating excellence in field and laboratory biology simultaneously. This capacity buildingexercise will help generating wealth through a prudent and sustainable use of the country'sbioresources.

The course consists of four semesters:

- The first year comprising two semesters is extensively field oriented and the second year is lab intensive.
- The first semester is devoted to taxonomy and diversity of various life forms and emphasizes on basic techniques of exploration of diversity.
- Second semester focuses on natural history and is supplemented adequately with quantitative techniques in biology and ecology. Biogeography component which forms the key component in shaping up of natural systems has also been included here.
- First and second semesters together emphasize on conceptual as well as empirical knowledge of the ways in which natural systems work.
- The first two semesters can make a good naturalist and ecologist.
- Third and fourth semester will expose students to various facets of environment, conservation and utilization of bioresources.

Eligibility Criteria:

a. Bachelor in - Science (any branch) / Agriculture / Fisheries / Pharmacy / Forestry / Medicine / Engineering (any branch) with minimum 50% of marks

b. Clearing the entrance examination

Admission: The candidate should appear for the entrance test. The merit list will be based only on marks obtained in entrance test. Marks of qualifying graduate examination will be considered for tie-breaking.

Fee Structure:As per Savitribai Phule Pune University guidelines for self supported postgraduate courses in colleges.

Workload: There shall be 15 teaching clock hours per credit, out of which classroom contacthours will be 12 and 3 hours for preparation of in-semester continuous assessment comprising of seminars, mini projects, assignments, library notes, extension works and short quizzes. Each practical session will occupy six hours / week / batch.

Examination: Assessment shall consist of an in-semester continuous assessment and end ofsemester assessment as per Savitribai Phule Pune University rules.

Guidelines for Internal and Project Assessment: The in-semester evaluation (internalassessment) shall be carried out as per the guidelines given by university for credit and semester system. Biodiversity course being field intensive, visits to natural systems and forested landscapes forms an integral part of the overall practical component. Practical examination will combine both field and lab exercises that test the knowledge and understanding of the subject.

Standard of Passing: The award of grades, ATKT and marks for passing, etc. will be as perthe Savitribai Phule Pune University rules.

Medium of instruction– English

Course structure: There shall be four semesters, at each semester there will be 3 theorycourses and 2 practical courses. In the first semester, there shall be only core / compulsory credits (TC). Second semester shall consist of 2 core / compulsory credits and 1 non-core / optional credit (TNC). In the third semester, there shall be 1 core / compulsory credits and 2 non-core / optional credit. In fourth semester, there will be 1 core/ compulsory credit and 2 non-core / optional credit, for theory. Each practical course shall have 4 core / compulsory credits (PC). Following is the outline of the course structure.

Semester	**Theory (48 credits)**		**Practical (32 credits)**
	Core /Compulsory Course (credits)	Non-core /Optional Course (credits)	Core / Compulsory Course (credits)
I	12	00	08
II	08	04	08
III	04	08	08
IV	04	08	08

Detail course outline of M.Sc. – Part I

Semester	Course Code	Name of the Subject	Credits	
Semester I	BD - TC 101 Theory	Introduction to Plant and Animal Taxonomy and Diversity	4	Core
	BD - TC 102 Theory	Microbial Diversity and Molecular Biology	4	Core
	BD - TC 103 Theory	Introduction to Ecology and Biodiversity Management	4	Core
	BD - PC 111 Practical	Taxonomy and Diversity: Field Methods	4	Core
	BD - PC 112 Practical	Taxonomy and Diversity: Lab Methods	4	Core
Semester II	BD – TC 201 Theory	Research Methodology and Quantitative Biology	4	Core
	BD – TC 202 Theory	Population Ecology and Evolutionary Biology	4	Core
	BD – TNC 203 Theory	Biogeography	4	Non Core
	BD-TNC 204 Theory	Environmental Journalism and Media	4	Non Core
	BD – PC 211 Practical	Quantitative and Field Techniques in Ecology	4	Core
	BD-PC 212 Practical	Biodiversity Internship	4	Core
	Total Credits		40	

Detail course outline of M.Sc. – Part II

Semester	Course Code	Name of the Subject	Credits	
Semester III	BD - TC 301 Theory	Scientific Communication and Biostatistics	4	Core
	BD – TNC 302 Theory	Wildlife and Conservation Biology	4	Non Core
	BD - TNC 303 Theory	Introduction to Environment Laws and Policies	4	Non Core
	BD - TNC 304 Theory	Agrobiodiversity and Livestock diversity	4	Non Core
	BD - PC 311 Practical	Quantitative Techniques and GIS	4	Core
	BD - PC 312 Practical	Dissertation I	4	Core
Semester IV	BD – TC 401 Theory	Chemical Diversity	4	Core
	BD –TNC 402	Bioinformatics and Phylogenetics	4	Non Core
	BD – TNC 403 Theory	Socio-economic Aspects of Biodiversity	4	Non Core
	BD – TNC 404 Theory	Environment Management and Restoration	4	Non Core
	BD - PC 411 Practical	Bioactivity of Secondary Metabolites and Bioinformatics	4	Core
	BD - PC 412 Practical	Dissertation II	4	Core
	Total Credits		40	

Semester III

Course Code and Title	Credit Title
BD – TC 301: Scientific Communication and Biostatistics	Theory behind Scientific Communication and research ethics
	Different modes of Scientific communication
	Advance Statistics
	Experimental Design and Multivariate Analysis
BD- TNC 302: Wildlife and Conservation Biology	Conservation
	Natural habitat and its Conservation
	Landscape Ecology
	People and Conservation
BD- TNC 303: Introduction to Environment Laws and Policies	India's National Environmental Policies
	Environmental Laws in India and Environmental Equity
	Biodiversity Laws in India and Implementation
	International Environmental Policies
BD TNC- 304: Agro and Livestock Diversity	Origin and Development
	Cultivation of Crops
	Livestock Management
	Future of Agro and Livestock Diversity
BD –PC 311: Quantitative Techniques and GIS	Quantitative Techniques I – Parametric tests, Non parametric tests, Correlation & Regression
	Quantitative Techniques II – ANOVA, PCA, Multivariate Analysis, Cluster Analysis
	Basics of GIS Querying and Analyzing Data
	Map Generation, Layout and Digitization

Semester IV

Course Code and Title	Credit Title
BD - TC 401: Chemical Diversity	Introduction to Chemical Diversity
	Natural Product Chemistry – Primary and Secondary Metabolites
	Screening of Bioactive Molecules
	Extraction and Analysis Methods- Physical and Chemical
BD - TNC 402: Bioinformatics and Phylogenetics	Overview of Bioinformatics
	Introduction to Sequence Alignment
	Tools used in Proteomics and Genomics
	Constructing Phylogenetic trees
BD TNC- 403: Socio-economic Aspects of Biodiversity	Resource Use patterns
	Economics of Natural Resource Use
	Knowledge Systems
	Qualitative Research Methods
BD TNC- 404: Environment Management and Restoration	Environment Impact Assessment
	Environmental Management Systems
	Environmental mitigation and Management
	Environmental awareness through practicing restoration ecology
BD PC-411: Bioactivity of Secondary Metabolites and Bioinformatics	Isolation of secondary metabolites from a natural source
	Screening for antimicrobial compounds from natural sources, Quantitative assays of antimicrobials
	Database Search
	Phylogenetic tree Construction

BD TC- 301: Scientific Communication and Biostatistics

Objective: Students completing this course will be able to: Communicate their scientific data effectively using different media such as papers, documentaries etc. Apply knowledge of scientific ethics and produce good quality of research material. Design and execute research plans using different statistical tools to answer disciplinary specific questions. Students will have basic knowledge of R programming.

A. Theory Behind Scientific Communication and Research Ethics (1 credit)

a. Importance of scientific communication, Types of scientific communications, Logical organization of scientific data, Ethics in Scientific communication
b. Social implications of research, Animal experimentation ethics, wild-life ethics and human experimentation ethics.
c. Ethics in science and research -data fudging, plagiarism, etc.

B. Different Modes of Scientific Communication (1 credit)

a. Proposal writing: Statement of Purpose (SOP) and Concept note, Proposal for funding, Report Writing
b. Scientific writing: Different types of research articles -Reviews, short notes, full paper, letter to editors andpeer review, thesis writing.
c. Oral forms of scientific communication: Transformation of written content to oral form, Poster presentation, Oral presentations
d. Legal forms of communication of science: IPR, patents submissions, registration of plant / crop variety, etc.

C. Advance Statistics (1 credit)

a. Parametric Tests t - test family – paired, unpaired,
b. Nonparametric tests – Mann Whitney U test, chi square.
c. Correlation - Pearson's correlation, Non-parametric correlation.
d. Regression - Linear regression, multiple regression.

D. Experimental Design, Multivariate Analysis (1 credit)

a. Factorial experiments, ANOVA, MANOVA. Experimental and Sampling design, CRD, RBD, Latin squares
b. Sampling strategies and selection of sampling strategies, Optimization of sample size.
c. Measuring and testing multivariate distances,
d. Cluster analysis, strategies of clustering– merits & demerits, Ordination and Principle Component Analysis using R software.

References

1. Cochran, W.G. and Snedeco, G.W. (1967). *Statistical Methods, 7th Edn*. Ames, IA: lowa State University Press.
2. Bailey, N.T.J. (1959). *Statistical methods in Biology*, English Universities Press Limited.
3. Anderson, D.R.; Sweeney, D.J. and Williams, T.A.. (1994) *Introduction to Statistics: Concepts and Applications*. West Group.
4. Martha Davis (2005) *Scientific Papers and Presentations*
5. Yatendra Joshi, *Communicating in Style,* New Delhi TERI 2003
6. Gore, A. P. and Paranjpe, S. A. (2001). *A Course in Statistical Ecology*. Kluwer Academic Publishers, Holland.
7. Zar, J.H. (1999). *Biostatistical Analysis, 4th Edn*. Northern Illinois University.
8. Sokal, R.. and Rohlf, F. J. (2012) *Biometry: Principles and practice of statistics in biological research, 4th Edn.* W. H. Freeman and Co**.**
9. Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani.*An Introduction to Statistical Learning with Applications in R*.
10. D. Freedman, R. Pisani, R. Purves (2007). *Statistics.*
11. Robert A. Donnelly, Fatma Abdel-Raouf (2016) *Statistics*, 3E (Idiot's Guides) 3rd Edition.

BD TNC- 302: Wildlife and Conservation Biology

Objectives: This course is in conjunction to the course BD TC 103 in the first semester which gave an overview of the biological diversity and its conservation practices. This course deals with various scientific aspects of conservation namely, wildlife; landscape approach and people.

A. Conservation (1 credit)

a. Scope of wildlife biology – Basics and historical perspectives
b. Wildlife and human welfare
c. Need and importance of conservation

B. Natural habitat and its Conservation (1 credit)

a. Types of habitat and their major ecological factors
b. Threats to the conservation of habitats –Habitat edges, ecotones and interiors, habitat patches & corridors, habitat quality.
c. Future of habitat conservation – policies and implementation

C. Landscape Ecology (1 credit)

a. History and definition of landscape ecology, its relationship to other subfields of ecology and conservation
b. Detecting and characterizing landscape patterns, landscape dynamics
c. Effects of landscape pattern on organisms, populations, communities and ecosystem processes

D. People and Conservation (1 credit)

a. Ethno ecological knowledge- past and present, Traditional conservation practices, Concept of Sacred Natural Sites, Community conserved areas, Heritage Sites
b. Cultural history and biodiversity, hunting practices, Human Wild life interactions
c. Natural resources documentation, Peoples' Biodiversity Register (PBR), Access benefit sharing.

Reference

1. Gary E Davis, *Science and Ecosystem Management in National Parks,* The University of Arizona Press, Tucson, 1996
2. India's 4th national reports on convention on Biodiversity, MOEF 2009.
3. Keya Acharya (2010),*Green pen*, Sage publications
4. Kailash C. Malhotra, Yogesh Gokhale, Sudipto Chatterjee, and Sanjeev Srivastava (2001). *Cultural and Ecological Dimensions of Sacred Groves in India*. Indian National Science Academy, New Delhi, and Indira Gandhi Rashtriya Manav Sangrahalaya, Bhopal.
5. *Maharashtra protection and preservation of trees Act*, 1975, Govt of Maharashtra, modified upto 9th June 2004.
6. Rosaleen Duffy (2010), *Nature crime: how we are getting conservation wrong*, Yale University Press, London,
7. Priya Ranja Trivedi and Uttam Kumar Singh*, Environmental laws on Wildlife*, Commonwealth Publishers
8. Rutwick Dutta*, Wildlife Law: A ready reckenor, A guide to wildlife Protection Act, 1972, as amended in 2002. Wildlife Trust of India, 2004*
9. Vivek Menon(1999)*,Wildlife Crime*, Natraj Publishers, Dehradun.

BD TNC -303:Introduction to Environment Laws and Policies

Objective: Environmental laws in India play an important role in the bureaucracy of natural resource management systems. The objective of the course is to make the students aware of the laws related to the subject and how they have changed with the time. The aim is also to relate how the steps taken internationally have a effect on our national laws and policies related to the environment.

A. India's National Environmental Policies (1 credit)

a. History of environmental awareness
b. Basics and principles related to development of environmental policies
c. Environment and Indian Constitution, Responsibilities of centre and state governments

B. Environmental Laws in India and Environmental Equity (1 credit)

a. Environmental laws:, Air Act, Water Act, Environmental Protection Act
b. Institutional setup and implementation authorities of the Act
c. Environmental Equity: Concept, Domestic issues, Proactive measures to sustain environmental equity

C. Biodiversity Laws in India and Implementation (1 credit)

a. Indian Forest Act, Wildlife Protection Act
b. Biodiversity Act, Forest Rights Act
c. Institutional setup and implementation authorities

D. International Environmental Policies (1 credit)

a. International laws, treaties (UNCHE, UNFCCC, Rio Earth Summit, CBD,Ramsar Convention, Kyoto Protocol, CITES, Paris Convention)
b. United Nation Sustainable Development Goals (UNSDGs), AICHI Targets
c. Linkages with national policies

Reference

1. Anjaneyulu Y. (2002) *Environmental Impact Assessment Methodologies.* B.S Publication Hyderabad.
2. Anjaneyulu, Y. and Manickam, V. (2002).*Environmental Impact Assessment Methodologies.* B.S. Publications.
3. Boland, R.G.A. (Ed) (1993).*Environmental Management Training*. Sterling Publishers Pvt. Ltd. New Delhi.
4. Canter, S.L.(1996)*Environmental Impact Assessment.2nd Edition.* McGraw-hill Book Company, New York.
5. Cutter, S.L. (1999) *Environmental Risks and Hazards.* Prentice Hall of India, New Delhi.
6. Declaration of: The Stockholm Conference, Rio, Rio+5 and Rio+10.
7. Glasson, J. Therivel, R. and Chadwick, A.(2006)*Introduction to Environmental Impact Assessment.* Routledge, London.
8. Jaswal,P.S. and Jaswal,N. *Environmental Law.* Pioneer Publications, Delhi. 2003.
9. Khitolia, R.K. *Environmental Management and Conservation ,* Chand Publication.
10. Kulkarni, V. and Ramachandra, T.V. (2006).*Environmental Management*. Capitol Pub. Co., New Delhi.
11. Leelakrishnan,*P*.(2005).*Environmental Law in India.* LexisNexis Butterworths Wadhwa, Nagpur.
12. Morris, P. and Therivel R. (Eds) (2001) *Methods of Environmental Impact Assessment. 2nd Edition,* Spon Press London.
13. Paliwal, U.L. (2002*) Environment Audit.* Indus Valley Publications. Jaipur
14. Petts, J. *Handbook of Environmental Impact Assessment- Volume 1 and 2.* Blackwell
15. Shastri, S.C. (2008) *Environmental law in India.* Eastern Book Co, Lucknow.
16. The Wildlife [Protection] Act, 1972 [as amended up to 1991, Natraj Publishers, Dehradun, India, 1994.
17. Tiwari, R. K. (2007) *Global Environmental Policies*. A B D Publishers.

BD TNC- 304: Agro and Livestock Diversity

Objective: India is primarily an agrarian country. Right from the origin of agriculture, over all these years, agriculture and related activities have had an effect on the natural resources in India. It isalso seen now in the light of climate change or erratic climatic patterns. This subject shall also be seen in the light of importance of traditional knowledge which has gained importance now-a-days. The emphasis is on the diversity related aspects and not on the methods of agriculture or seed production.

A. Origin and Development (1credit)

a. History of domestication of plants and animals
b. Centres of origin and wild relatives of crops and animals
c. Spread across the globe

B. Cultivation of Crops (1credit)

a. Green revolution with specific reference to Asia, Commercialization of agriculture
b. Importance of traditional crop varieties, laws associated with them
c. Traditional and Modern methods of cultivation (traditional agriculture practices, shifting cultivation, home-gardens, Common/co-operative)
d. Mono-cropping versus poly-cropping - Intercropping, Mixed cropping, Sequential cropping, Overlapping cropping, Crop interactions and Allelopathy

C. Livestock Management (1credit)

a. Varieties/breeds of cattle, buffaloes, goat, sheep, pigs and their economic importance
b. Management and scope in Aquaculture / Pisciculture, Sericulture, Apiary, Poultry,
c. Opportunities and challenges in livestock sector

D. Future of Agro&Livestock Diversity (1credit)

a. Precision farming, Vertical farming and urban farming approaches
b. Issues associated with diversified farming, changing cropping pattern
c. Effect of Climate change, developmental projects on agro & livestock diversity with special reference to Indian scenario

Reference

1. Amalendu Chakraborty, *Handbook of Animal Husbandry Sciences*
2. Dahama, O.P & O.P.Bhatnagar (1994). *Education and Communication for development,* New Delhi, IPH
3. Directorate of Extn. Govt. of India (1961). *Extension Education in Community developments*
4. Hans Raj (1992). *Theory and Practice in Social Research*.
5. Handbook of Animal Husbandry, ICAR publication
6. Kuppuswamy,B. (1994). *Social Change in India*
7. Sastry, N.S.R, Reddy, D.P.R. and Hermon,R.R, (1993). *Planning for Development of Animal Husbandry Sector*. National Institute of Rural Development, Hyderabad.
8. Sastry, N. S. R and Thomas, C. K. (2005). *Livestock Production Management*, Kalyanai Publishers, Ludhiana: Chapters on " Extension and livestock development, Livestock Extension, Participatory and Rapid Rural Appraisal"
9. Food and Agriculture Organization of the United Nations Fisheries and Aquaculture Department (2005)
10. Functioning of Central Silk Board & Performance of Indian Silk Industry Central Silk board India (2018)

BD PC- 311: Quantitative Techniques and GIS

A. Quantitative Techniques –I **(1 credit)**

a. Parametric Test- t - Test family – paired, unpaired.

b. Nonparametric tests – Mann Whitney U test, chi squared.

c. Correlation - Pearson's correlation, Non-parametric correlation.

d. Regression - Linear regression, Multiple regression.

B. Quantitative techniques-II **(1 credit)**

a. Factorial experiments, ANOVA,

b. Measuring and testing multivariate distances

c. Ordination and Principle Component Analysis

d. Cluster analysis

C. Basics of GIS, Querying and Analyzing data **(1 credit)**

a. Introduction to open GIS softwares, vector and Raster

b. Visualizing the data

c. Import / Export of shapefiles

d. Vector layer preparation

D. Map generation / Layout & Digitisation **(1 credit)**

a. Design andUnderstanding different components in layout

b. Understanding tools of Q-GIS soft wares

c. Georeferencing

d. Map editing

BDPC- 312 (Dissertation – I) and PC 412 (Dissertation – II)

Students will undertake a dissertation in the second year.

1. Students will undertake dissertation in the second year, in the third and fourth semester. The final evaluation of the dissertation shall be conducted at the end of the second year as per the rules of SPPU.
2. Dissertation can be carried out by a single student or by group of maximum three students. The dissertation report will be prepared as per the thesis format. One copy of the report will be preserved in the department. If there is more than one student carrying out a single dissertation, a single report can be submitted. These students will be assessed based on presentation. In such case, presentation should be carried out by all the students; dividing the presentation equally among them.
3. Students must submit a concept note regarding the topic of dissertation. The note should contain details like the proposed area of work, brief description of the problem, brief methodology and name and signature of the student and supervisor. For project work chosen outside College, involving other research Institutes and supervisors, there should be one faculty coordinator from the Dept. who will interact with the student and external supervisor throughout the project period.
4. Assessment will be as per the norms laid by SPPU. Students may present their work using posters, blackboard, transparencies, model or LCD projector.

5. The assessment of the dissertation is for total of 200 marks. The assessment will be conducted as per following matrix.

Subject	In-semester evaluation (Marks)	End-semester evaluation (Marks)	Total (Marks)
BD PC-311	30	70	100
BD PC-411	30	70	100

6. The assessment will be carried out on the basis of the points given in the accompanied guidelines. Head of the department should communicate this point wise assessment system to the dissertation supervisor (Guide), well in advance. Guide will give appropriate marks, point-wise and submit it in a sealed envelope to the Head of the respective department.

I. Guidelines for dissertation evaluation:

BD PC- 312: Dissertation I (In-Semester evaluation)

Point-wise marking schemeto be filled by department

Criteria	Max. Marks
Project Concept / Defining scope of work / Hypothesis generation	10
Presentation at the end of 3rd Semester	20
Total	**30**

BD – PC 412- Dissertation – II (In-Semester evaluation)

Point-wise marking scheme

Criteria	Max. Marks
Field book or lab diary	10
Presentation at the end of 4thSemester	10
Developing independent proposal for funding	05
Presentation at National / International Symposia	05
Total	**30**

II. Guidelines for dissertation evaluation:

BD PC-312:Dissertation - I (End-Semester evaluation)

Point-wise marking scheme to be filled in by the Guide/Supervisor

Criteria	Max. Marks
Literature Review	15
Inputs of students in development of work plan, ideas, implementation	10
Field work/Experimentation/data collection	25
Motivation,Punctuality,perseverance,meeting deadlines	05
Ability to work with others & communication skill	05
Evaluation of Bimonthly progress reports	10
Total	**70**

BD PC- 412: Dissertation - II (End-Semester evaulation)

Point-wise marking scheme to be filled in by the **External Examiner**

(Based on final report submitted by the candidate)

Name of the Student ----------

Title of the Dissertation ----------

Name of the Subject Expert ----------

Please grade the student on a scale of 1 to 10 for each criterion. : ***Encircle*** the grade.

1. How do you grade the student regarding understanding of the basic concepts related to the project work?

   1 2 3 4 5 6 7 8 9 10

2. Quality of the project report (Data generation & presentation).

   1 2 3 4 5 6 7 8 9 10

3. Background Literature survey and Discussion

   1 2 3 4 5 6 7 8 9 10

4. Methodology

   1 2 3 4 5 6 7 8 9 10

5. Novelty of work

   1 2 3 4 5 6 7 8 9 10

6. According to you, is the work performed publishable/ patentable?

   1 2 3 4 5 6 7 8 9 10

7. Rate the quality of work with the work on the same lines being carried out elsewhere.

   1 2 3 4 5 6 7 8 9 10

Other comments:

BDTC- 401: Chemical Diversity

Objective: Metabolites from animals, plants and microbes represent a vast array of chemical substances. These metabolites play a role in mediating a dynamic interaction between microbes, plants and animals. A large number of such compounds from natural sources largely remain unexplored. This course intends to train the students in the methods of detecting and assaying such a compound and encourage them to find new compounds.

A. Introduction of Chemical diversity in Biodiversity study (1 credit)

a. Introduction to Chemical Ecology- Chemical signals like olfactory cues, pheromones, Allelopathy
b. Understanding the chemicals used in Defense by plants, microbes.
c. Application of chemical cues: Communication, habitat selection, pest management, yield improvement in agriculture and medical industry.

B. Natural product chemistry – Primary and Secondary Metabolites (1 credit)

a. Importance and production of Secondary Metabolites (from Plants, Animals and Microbes)
b. Introduction to classes of naturally occurring compounds: Fatty acids, Alkaloids, Terpenoids, Steroids, Flavonoids, Anthocyanins, Carbohydrates, Essential oils
c. Case studies like aphid alarm signal, interaction with milkweed, plant pollinator interaction, sex pheromone and mate preference, interaction due to herbivore induced volatile organic compounds

C. Screening of bioactive molecules (1 credit)

a. Drug discovery and evaluation: pharmacological Assays, pharmacological screening, high throughput screening, hit and lead molecule, chemical libraries
b. Antimicrobial Bioassays: Bioactive, classification of bioassay *in vitro*/*in vivo* assay, Types of bioassay- Qualitative and Quantitative, Antimicrobial susceptibility tests, diffusion, dilution, bioluminescence, MIC, MBC, LC_{50}, ED_{50}.
c. Laboratory evaluation of new compounds/antibiotics: Animal models for activity testing, toxicity, tolerability, carcinogenicity, and allergy testing

D. Extraction & Analysis methods – Physical and chemical (1 credit)

a. Extraction of Phytochemicals: Maceration, Soxhlet extraction, Steam distillation, Hydrodistillation, Wax extraction
b. Physical Methods, Elemental analysis- Kjeldahl method
c. Chromatographic Techniques- Paper chromatography, column chromatography, Gas chromatography, high performance liquid chromatography, spectral methods- NMR, X-ray spectroscopy.

References

1. Harborne, J. B. (1973) English, Book, *Illustrated edition: Phytochemical methods : a guide to modern techniques of plant analysis*.
2. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). *Methods for dilution antimicrobial susceptibility testing for bacteria that grows aerobically*. Approved Standards M7-A4. Villanova, PA: NCCLS, 1997.
3. National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). *Performance standards for antimicrobial susceptibility testing*; 12th information supplement (M100-S1). Villanova, PA; NCCLS: 2002
4. Silverstein R. M., Bassler G. C., (1968), *Spectrometric Identification of Organic Compounds, 2nd Ed.*
5. Trease & Evans, (2008), *Pharmacognosy 15th Ed, Elsevier Publication (India)*
6. Thomas Eisner, in Insect Biology in the Future, 1980.*Chemistry, Defense, and Survival: Case Studies And Selected Topics*.
7. Yi-Ping Phoebe Chen, Paolo Carloni (2010) *Modern Methods in Natural Products Chemistry*, Comprehensive Natural Products II.
8. Chemical Ecology:The Chemistry of Biotic Interaction (1995); The Chemistry of Defense theory and Practice.
9. Herbivores Their Interactions with Secondary Plant Metabolites, Second Edition, Volume II: Ecological and Evolutionary Processes
10. Martin Luckner (1984). *Secondary metabolism in microorganisms, plants and animals*. Springer.
11. Stevenson P., Nicolson S., Wright G. (2017) *Plant secondary metabolites in nectar: Impacts on pollinators and ecological functions.* Functional Ecology, 31(1), 65-75.
12. James Hanson. *Natural Products: The Secondary Metabolites*. Royal Society of Chemistry.
13. Vogel Text book of Practical Organic Chemistry, fifth edition

BD TNC- 402: Bioinformatics and Phylogenetics

Objective: Students will be able to use bioinformatics tool and perform *in silico* analysis of biological queries. Application of genome sequence has made the understanding of genetic and epigenetic components of different organisms easy. This course intends to bring the interdisciplinary approach of computer science, mathematics and statistics to analyze and interpret biological data.

A. Overview of Bioinformatics (1 credit)

a. Major bioinformatics resources, biological databases
b. Nucleic acid sequence databases: GenBank, RefSeq, EMBL, DDBJ.
c. Protein sequence databases: PIR-PSD, SwissProt, UniProtKB, TrEMBL/GenPept.

B. Introduction to Sequence Alignment (1 credit)

a. Introduction to BLAST and FASTA
b. Pairwise sequence alignment, Global and local sequence alignment- Needleman Wunsch algoritm and Smith Waterman algorithm
c. Molecular Phylogenetics – comparison of sequences, global and local alignments, Pair-wise and Multiple sequence alignments, comparative genomics tools.

C. Tools used in Proteomics & Genomics (1 credit)

a. Tools in proteomics: Isoelectric focusing, PAGE, 2D PAGE, X-ray crystallography, Mass Spectrometry and Maldi-Tof, Protein Microarray
b. Genome/Transcriptome Sequencing: Basic DNA sequencing Classical sequencing Methods, automated DNA sequencing, Next generation sequencing methods
c. Data analysis principles.

D. Constructing Phylogenetic trees (1 credit)

a. Fundamentals of a phylogenetic tree- node, clade, root, paralog, ortholog, homolog
b. Constructing phylogenies and estimating molecular distances
c. Different types of Phylogenetic tress based on distance-based methods (UPGMA & Neighbour joining), parsimony, Maximum likelihood, and Bayesian inference methods.

Reference

1. Warren J. Ewens and Gregory R. *Grant Statistical Methods in Bioinformatics*.
2. Supratim Choudhuri *Bioinformatics for Beginners: Genes, Genomes, Molecular Evolution, Databases and Analytical Tools*
3. Angelika Börsch-Haubold and Bernhard Haubold *Bioinformatics for Evolutionary Biologists: A Problems Approach*.
4. Baxevanis, A.D. & Ouellette, B,F.F.: *Bioinformatics: a practical guide to the analysis of genes and proteins*. 2nd Ed.. 2002. John Wiley & Sons, Inc. Publications, New York.
5. Guigo R. Ed. & Gusfield D. *Algorithms in bioinformatics* by Ed.: Berlin. Springer-Verlag
6. Orengo, C., Jones, D. & Thornton, J.: *Bioinformatics: genes, proteins and computers*.2003. Bios Scientific Publishers, Ltd. Oxford.
7. Supratim Choudhuri (2014). *The Beginning of Bioinformaticsin Bioinformatics for Beginners*.
8. David Mount (2004). *Bioinformatics Sequence and Genome Analysis*. Cold Spring Harbor laboratory Press.
9. Christine Orengo, David Jones, Janet Thornton (2003)*Bioinformatics: Genes, Proteins and Computers* (Advanced Texts) 1st Edition.
10. Jin Xiong (2006) *Essential Bioinformatics*, Cambridge University Press.
11. Arthur Lesk (2008) *Introduction to Bioinformatics*, Oxford University Press.

BD TNC- 403: Socio-economic Aspects of Biodiversity

Objective: Management of bioresources is equally about management of people. Understanding the human angle is perhaps the most importance aspect of conservation. The course aims at giving conceptual understanding of the human factors involved and the economics related to the bioresources.

A. Resource Use patterns **(1 credit)**

a. Interaction between social organization and resource use patterns
b. Diversity, specificity and sustainability in the use of bioresources
c. Tribal, Agrarian, Coastal communities, Indian & Global examples

B. Economics of natural resource use **(1 credit)**

a. Use value analysis, direct and indirect economic values, markup& value chain, value addition, commercialization
b. IPR study of household and community economy, local markets, national and international trade in Biodiversity
c. Environmental economics- externality, Cess, tax, incentives

C. Knowledge systems **(1 credit)**

a. Folk biology, traditional knowledge system, traditional health care system, modern knowledge
b. Important medicinal plants and their uses
c. Survey techniques in ethnobiology

D. Qualitative Research Methods **(1 credit)**

a. Rapid Rural Appraisal (RRA), participant observation, identifying informants and structured interactions (Interviews)
b. Listening, analysis- pairwise ranking, pile sorting, triad testing.
c. Transect walk, history trend line
d. Participatory Rural Appraisal (PRA)

Reference

1. AbhijitDutta *et.al* (2005), Environmental Economics, APH Publishing Corporation, New Delhi
2. Hackett, S. C. (1998). Environmental and Natural Resource Economics. M. E. Sharpe, London
3. Karpagam, M. (1991). Environmental Economics. Sterling Pub., New Delhi 10. Katar Singh & Anil Shishodia(2007) ,Environmental Economics, Sage publications, New Delhi
4. GadgilMadhav and GuhaRamachandra, *This Fissured Land: An Ecological History of India.* Oxford India Perennials Series.
5. G. Socio Economic Review of Districts- Directorate of Economics and Statistics .g. -aMaMaMrahaMhttps://mahades.maharashtra.gov.in/publication.do?pubCatId=DSA
6. H. Mark Q. Sutton and E.N. Anderson. *Introduction to Cultural Ecology*. Rowman& Littlefield Publishers Inc. Second Edition.
7. Jha, A. 2002. *Traditional Knowledge Systems in India*
8. Narayanasamy, N. 2009. P*articipatory Rural Appraisal: Principles, Methods and Application*. SAGE Publications India Pvt Ltd

BD TNC- 404: Environment Management and Restoration

Objective:This course aims to provide application based environment management studies pertaining to policy level developments and introducing upcoming practices like bioremediation and restoration. Understanding this course will aid to design several management and mitigation strategiesto maintain ecological balance and ecosystem stability.

A. Environment Impact Assessment (1 credit)

a. Background need and concept, types of EIA

b. Environment, Biodiversity and Socio-economic aspects of EIA

c. EIA notification in India, categories of Industries/establishments requiring EIA

d. Environment clearance process

B. Environmental Management Systems (1 credit)

a. Concept and scope, standards- National and International

b. Cost benefit analysis, Environmental audit

c. Life cycle Analysis- goals, scope, life cycle inventory

d. Environment management plan (EMP)

C. Environmental mitigation and Management (1 credit)

a. Bioremediation and Phytoremediation- Types of contaminants/pollutants, Fate and Transport of contaminants, Levels of Bioremediation (Biostimulation, bioaugmentation, Bioventing, Biosparging)

b. Potential Use of GMOs in Bioremediation

c. Biodegradation of common contaminants, Degradation of xenobiotics and elimination of toxicants.

D. Environmental awareness through practicing restoration ecology (1 credit)

a. Definition, aims and objectives of restoration, principles, concepts and strategies (long term vs. short term); physical, chemical and biological restoration; role of ecological principles in restoration, holistic approach in restoration.

b. Restoration of natural resources; restoration of biodiversity; degraded land/waste land, range land, forest, river corridor, water resources and mine spoils.

c. The concept of sustainable development, environmental degradation and conservation issues, global change & sustainable issues

Reference

1. Abbasi,S.A. (2001) *Water resources projects and their environmental impacts*. Discovery publishing house, New Delhi.
2. Gangstad, I. (1990). *Natural Resource management of water and land*. Van Norstrand Reinhold, New York.
3. Petak, w.J and Atkisson, A.A. (1982). *Natural Risk Hazard Assessment and Public policy*. Springer- Verlag, New York.
4. M. A. Palmer, J. B. Zedler and D. A. Falk. Editors. 2016. *Foundations of Restoration Ecology*. Second Edition. Island Press. ISBN-13: 978-1610916974 and ISBN ISBN-10: 1610916972 2) A. F. Clewell and J. Aronson. 2013.
5. *Ecological Restoration: Principles, Values, and Structure of an Emerging Profession*. Island Press. ISBN 978-1-610911672 (Hardcover), 978-1-610911689 (Paperback), 978-1-597263238 (Ebook).
6. EIA- EMP manual/. Review/. Case studies book. Paper.
7. Sheldon Christopher, Yoxon Mark (2006). *Environmental Management Systems: A Step-by-Step Guide to Implementation and Maintenance*, Earthscan.
8. Cheremisinoff Nicholas (2006) *Environmental Management Systems Handbook for Refineries*, Gulf Publishing Company.

BD PC-411: Bioactivity of Secondary Metabolites and Bioinformatics

A. Extraction of Secondary Metabolites from Natural Sources (1 credit)

a. Single step and Multi step Extractions; Hot and Cold Extractions.
b. Hydrodistillation method for extracting Essential oil

B. Screening and Isolation of Secondary Metabolites from a Natural Source (1 credit)

a. Phytochemical analysis to detect the presence of flavonoids, alkaloids, tannins etc.
b. Separation techniques of metabolites (PC, TLC HPLC, CC, GC etc.)
c. Antimicrobial Assay

C. Database search (1 credit)

a. Explore the NCBI resource and to query GenBank, RefSeq, UniProtKB protein sequence databases using the various search strategies.
b. Perform pair-wise, multiple sequence alignments

D. Phylogenetic tree construction (1 credit)

a. To construct phylogenetic trees using MEGA/PHYLIP
b. Construction of Dendograms, rooted and unrooted trees, interpreting phylogenetic relationships.