Tribhuvan University

Institute of Science and Technology

Central Department of Botany

Kirtipur, Kathmandu

MSc Biodiversity and Environmental Management Curriculum

Third and Fourth Semester

2074 (2017)

M.Sc. in Biodiversity and Environmental Management

COURSE STRUCTURE (2074)

SEMESTER III: Theory + Practical

Credit: 14; Full marks: 350

Course No		**Title**	**Credit**	**FM**
Paper XI	BEM 601	Agro-ecology (theory)	2	50
	BEM 602	Agro-ecology (practical)	1	25
Paper XII	BEM 603	Environmental Biotechnology (theory)	2	50
	BEM 604	Environmental Biotechnology (practical)	1	25
Paper XIII	BEM 605	Environmental Assessment and Monitoring (theory)	2	50
	BEM 606	Environmental Assessment and Monitoring (practical)	1	25
Paper XIV	BEM 607	Microbes and Soil Health (theory)	2	50
	BEM 608	Microbes and Soil Health (practical)	1	25
Paper XV	BEM 609	Research Design and Dissertation Planning (theory + proposal writing and presentation)	2	50
Total			**14**	**350**

SEMESTER 4: Theory + Practical + Dissertation

Credits: 12 credits; Full marks: 300

Course No		**Title**	**Credit**	**FM**
Paper XVI	BEM 651	Methods of biological data analysis (theory)	2	50
	BEM 652	Methods of biological data analysis (practical)	2	50
Paper XVII	BEM 653	Dissertation	8	200
Total			**12**	**300**

Paper XI. Agroecology

Course title: Agroecology	**Total credit:** 2
Course No: BEM 601	**Full marks**: 50
Nature of the course: Theory	**Pass marks**: 25
Level: M.Sc. BEM, III semester	**Credit hours**: 3

OBJECTIVES

The general objective of the course is to impart knowledge on ecological principles in agricultural systems and practices. The specific objectives are to:

- Provide agroecological concepts and principles
- Give the students basic understanding of design, management and assessment of sustainable farming system and food chains
- Aware them about the management of agro-ecosystems to enhance productivity and preserve natural resources.

COURSE CONTENTS

***Unit 1. Introduction*:** (i) Agroecology as a science, a movement and a practice; spread of agriculture and agricultural crops; (ii) The agroecosystem concept; (iii) Agroecology and ecoagriculture; (iv) Agroforestry **5 h** (1+2+1+1)

Unit 2. Plants and environmental factors: (i) Plants: species diversity in agro-ecosystems; (ii) Climatic factors: light, temperature, humidity and rainfall, wind, soil (soil types, nutrients, soil organisms, soil erosion), fire; (iii) Biotic factors: food web, competition, mutualism; (iv) Fertilizers: manures and chemical fertilizers, pesticides/insecticides; (v) Agroecological zones of Nepal. **10 h** (1+4+2+2+1)

Unit 3. System level interactions: (i) The energetics of agroecosystem: flow of energy and materials through agroecosystems; (ii) Species interactions in crop communities: weeds, allelopathy, parasitic plants; (iii) Agroecosystem diversity and stability: cropping patterns, intercropping, cover cropping, conservation agriculture; (iv) Disturbance, succession and ecosystem services associated with agro-ecosystems; (v) Agrobiodiversity: genetic resources in agro-ecosystems (land races, wild relatives, exotic varieties, invasive species, seed banking, animals in agroecosystems, culture and agroecosystems. **12 h** (1+1+3+2+5)

Unit 4. Sustainability of agroecosystems: (i) Governance of agroecosystems: stakeholders, policies; (ii) Management: weed management, pest management, pathogen management; (iii) Global change: population growth, agricultural production, climate change, GM crops, agroecology and food sovereignty. **5 h** (1+2+2)

Course title: Agroecology	**Total credit:** 1
Course No: BEM 602	**Full marks**: 25
Nature of the course: Practical	**Pass marks**: 12.5
Level: M.Sc. BEM, III semester	**Lecture hours**: 16×4

COURSE CONTENTS

1. To estimate soil moisture content at different agricultural systems.
2. To estimate soil pH at different agricultural systems.
3. To estimate soil organic matter content at different agricultural systems.
4. To study soil nutrient contents (N, P, K) at different agricultural systems.
5. To study plant species diversity/crop diversity in different agricultural systems.
6. Seed viability test
7. To study faunal species diversity at different agricultural systems.
8. To study management practices at different agricultural systems and prepare group and/or individual reports.
9. Weed seed bank
10. Case studies/field reports (pollinators)/ seminars

TEXT AND REFERENCE BOOKS

Altieri, M.A. 1987. Agroecology. The Scientific Basis of Alternative Agriculture. Division of Biological Control. University of California

Gliessman, S. R. 2007. Agroecology: Ecological Processes in Sustainable Agriculture. 2nd. Ed. An Arbor Press, Chelsea, MI

Jarvis,D.I.,C. Padoch, and H. D. Cooper.2010. Managing Biodiversity in Agricultural Ecosystems.Columbia University press

Konrad M. and Sauerborn J. 2013. *Agroecology*. Springer, NY, USA.

Odum E.P. and Barrett G.W. 2005. *Fundamentals of Ecology*. Thompsom Books/Cole.

Powers, L.E., and R. McSorley. 2000. Ecological principles of agriculture. Delmar Thomson Learning, Albany, NY.

Singh J.S, Singh S.P. and Gupta S.R. 2006. Anamya Publishers. New Delhi

Tivy, J. 1990. Agricultural Ecology. Longman Group. Ltd. Essex UK.

Zobel et al. 1987. Practical Manual of Ecology. Ratna Paustak Bhandar, Kathmandu.

Paper XII. Environmental Biotechnology

Course title: Environmental Biotechnology	**Total credit:** 2
Course No: BEM 603	**Full marks**: 50
Nature of the course: Theory	**Pass marks**: 25
Level: M.Sc. BEM, III semester	**Lecture hours**: 32

OBJECTIVES

The general objective of the course is to give knowledge on the use of biological organisms and their products to address the environmental problems. The specific objectives are:

- To discuss various types of environmental problems;
- To explore the use of biological organisms and their products to improve the degraded environments and ecosystems;
- To understand the use of modern biotechnological tools for solving emerging environmental problems.

COURSE CONTENTS

Unit 1. Introduction: (i) Historical account of environmental management; (ii) Biotechnology and environmental management. **2 h** (1+1)

Unit 2. Environmental bio-monitoring: (i) Bio-monitoring of air pollution; (ii) Air pollution tolerant plant species (including air pollution tolerance index); (iii) Bio-monitoring of water quality (Bio-technological tools for water quality). **4 h** (1+1+2)

Unit 3. Biotechnology for waste management: (i) Solid waste management: composting (vermi-composting); (ii) Sewage and waste water treatment: general process of waste water treatment, biological (secondary) treatments; (iv) Biodegradation of specific wastes (biodegradable plastics); (v) Bioconversion of waste. **10 h** (2+3+3+2)

Unit 4. Bioremediation: (i) *Ex-situ* and *in-situ* bioremediation; ii) Microorganisms involved in bioremediation (aerobic microbes, anaerobic microbes, lignolytic fungi); iii) Factors affecting bioremediation (bacterial chemotaxis, biofilm, biosurfactants, abiotic factors); iv) Bioremediation of contaminated soil and oil spill. **7 h** (1+3+1+2)

Unit 6. Biotechnology and biodiversity conservation: (i) *Ex situ* conservation (Botanical garden, seed bank management, DNA banking, cryopreservation; (ii) Tissue culture of threatened species; (iii) DNA bar coding for identification of threatened species in trade; (iv) GMO's. **7 h** (4+1+1+1)

Unit 7. Environmental biotechnology in Nepal: status and prospects of environmental biotechnology in Nepal (with case studies). **2 h**

Course title: Environmental Biotechnology	**Total credit:** 1
Course No: BEM 604	**Full marks**: 25
Nature of the course: Practical	**Pass marks**: 12.5
Level: M.Sc. BEM, III semester	**Lecture hours**: 16×4

COURSE CONTENTS

Any 4 of the following:

- Seed banks/Gene banks for biodiversity conservation
- Composting of municipal solid waste
- Vermicomposting as a tool for solid waste management
- Use of biopesticides and green manure in agro-ecosystems
- Biological control of invasive species in Nepal
- Biochemical oxygen demand (BOD) of surface water
- Application of plant species in waste water treatment
- Identification of pollution tolerant plant species
- Propagation of some woody plants by *ex vivo* rooting
- Management of degradable and non-degradable waste

TEXT AND REFERENCE BOOKS

Chatterji AK. 2011. *Introduction to Environmental Biotechnology*. 3rd edition. PHI Learning Pvt. Ltd. New Delhi, India.

Dubey, R.C. 2014. Advanced Biotechnology. First Edition. S.Chand and Company Pvt. Ltd., Ramnagar, New-Delhi.

Evans G.M. and Furlong J.C. 2011. *Environmental Biotechnology: Theory and Application*. John-Wiley and Sons Ltd.

Nicholas P. and Cheremisinoff. 1996. Biotechnology for Waste and Waste Water Treatment. Noyes Publications, USA.

Vallero DA. 2010. *Environmental Biotechnology: A Biosystems Approach*. Academic Press, UK.

Paper XIII. Environmental Assessment and Monitoring

Course title: Environmental Assessment and Monitoring	**Total credit:** 2
Course No: BEM 605	**Full marks**: 50
Nature of the course: Theory	**Pass marks**: 25
Level: M.Sc. BEM, III semester	**Lecture hours**: 32

OBJECTIVES

The general aim of this course is to provide training/understanding in environmental impact assessment and EIA report preparation.

COURSE CONTENTS

Unit 1. Environmental assessment (EA): (i) Introduction: History, types, benefits and cost of EIA, misconception about EIA, values and principles, EIA process, EA and the project cycle, EA in Nepal; (ii) environmental justice; (iii) Regulatory context: non-legally binding instrument, legally binding instrument; Nepalese context: policies and strategies, legal provisions, EIA guidelines and manuals, environmental standards; (iv) Environmental screening, scoping and ToR: Environmental Screening, choice of environmental assessment, Environmental Scoping, Terms of Reference (ToR), report format. **9 h** (2+1+3+3)

Unit 2. Baseline Information*:* (i) Data acquisition: major environmental parameters, data source, methods of data collection (general methods, resource based methods, survey methods), data processing (physical, biological, socio-economic); (ii) Alternative analyses: types, legal provision, comparison of alternatives **5 h** (3+2)

Unit 3. (i) Identification, prediction, evaluation of impacts: categorization of impacts; impact identification methods; impact prediction methods, impact evaluation; (ii) Environmental protection methods: selection of methods, benefit augmentation measures, adverse impact mitigation measures, implementation of EPMs **6 h** (3+3)

Unit 4. (i) Environmental monitoring: types (baseline, compliance, impact, surveillance); Monitoring methods: monitoring methods, monitoring locations, schedules/timing, monitoring responsibility; (ii) Environmental auditing: types, methods and approaches, auditing parameters, auditing responsibility **6 h** (3+3)

Unit 5. (i) Preparing EIA report: Terms of reference; IEE; EIA; (ii) Report review: weights assigned for scoping, grading approach for ToR, weights assigned for IEE, EIA reports; (iii) Public participation in EIA **6 h** (2+3+1)

Course title: Environmental Assessment and Monitoring	**Total credit:** 1
Course No: BEM 606	**Full marks**: 25
Nature of the course: Practical	**Pass marks**: 12.5
Level: M.Sc. BEM, III semester	**Lecture hours**: 16×4

COURSE CONTENTS

1. To review TORs of EIA.
2. To review scoping documents of EIA study.
3. To review EIA reports and present its contents.
4. To visit a project site to determine major environmental parameters for an EIA.
5. Term paper/Bibliographic review of the topics provided in the class/case study

TEXT AND REFERENCE BOOKS

Glasson J, Therivel R and Chadwick A. 2005. *Introduction to Environmental Impact Assessment*. Routledge-Taylor & Francis Group, NY.

Wathern P. 1990. *Environmental Impact Assessment: Theory and Practice*. Routledge-Taylor & Francis Group, NY.

Singh JS, Singh SP and Gupta SR. 2006. *Ecology, Environment and Resource Conservation*. Anamaya Publishers, New Delhi.

Uprety BK. 2003. *Environmental Impact Assessment: Process and Practice*. Mrs. Uttara Uprety, Koteshowr, Kathmandu

Paper XIV. Microbes and Soil Health

Course title: Microbes and Soil Health	**Total credit:** 2
Course No: BEM 607	**Full marks**: 50
Nature of the course: Theory	**Pass marks**: 25
Level: M.Sc. BEM, III semester	**Lecture hours**: 32

Objectives: The general aim of this course is to provide theoretical and practical knowledge on microbes and soil health. The specific objectives are:

- To elaborate knowledge on soil and microbes
- To impart knowledge on their significance in plant growth, development and interaction

COURSE CONTENTS

Unit I. Microbial Diversity: (i) Overview; Bacterial and fungal functional diversity: Phototrophic bacteria; Chemolithotrophic bacteria; Spirochetes; Rickettsias; Chlamydias; Mycoplasmas; Myxobacteria and Extremophiles thermophilic, halophilic, acidophilic and alkalophilic bacteria; mycorrhizae and other fungi; Soil microfauna **4 h**

Unit II. Microbes and Environment: (i) Population interactions (microbe-microbe interactions, plant-microbe interactions, animal-microbe interactions); (ii) microbial consortia; bacterial biofilms- formation and applications; (iii) microbes and material cycling; (iv) Fungi as environmental indicators; (v) Mycoremediation: fungal bioremediation, biological treatment of wastes and pollutants: solid wastes disposal, biodegradation of environmental pollutants: bioremediation of heavy metals; bioleaching and recovery of metals. **10 h** (2+2+1+1+3)

Unit III. Microbes in Agriculture: (i) Biological nitrogen fixation, nitrogenase and alternative nitrogenase system, nif genes; (ii) degradation of cellulose, hemicellulose and lignin, production of biofertilizers (mass production of *Rhizobium*, *Azotobacter*, BGA); (iii) Microbial control of insects; (iv) Use of viruses in agriculture. **6 h** (2+2+1+1)

Unit IV. Soil health: (i) Introduction: soil formation; soil structure, soil health concepts; (ii) hyperparasitism and its significance; (iii) characteristics of a healthy soil; common soil constraints; microbes and soil nutrient availability; organic manure's and inorganic fertilizers; (iv) Soil Health Assessment, Soil Health Indicator Protocols and Scoring Functions: test-Potentially Mineralizable Nitrogen, Root Pathogen Pressure, Salinity and Sodicity.

12 h (2+2+3+5)

Course title: Microbes and Soil Health	**Total credit:** 1
Course No: BEM 608	**Full marks**: 25
Nature of the course: Practical	**Pass marks**: 12.5
Level: M.Sc. BEM, III semester	**Lecture hours**: 16×4

COURSE CONTENTS

1. To isolate bacterial species from root nodule and soil.
2. To isolate and identify non-pathogenic fungi.
3. To study the effect of antibacterial agents on bacterial growth by Kirby Bauer's method.
4. To study soil microfauna
5. Compost preparation by conventional method, using EMO and by vermicomposting.
6. To study the Standard Nutrient Analysis of soil.
7. Soil Health Assessment
8. Microbial ecology in relation to the plants-Introduction to field and lab techniques to study plant-microbe interactions and isolation and maintenance of pure cultures using common microbiological media.

Reference Books

Atlas, M. and Bartha, R. (2000). *Microbial Ecology*. Longmann, New York.
Black, J. G. (1999). *Microbiology –Principles and Explorations*. Prentice Hall, London.
Harbhajan Singh. (2006). *Mycoremediation: Fungal Bioremediation*. Wiley, 608 pp.
Hanson, James. (2008). *The Chemistry of Fungi*. Royal Society of Chemistry, 221 pp.
Lacey, A. J. 1989. Light microscopy in biology a practical approach, IRL Press, Oxford University, UK.

Paper XV. Research Design and Dissertation Planning

Course title: Research Design and Dissertation Planning	**Total credit:** 2
Course No: BEM 609	**Full marks**: 50
Nature of the course: Lecture and seminar presentation	**Pass marks**: 25
Level: M.Sc. BEM, III semester	**Lecture hours**: 32

OBJECTIVES

The aim of this course is to provide fundamental understanding on research design and training in essential scientific communication skills such as dissertation proposal writing and giving oral presentations.

COURSE CONTENTS

Unit 1: Research design and hypothesis testing: (i) Research design: introduction, types of research design; (ii) Populations, samples and observations; types of variables – scale and measurement; (iii) Designing experiments: types of experiments, replication, controls, randomization, independence; (iv) Hypothesis testing: biological and statistical hypotheses, deductive and inductive reasoning, the hypothetico-deductive method; (v) Research ethics, risk and safety measures. **8 h** (1+2+2+2+1)

Unit 2: Scientific writingand communication: (i) Writing research proposal, report, paper: general processes and approaches; (ii) Literature review: introduction to web-based scientific literature, journals, periodicals and other sources; basic approaches of literature review; (iii) Poster preparation: basic instructions; methods of effective oral presentation/talks.

8 h (3+3+2)

Unit 3: Term paper and seminar: Guided work and assignments in literature research in the area of interest and proposal writing for original research project (M.Sc. thesis to be conducted in 4th semester), seminar presentation. **16 h**

TEXT AND REFERENCE BOOKS

Fowler J., Cohen L. and Jarvis P. 1998. *Practical Statistics for Field Biology*. John Wiley and Sons.

Gotelli N.J. and Ellison A.M. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.

Jha P.K., Shakya D.D., Joshi S.D., Chaudhary R.P. and Sakya S.R. 2004. *Research Methods and Practice*. Buddha Academic Publishers and Distributers Pvt. Ltd., Kathmandu, Nepal.

Kothari C.R. 1993. *Research Methodology*. Wiley Eastern Ltd., New Delhi, India.

MuazJ.M. 2013. *Practical Guidelines for Conducting Research. Summarising Good Research Practice in Line with the DCED Standard*. http://www.enterprise-development.org/page/download?id=2133

Stuart C. 2005. *Speak for Yourself: How to Give Persuasive Presentations and Entertaining Talks - with Confidence*. Piatkus, London.

Paper XVI. Methods of biological data analysis

Course title: Methods of biological data analysis	**Total credit:** 2
Course No: BEM 651	**Full marks**: 50
Nature of the course: Theory	**Pass marks**: 25
Level: M.Sc. BEM, IV semester	**Lecture hours**: 32

OBJECTIVES

The overall aim of this course is to give students basic training in methods of biological data analysis. The specific objectives are:

- To develop computational and analytical understanding necessary for processing and analyzing biological data;
- To develop skills in original research.

COURSE CONTENTS

Unit 2. Biological data analysis – an introduction: (i) Managing and curating data; (ii) Descriptive analysis: introduction, measures of central tendency, frequency tables and histograms, stem and leaf plots, measures of dispersion, box-plots and outliers; (iii) Inferential statistical analysis: hypothesis testing and inferential statistics, sampling and inferential statistics, parametric and non-parametric statistics,testing basic assumptions of parametric tests, data transformation methods. **7 h** (2+2+3)

Unit 3. Basic analysis: (i) Tests for nominal variables: Chi square test; (ii) Tests for one measurement variable: parametric methods (Student's t-test, paired t-test, analysis of variance), non-parametric methods; (iii) Tests for multiple measurement variables: correlation and regression analysis (GLM, logistic, multiple regression). **12 h** (2+6+4)

Unit 4. Multivariate analysis: (i) Introduction, aims of multivariate analysis, nature of multivariate data, concept of similarity, distance measures, multivariate normality; (ii) Ordination and gradient analysis: introduction and concepts, data matrix, constrained and unconstrained analyses, main techniques (DCA, PCA, CA, CCA, RDA, NMDS); (iii) Classification: Hierarchical and *K*-means clustering, discriminant analysis. **13 h** (2+8+3)

Course title: Methods of biological data analysis	**Total credit:** 2
Course No: BEM 652	**Full marks**: 50
Nature of the course: Practical	**Pass marks**: 25
Level: M.Sc. BEM, IV semester	**Lecture hours**: 16×4

COURSE CONTENTS

1. ***Basics***

   1.1 Application of spreadsheets in managing, manipulating and analyzing raw data, displaying results in graphs and tables (2 practical)

   1.2 Checking the data for outliers, errors and missing data (1 practical)

   1.3 Computer software for univariate and multivariate data analysis (2 practical)

2. ***Statistical Methods and Data Analysis I***

   2.1 Descriptive statistics, testing basic assumptions of parametric tests, data transformation methods (2 practical)

   2.2 Student's t-test, paired t-test and analysis of variance (5 practicals)

   2.3 Non-parametric methods (2 practical)

   2.4 Correlation and regression analysis (5 practicals)

   2.5 Categorical data: chi-squared test (1 practical)

3. ***Statistical Methods and Data Analysis II: Multivariate Analysis***

   3.1 *Ordination*: obtaining eigenvalue and length of gradient, explorative analysis (DCA), unconstrained analysis (PCA, CA), constrained analysis (CCA, RDA), NMDS (6 practicals)

   3.2 Defining groups with multivariate data: cluster analysis (2 practicals)

   3.3 Comparing groups: discriminant analysis (2 practical)

TEXT AND REFERENCE BOOKS

Fowler J., Cohen L. and Jarvis P. 1998. *Practical Statistics for Field Biology*. John Wiley and Sons.

Lepš J. and Šmilauer P. 1999. *Multivariate Analysis of Ecological Data*. Faculty of Biological Sciences, University of South Bohemia, Ceské Budejovice

Sokal R.R. and Rohlf F.J. 1995. *Biometry*, 3rd edition. W.H. Freeman & Company, NY, USA.

SUGGESTED FURTHER READINGS

Crawley M.J. 2007. *The R Book*. John Wiley & Sons Ltd, England, UK.

Crawley M.J. 2012. *Statistical Computing: An Introduction to Data Analysis Using R*.

Gauch H.G. 1982. *Multivariate Analysis in Community Ecology*. Cambridge University Press, Cambridge, UK.

Gotelli N.J. and Ellison A.M. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.

Legendre P. and Gallagher E.D. 2001. Ecologically meaningful transformations for ordination of species data. *Oecologia*, 129: 271–280.

Legendre P. and Legendre L. 2012. *Numerical Ecology*. 3rd English edition. Elsevier Science BV, Amsterdam.

McCullagh P. and Nelder J.A. 1989.*Generalised Linear Models*. Second Edition. Chapman and Hall, London.

McCune B. and Grace J.B. 2002. *Analysis of Ecological Communities*. MjM Software Design, Oregon, USA.

Quinn P.G. and Keough J.M. 2002. *Experimental Design and Data Analysis for Biologists*. The press Syndicate of the University of Cambridge, Cambridge, UK.

Silbershatz A., Korth H., Sudarshan S. 2005. *Database Systems Concepts*, 5th ed., McGraw-Hill.

Venables W.N., Smith D.M. and the R Development Core Team. 1999–2006. *An Introduction to R*. R Development Core Team.

Paper XVI. Dissertation

Course title: Dissertation	**Full marks:** 200
Course No.: BEM 653	**Pass marks:** 100
Nature of course: Dissertation	**Credits:** 8
Level: MSc, BEM IV Semester	**Credit hours:** 120

Objectives

This course has following objectives:

- Enable students to design the experiment, collect primary data, analyze data using appropriate statistical method, and prepare a scientific research report
- Enable students to formulate hypothesis/research questions and test/answer them using primary data.
- Develop skill to present research finding in scientific meeting.

Evaluation

Evaluation will be made based on (i) two mid-term progress reports submitted during the six months period, and (ii) final report and *viva voce*.