Department of Environmental Studies
North-Eastern Hill University, Shillong- 793022

SYLLABUS

M. Sc. Environmental Science (Two Years Course)
Under Choice Based Credit System

1. The total duration of the M. Sc. Course in Environmental Science shall of four Semesters of total 72 credits.
2. Candidates having a graduate degree with major in any of the following subjects: Environmental Science/ Botany/ Zoology/ Forestry and Geology shall be eligible to take admission.
3. The total number of seats will be 25.
4. Course shall comprise of Core papers of 60 credits and Open papers of 12 credits.
5. In order to complete M. Sc. Environmental Science students have to earn 60 credits from Environmental Science core papers and remaining 12 credits from open choice courses offered by the department or other departments of the University.
6. The open courses offered by the Department shall be notified well in time.

Semester I

Code	Course	Credit
ENV-C101	Environment, Ecology and Ecosystem Dynamics	4
ENV-C102	Forestry and Water Resources	4
ENV-C103	Environmental Pollution	4
ENV-C104	Practical	6

Semester II

ENV-C201	Environmental Microbiology, Biotechnology and Toxicology	4
ENV-C202	Environmental Impact Assessment and Environmental Policies	4
ENV-C203	Practical	4
ENV-O204	*Remote Sensing and Geographical Information System* or	4
ENV-O205	*Environmental Law*	2
ENV-O206	*Radiation Biology*	2
ENV-O207	*Natural Resource Management*	2

Semester III

ENV-C301	Environmental Geoscience and Energy	4
ENV-C302	Research Methods, Techniques and Statistical Analysis	4
ENV-C303	Practical	4
ENV-O304	*Disaster Management*	4
ENV-O305	*Environmental Issues and Problems of North East India*	2

Semester IV

ENV-C401	Environmental Economics and Sociology	4
ENV-C402	Forest Management and Biodiversity Conservation	4
ENV-C403	Practical	4
ENV-C404	Project Work and Field work/ Study Tour	6

Credits of Core Papers- 60 + Credits of Open Choice Papers- 12 = **TOTAL CREDITS** **72**

ENVC- Core Paper ***ENVO- Open Choice Paper***

SEMESTER I

ENV-C-101 Environment, Ecology and Ecosystem Dynamics Credits- 4

Unit I: Concept of environment, scope of Environmental Science, environmental components, scope and subdivisions of ecology, ecological principles pertaining to population, community, ecosystem and biome.

Unit II: Population dynamics and population regulations, concept of carrying capacity, population fluctuations, population dispersion, r and k selection, ecotypes and ecophene, habitats and niches.

Unit III: Energy in ecosystem, Primary and secondary production, Biomass, Methods of measuring productivity, Pattern of primary production in the major ecosystems of the world, Energy flow in ecosystems, Feedback and control mechanism, Pathways of energy transfer- grazing and detritus food chain, Ecological efficiency and ecological pyramids.

Unit IV: Biogeochemical cycles: nutrient cycling in the ecosystems, Gaseous cycles (Carbon and Nitrogen) and sedimentary cycles (Phosphorus and Sulphur), Impact of man on nutrient cycles; Major ecosystems of the world: A general idea of forest, grassland, desert, wetland, freshwater and marine ecosystems.

Suggested Readings:

1. Botkin, Daniel B. (2011) *Environmental Science: Earth as a Living Planet*, John Wiley and Sons, New Delhi.
2. Miller, G. Tyler and Scott Spoolman (2011) *Essentials of Ecology*, Brooks/Cole Learning, USA.
3. Odum, E. P. (1996) *Fundamentals of Ecology*, Nataraj Publisher, Dehra Dun.
4. Dakshini , K.M.M. (1999) *Principle and Practices in Plant Ecology*, CRC, Boston.
5. Dash, M.C. (1994) *Fundamentals of Ecology*, Tata McGraw Hill, New Delhi.
6. Molles Jr, M. C. (1999) *Ecology- Concepts and Application*, McGraw Hill, New Delhi.
7. Ingegnoli, V. (2002) *Landscape Ecology: a widening foundation*, Springer, Bonn.
8. Kormondi, E.J. (1999) Concepts *of Ecology*, Prentice Hall of India, New Delhi.
9. Chapman, J. L. and Reiss M.J. (2005) *Ecology Principles and Applications*, Cambridge University Press, London.
10. Odum , E.P. and G. W. Barrett (2005) *Fundamentals of Ecology*, Thomson Asia Pvt. Ltd., Singapore.
11. Rana, S.V.S. (2005) *Essentials of Ecology and Environmental Science*, Prentice Hall of India, New Delhi.
12. Chapin, III**,** F. Stuart**,** Matson**,** Pamela A., Vitousek, (2012) *Principles of Terrestrial Ecosystem Ecology*, Springer
13. Reddy, Anji, M. (2005) *Textbook of Environmental Science and Technology*, BSP Books Pvt. Ltd., Hyderabad.
14. Anjaneyulu, Y (2009*) Introduction to Environmental Science*, BSP Books Pvt. Ltd., Hyderabad.

ENV-C-102 Forestry and Water Resources Credits- 4

Unit I: Forest: definition, growth stages, crown differentiation, forest types of India, measurement of height and girth of trees, form factor, estimation of volume of logs, Role of plantation forestry in environmental conservation.

Unit II: Social Forestry: Origin, definitions, objectives, scope, place of social forestry in National Forest Policies., Multipurpose tree species (MPTs), Nitrogen fixing tree species (NFTs), characteristics of MPTs, NFTs. Community participation in social forestry programme, Pattern of planting, calculation of number of plants (line, square, triangular and quincunx), Ecorestoration of eroded hill slopes and degraded *Jhum* land. Tree species suitable for different edaphic conditions

Unit III: Agroforestry: Origin and definition, type, gains of agro forestry system, Tree and crop management, Production potential of alley cropping, Agroforestry models developed for hill farming system- Three tier system, Tree-greenhedge-crop Farming system and Contour- Tree-Greenhedge-Crop Farming system, Acidic, Saline and alkaline soils and their reclamation techniques.

Unit IV: Water resources: Hydrologic cycle, distribution and extent, water availability and uses, freshwater shortages, impact of climate change on freshwater resources, Management and conservation of water resources, Role of forestry in watershed management.

Suggested Readings:

1. Khanna, L.S. (1985) *Forest Mensuration*, Intl. Book Distributors, Dehradun.
2. Agrawal,P.(2008) *Forest Mensuration*, Bishen Singh Mahendrapal Singh,Dehradun
3. Ghosh, S.K. and Singh, R. (2003) *Social Forestry and Forest Management*, Global vision publication, Delhi.
4. Dwivedi, A.P. (2003) *A Text Book of Silviculture*, Intl. Book Distributors, Dehradun.
5. Jha, L.K. and Sen Sarma, P.K. (2008) *Forestry for the people*, APH publishing corporation, New Delhi
6. Jha, L.K. and Sen Sarma, P.K. (2008) *Agroforestry: Indian Perspectives*, APH publishing corporation, New Delhi.
7. Jha, L.K. (2009) *Advances in Agroforestry*, APH Publication Corporation, New Delhi
8. Jha, L.K. (1995) *Shifting Cultivation*, APH Publishing Corporation, New Delhi.
9. Majumdar, D.N. (1994) *Shifting cultivation in North East India*, Om Sons Publications, New Delhi
10. Singh, G., Arora, Y.K. Narain, P. and Grewal, S.S. (1990) *Agroforestry Research in India and Other Countries*, Surya Publication, Dehra Dun.
11. Biswas A. K. (2007) *Water resources: Environmental Planning, Management, and Development*, McGraw-Hill, New Delhi.
12. Fai Fung, C. and Ana Lopez, Mark *eds* (2011) *Modelling the Impact of Climate Change on Water Resources***,** Wiley Blackwell,
13. Kenneth D. Frederick (1997) *Water Resources and Climate Change*, Edward Elgar,
14. Chatterjee, S.N. (2008) *Water Resources, Conservation And Management*, Atlantic Publishers & Dist,
15. David Keith Todd, Larry W. Mays (2004) *Groundwater Hydrology*, John Willey and Sons, New York.
16. Vedula, S., P. P. Majumdar (2007) *Water Resources Systems modeling techniques and analysis* ,
17. Elizabeth M Shaw, Keith J Beven, Nick A Chappel, Rob Lamb (1994) *Hydrology in Practice*, John Willey and Sons, New York.

ENV-C-103 Environmental Pollution Credits - 4

Unit I: Types and sources of air, water and soil pollution, monitoring of air and water pollution, noise pollution, impact of pollution on human health, environment and assets; Water Pollution control technologies: Waste water treatment, primary treatment, secondary treatment and Advance treatment.

Unit II: Air pollution control technologies and devices: Limestone injection and fluidized bed combustion, Desulfurization; Catalytic converter and control of vehicular emission, Gravity settling chamber, Centrifugal collectors- cyclone collector and dynamic precipitators; Electrostatic precipitators; Fabric filters.

Unit III: Solid, Toxic, and Hazardous waste management; solid waste disposal methods – open dumps, ocean dumping, Landfills, Incineration; Recycling and reuse, Organic pollutants; pesticides-organochlorine insecticides, organophosphates and carbamates; fertilizers, Hazardous waste disposal and management corporate social Responsibility.

Unit IV: Electronic waste (E-waste): Sources and types, constituents of E-wastes, recycling of e-waste and its environmental consequences, Transboundary movement and management of e-wastes, Basel convention, Radioactive wastes: Types, hazards, storage and management.

Suggested Reading:

1. Botkin, Daniel B. (2011) *Environmental Science: Earth as a Living Planet*, John Wiley and Sons, New Delhi.
2. Cunningham, W.P. and W.B. Saigo (2005) *Environmental Science*, McGraw Hill, New York.
3. Bell, J.N.B. (2002) *Air Pollution and Plant Life*, (II ed.), John Wiley and Sons, New Delhi.
4. Cheremisinoff, N.P (1996) *Biotechnology for Waste and Wastewater Treatment,* William Andrew Publishing, New York.
5. Fellenberg, G. (1999) *Chemistry of Pollution,* John Wiley and Sons, New Delhi.
6. El-Halwagi, M.M. (1997) Pollution *Prevention through Process Integration*, Academic Press, Washington.
7. Tirvedi, R. K. and Geol, P. K. (*2010*) *An Introduction to Air Pollution, (II Ed),* DVS Publication, New Delhi.
8. Kush, S. (2001) *Automobile Pollution*, Sarup Publications, New Delhi.
9. Finlayson-Pitts, (1986) *Atmospheric Chemistry: Fundamentals and Experimental Techniques*, John Wiley and Sons, New Delhi.
10. Arya, S.P. (1999) *Air Pollution Meteorology and Dispersion,* Oxford University Press, London.
11. Reddy, P. Jayarama (2011) *Pollution and Global Warming*, BSP Books Pvt. Ltd, Hyderabad.
12. De, A. K. (2000) *Environmental Chemistry* New Age International P. Ltd., New Delhi.
13. Rao, M. N. and Sultana, R. (2011) *Solid and Hazardous Waste Management*, BPS Books Pvt. Ltd, Hysrabad.
14. Santra, S. C. (2001) Environmental *Science*, New Central Book Agencies, Pvt., Ltd. Kolkata
15. Abbasi, S. A. and E., Ramasami (1999) *Biotechnological Methods of Pollution Control*, University Press, Hyderabad.
16. Reddy, Jayarama P. (2011) *Municipal Solid Waste management: Processing, Energy Recovery Global Examples*, BSP Books Pvt. Ltd, Hyderabad.

ENV-C- 104	**Practical**	**Credits- 6**

Part-A

1. Study of community structure in terrestrial ecosystem by frequency, density, abundance and IVI.
2. Study of species composition in terrestrial and aquatic ecosystems.
3. Measurement of primary productivity of a grassland and pond ecosystems.
4. Estimation of moisture, pH and conductivity of soils under different land uses.
5. Inventorization of multipurpose trees (MPTs).
6. Inventorization of Nitrogen fixing trees (NFTs).

7. Comparative study of NPK content of soils under different land uses.

Part-B

8. Estimation of temperature, pH, conductivity and turbidity of water samples.
9. Determination of SPM in Ambient air by Respirable dust sampler.
10. Estimation of dissolved oxygen (DO) and biochemical oxygen demand (BOD) of water samples.
11. Estimation of chloride, nitrate, sulphate and phosphate in water samples.
12. Measurement of noise pollution.
13. Study of composition of municipal solid waste.

Suggested Reading:

1. Misra, R. (1968) *Ecology Workbook*, Oxford &IBH Publications Co., New Delhi.
2. American Public Health Association (2003) *Standard Methods for Examination of Water and Wastewater*, APHA, AWWA, WPCF (21st ed.), American Public Health Association Inc., Springfield, New York.
3. Maiti, S.K. (2003) *Hand Book of Methods in Environmental Studies*, Vol. I & II, ABD Publishers, Jaipur.

SEMESTER II

ENV-C-201 Environmental Microbiology, Biotechnology and Toxicology Credits - 4

Unit I: Scope and importance of microorganisms; Microorganism in different environments- soil, water, air and extreme environments, Reproduction and growth, methods for determining bacterial numbers, Role of microorganisms in waste treatment, Anaerobic (methanogenesis) and aerobic (trickling filter, activated sludge, oxidation pond) treatment of wastewater, production of enzymes and alcohol.

Unit II: Basic techniques in genetic engineering: Nucleic acid hybridization and polymerase chain reaction as sensitive detection methods, Gene cloning, Introduction of cloned genes into new hosts using plasmids and phage vector systems, expression of genes in new host, Genetically Modified Organisms (GMOs) and their possible environmental implications.

Unit III: Principles in toxicology; Toxicants and toxicity, Factors affecting concentration of toxicants in environment, Toxicity tests and concepts of LD_{50} and $LC_{50,}$ Sources and types of toxicants and their health hazards, Dose-effect and Dose response relationship, Absorption, translocation and excretion of toxicants.

Unit IV: Global dispersion of toxic substance, Dispersion and circulating mechanisms of pollutant, degradable and non-degradable toxic substances in food chain, Ecosystem influence on fate and transport of toxicants, Bio-absorption of heavy metals and Bio-accumulation, Biomagnification.

Suggested Readings:

1. Atherly Alan G, Jack R. Girton and John F. McDonald (1998) *The Science of Genetics*. Saunders College Publishing, New York.
2. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. (2002) *Molecular Biology of the Cell* (IV ed.), Gasland Science, New York.
3. Verma, P.S. and Agarwal, V.K. (1998) *Cell Biology, Genetics, Evolution and Ecology.* S. Chand and Co. Ltd., New Delhi.
4. Abbasi, S. A. and E Ramasami (1999) *Biotechnological methods of Pollution control* University Press, Hyderabad.

5. Alan Scrogg (2005) *Environmental Biotechnology*, (II ed.), Oxford University Press, New York.
6. Jemba, P.K. (2004) *Environmental Microbiology*, Science Publishers, USA.
7. Srivastava, M. L. (2003) *Basic Environmental Microbiology*, Manohar Books, New Delhi.
8. Raina, M., I. Pepper and C. Gerba (2006) *Environmental Microbiology*, Academic Press, New York.
9. Alan Scrogg (2005) *Environmental Biotechnology* (II ed.), Oxford University Press, New York.
10. Murugesan, A.G. and Rajakumari. C. (2006) *Environmental Science and Biotechnology*, MJP Publishers, Chennai.
11. Pery, G. (1980) *Introduction to Environmental Toxicology*, Elsevier, Amsterdam.
12. Hayes, W. A. (2001) *Principles and Methods of Toxicology*, CRC, USA.
13. Wright, D. A. and Welbourn, P. (2002) *Environmental Toxicology*. Cambridge University Press, London.
14. Klaassen, C. D and Watkins, J.B. (2003) *Essentials of Toxicology*, McGraw-Hill Professional, New Delhi.
15. Jacobson-Kram, D. (2006) *Toxicological Testing Handbook: Principles, Applications and Data Interpretation.* Taylor & Francis, New York.
16. Pelczar, Jr. M. J, Chan, E.C.S. and Krieg, N. R. (2009) Microbiology, (V Edition), Tata McGraw-Hill New Delhi.
17. Walker , C. H. , R. M. Sibly, S.P. Hopkin, and D. B. Peakall (2012) *Principles of Ecotoxicology*, (IV Edition), CRC Press, New York.
18. Bommanna G. Loganathan and Paul Kwan-Sing Lam (2011) *Global Contamination Trends of Persistent Organic Chemicals*, CRC Press, New York.

ENV-C-202 Environmental Impact Assessment, Environmental Policies and Ethics Credits- 4

Unit I: Introduction to environmental impact assessment (EIA), origin and development of EIA, Environmental impact statement and environmental management plan. EIA Notifications & Guidelines 1994, 2006, and 2009, Stages of granting Environmental Clearance: Screening, Scoping, Public consultation, Appraisal & recommendations and grant of environmental clearance and its validity.

Unit II: Components of an EIA report; Generation of baseline data & preparation of EIA report, procedure for reviewing EIA report, Authorities/ Institutions involved in granting environmental clearance at Central & State Government levels.

Unit III: Environmental policy 2006, Environmental policy resolution, Legislation, Public policy strategies in pollution control, International and National Conservation agencies, policies and strategies, Convention on biodiversity, Convention on Climate change, Kyoto protocol, Carbon credit and Carbon trading.

Unit IV: Concept of environmental ethics, philosophies of biocentrism and ecocentrism, application of ethics to environmental issues, eastern and western philosophical traditions/religious treatises on the relationships between humans, animals, and the natural environment, value of wilderness.

Suggested Readings

1. Charles, H. Eccleston (2011) *Environmental Impact Assessment*, CRC Press, New York.

2. Anjaneyulu, Y. and Manickam W. (2010) *Environmental Impact Assessment Methodologies*, BSP Books Pvt. Ltd., Hederabad
3. Lawrence, D. P. (2003) *Environmental Impact Assessment: Practical Solutions to Recurrent Problems*, John Wiley and Sons, New Delhi.
4. Glasson, Therivel and Chadwick (1999) *An Introduction to Environmental Impact Assessment,* UCLA, Los Angeles.
5. Morris, P. and R. Therivel (2001), *Methods of Environmental Impact Assessment,* Spoon Press.
6. Carter, L. (1996) *Environmental Impact Assessment,* McGraw Hill, New Delhi.
7. Anjanejuly , Y. (2002) *Environmental Impact Assessment Methodologies,* B.S. Publications, New Delhi.
8. Weston, J. (1997) *Planning and EIA in Practice,* Longman.
9. Jos Arts and Angus Morrison-Saunders (2004) *Assessing Impact - Handbook of EIA and SEA follow-up*, Earthscan, London.
10. website of MoEF, GOI, New Delhi
11. Srivastava, D. C. (2005) *Readings in Environmental Ethics: Multidisciplinary perspectives*, Rawat Publications, Jaipur.

ENV-C-203 Practical Credits- 4

1. Estimation of microflora in soil and water through dilution plate method.
2. Determination of heavy metal toxicity by germination and seedling growth tests.
3. Measurement of toxic effect of pesticides on soil organisms.
4. Determination of LC_{50} /LD_{50} value of a toxicant.
5. Comparative study of soil biodiversity in polluted and unpolluted site.
6. Study of an EIA report.
7. Visit to Industrial/Mining sites and preparation of report.
8. Analysis of air, water and soil quality data of an EIA report.
9. Study of socio-economy of an area with the help of Census data.

Suggested Readings:

1. Gurumani, N. (2006) *Research Methodology for Biological Sciences*, MJP Publishers, Chennai.
2. Jacobson-Kram, D. (2006) *Toxicological Testing Handbook: Principles, Applications and Data Interpretation.* Taylor & Francis, New York.
3. Gurumani, N. (2006) *An introduction to Biostatistics*, MJP Publishers, Chennai.
4. Murugesan, A.G. and Rajakumari. C. (2006) *Environmental Science and Biotechnology*, MJP Publishers, Chennai.

ENV-O-204 Remote Sensing and Geographical Information System Credits- 4

Unit I: Remote sensing: definition and scope; Electro-magnetic radiation: characteristics, interaction with matter and spectral regions. Aerial photos: Types, Scale, Resolution; Stereoscopy; Geometric properties of aerial photos; Stereoscopic parallax; Relief displacement.

Unit II: Types of remote sensing; Remote sensing regions and bands. Indian and foreign Remote Sensing Satellites- LANDSAT, IRS, IKONOS, QUICK BIRD, CARTOSAT. Platforms and sensors-principles and geometry.

Unit III: Image classification procedures; supervised and unsupervised classifications. Elements of aerial photo-interpretation, Elements of Visual Interpretation. Satellite Imageries and its application in Environmental Monitoring, Landuse Mapping, Habitat Analysis, Drought Monitoring and Flood

Studies, Soil Conservation and Watershed Management, Urban sprawl, Landslide hazard zonation and geosciences.

Unit IV: GIS: Introduction, components and software modules. Geographic data: spatial and non-spatial. Data-structure. Application of GIS in Land use Mapping, Habitat Analysis, Urban sprawl and Landslide hazard zonation. GIS as a decision support system; Global positioning system: Basic principles, instruments, components and applications of Global Positioning System (GPS) Measurement of coordinates using GPS, Demonstration of GIS Software module.

Suggested Readings:

1. Lillesand, T.M. and Kiefer, R.W. (1987) *Remote Sensing and image interpretation*, John Wiley, Cambridge.
2. Chang, Kang-tsung (2000) *Introduction to GIS*, Tata Mc Graw Hill, New Delhi.
3. Panday, Shiv N. (1987) *Principles and applications of Photogeology*, Wiley Eastern Limited, New Delhi.
4. Rao D.P. (*ed.*) (1998) *Remote Sensing for Earth Resources*, Association of Exploration Geophysicist, Hyderabad.
5. Basudeb Bhatta (2011) *Remote Sensing and GIS*, Oxford University Press, New York.
6. Susan L. Ustin (2004) *Remote Sensing for Natural Resource Management and Environmental Monitoring*, John Wiley & Sons,
7. Eric Charles Barrett, Leonard Frank Curtis (1992) *Introduction to Environmental Remote Sensing*, Routledge, Taylor and Francis, New York.
8. Wing, Michael G., Pete Bettinger (2008) *Geographic Information Systems: Applications in Natural Resource Management*, Oxford University Press, New York.
9. Alberto Carrara, Fausto Guzzetti (1996) *Geographical Information Systems in Assessing Natural Hazards*, Kluwer Academic Publishers, Netherlands.
10. Conway, Eric D. (1997) *An Introduction to Satellite Image Interpretation*, Maryland Space Grant Consortium.
11. Johnson, Arnold Ivan, C. Bernt Petterson (2008) *Geographic Information Systems (GIS) and Mapping: Practices and standards*, ASTM International.
12. Ahmed El-Rabbany (2002) *Introduction to GPS: The Global Positioning System*, Artech House
13. Remote, John R Jensen (2000) *Sensing of the Environment*, Prentice Hall
14. Reddy, M Anji (2008) *Textbook of Remote Sensing and Geographical Information Systems* (2nd edition), Book Syndicate

ENV-O-205	Environmental Law	Credits - 2

Unit I: Basics of Law: Rights and Privileges ,Article 21 of the Constitution of India, Acquisition of Rights Indian Penal code; Laws of Criminal procedure ,Cognizable and non –cognizable offences, Search warrant; Indian Forests Act 1927: Application of Indian Penal code (Act XLV of 1860 to forest offences, Land Acquisition Act ,1894 Forest Act :Salient features and amendments.; Classification of forests as per IFA, 1927:Reserved forests (Sections 3, 4, 6, 7, 9, 10, 11, 13, 20, 23, 25, 26 and 27); Village forests (Section 28) and Protected forests (Sections 29, 30, 32), Biological Diversity Act (2002) Forest (Conservation) Act, 1980.with explanations (amendments made on the basis of verdict of the High Court and Apex court) Sixth schedule and Article 371A of the Constitution of India: Vis-a Vis Forest Conservation Act,1980: A critical appraisal.

Unit II: Environment (Protection) Act, (1986) and Rules (1986); Water Prevention and control of Pollution Act, 1974; Air Prevention and control of Pollution Act, 1981, Disaster management act 2005; Disaster management and administrative reforms. Salient features of Wildlife (Protection) Act, 1972: Protection of specified plants (Sections 17A to 17H). Sanctuaries, National parks and Closed areas (Sections 18 to 38). Trade in wild animals, animal articles and trophies (Sections 39 to 41). Major amendments of Wildlife (Protection)Act, 1972.

Suggested Readings

1. Basu, D. D. (2003) Introduction *to the Constitution of India,* Wadhwa and Company Law Publisher, New Delhi.
2. Sands, P. (2003) *Principles of International Environmental Laws,* Cambridge University Press, London.
3. Choudhury, S.K. (1996) *Environmental Legislation in India,* Oxford IBH, New Delhi.
4. Trivedi, R.K. (2010) *Handbook of Environmental Laws, Acts, Guidelines, Compliance and Standards*, Vol I & II, B.S. Publications, Hyderabad.
5. Negi, S.S. (2000) *Forest law with explanation*, Bishen Singh Mahendrapal Singh Pal, Dehradun.

ENV-O-206	**Radiation Biology**	**Credits - 2**

UNIT I: Types of radiation, natural and man-made radiations; Radiation interaction with water/matter, units of radiation; Radiation interaction with biological materials: Nucleic acids (DNA & RNA), proteins, carbohydrates, lipids and membranes; Radiation as mutagen.

UNIT II: Target theories, acute and delayed cellular effects by radiation, radiation syndromes, chromosomal aberrations; applied aspects of radiation: cancer therapy, food preservation, alternative energy sources.

Suggested Readings:

1. Uma Devi, P., A. Nagarathnam, B.S.S., Rao (2000) *Introduction to Radiation Biology*, B. I. Churchill Livingstone, New Delhi.
2. Kiefer, Jurgen (1990) *Biological Radiation Effects*, Springer-Verlang, Gieben, Germany.
3. Alper, Tikvah (1979) *Cellular Radiation*, Cambridge University Press, London.
4. Altman, Kurt I., Georg, B. Geber and S. Okada (1970) *Radiation biochemistry*, Academic Press, New York.
5. Casarett, Alison P. (1968) R*adiation Biology*, Prentic-Hall, Inc. New Jersey.

ENV-O-207	**Natural Resource Management**
Credits-4	

Unit I: Natural resources: Concept and major types of natural resources, Land Resources: Land use and land cover, land use change, drivers of land use change, impact of land use change on environment; Soil resource: soil types, profile and composition, degradation of land and soil; Mineral Resources: metal and non-metal minerals and their reserve and distribution, environmental effects of mineral exploitation.

Unit II: Energy and Mineral Resources**:** Definition of Energy; Sources of energy; Energy units; Energy Resources: Oil and natural gas, coal, solar and wind energy, biomass energy, geothermal energy,

hydropower; Environmental implication of energy use; Mineral resources: types, distribution and reserves.

UNIT III: Water Resources: Introduction of water resources, distribution and supply: Global, national and regional; hydrological cycle, Water resource type: surface water, ground water; Causes of water resource depletion: Use and over use of water resources, Methods for managing water resources: Ground water recharging, rain water harvesting; Watershed management: Concept, and objectives, land use planning, flood control; Wetlands: definition, importance and classification.

Unit IV: Forest and Biodiversity: Forest as natural resource: importance, classification and extent of forests in India; deforestation and conservation strategies; Role of forests in carbon management; forest fragmentation, national forest policy; Biodiversity: introduction, levels, importance, threats to biodiversity, modern and traditional biodiversity conservation strategies, global biodiversity hotspots; threatened and endemic species.

Suggested Reading

1. Daniel D. Chiras and Reganold, John P. (2009) *Natural Resource Conservation: Management for a Sustainable Future* (X Ed.), Addison Wesley, Boston.
2. Thapar, S. D. (1975) *India's Forest Resources*, Macmillan India, New Delhi.
3. Flintan, F. and Tedla, S. (2010) *Natural Resource Management: The impact of gender and Social Issues*, IDRC, New Delhi.
4. Verhoeven, J. T. A. (2006) *Wetland and Natural Resource Management*, Springer, New York.
5. Rajora, Rajesh (1998) *Integrated Watershed Management: A Field Manual for Equitable, Productive and Sustainable Development*, Rawat Publications, Jaipur.
6. Tripathi, R. P. and Singh, H. P. (1993) *Soil Erosion and Conservation*, Wiley Eastern Limited, New York.
7. Quentin Grafton, R. and Hussey, Karen (2011) *Water Resources Planning and Management*, Cambridge University Press, London.
8. Sinha, P. C. and Mohanty, R. (2002) *Wetland: Management Policy and Law*, Kanishka Publications, Bhubaneswar.
9. Abbasi, S. (1997) *Wetlands of India: Ecology and Threats*, (vol: I-III), Discovery Publishing House, New Delhi.
10. Kesler, P. (2002) *Mineral resources: Economics and Environment*, CBS Publishers & Distributors, New Delhi.
11. Tiwari, G.N. (2005) *Solar Energy*, Narosa Publishing, New Delhi.
12. Devins, D. W. (1982) *Energy: Its Physical Impact on the Environment*, John Wiley and Sons Inc., New York.
13. Nakicenovic, N. (1998) *Global Energy Perspectives*, Cambridge University Press, London.
14. Fowler, J. M. (1984) Energy and the Environment, McGraw Hill.
15. Ravindranath, N. H., Usha Rao, K., Natarajan, B. and Monga, P. (200) *Renewable Energy and Environment - A Policy Analysis for India*, Tata-McGraw Hill, New Delhi
16. Brooks, K. N. (2003) *Hydrology and Watershed Management*, Iowa State Press, New York.
17. Kumar, Arun, Sati, J. P., Tak, P.C., and Alfred, J.R.B. (2005) *Handbook on Indian Wetlands and Their Conservation*, Zoological Survey of India, Kolkata.
18. Collins, W.W. and Qualset, C.O. (1998) *Biodiversity in Agro-ecosystem*, CRC, Boston.
19. Krishnamurthy, V.K. (2003) *Text Book of Biodiversity*, Science Publisher, Chennai.
20. Singh, O.P. (2006) *Environment and Natural Resources*, Regency Publications, New Delhi.
21. Das, A. P. (2002) *Prospectives of Plant Biodivesity*, Bishan Singh Mahendra Pal Singh, Dehradun.

22. Singh N. Irabanta (2008) *Endemic Bioresources of India*, Bishan Singh Mahendra Pal Singh, Dehradun.

SEMESTER III

ENV-C- 301	Environmental Geoscience and Energy	Credits- 4

Unit I: Primary differentiation and formation of core, mantle, crust, atmosphere and hydrosphere; Geomagnetism: remnant magnetization, paleomagnetism. Gravity and figure of the Earth: mass inhomogeneties and associated gravity anomalies; Stress and Strain: Definition, classification and types. Behavior of rocks under of stress and strain.

Unit II: Seismology: causes and space distribution of earthquakes; seismic waves; (body and surface waves), Precursors to the earthquakes. Sea floor spreading; Plate tectonics theory: types of plate boundaries, processes and corresponding geophysical and geological signatures; Himalayan tectonics.

Unit III: Energy resources and their exploitation. Energy: Conventional and non-conventional energy sources. Renewable sources of energy- hydroelectric power, solar, tidal, wind, geothermal energy, biomass and biofuels. Environmental impacts of conventional and renewable energy. Sun as source of energy, nature of solar radiation, heat budget of the earth, earth's temperature and atmosphere, Photovoltaics and Solar collectors. Energy use pattern in India and the world.

Unit IV: Concept of Minerals and Rocks. Atomic minerals as a source of energy. Atomic fuel, radioactive wastes and their management, Fossil fuels- physico-chemical characteristics and energy content of coal, petroleum and natural gases, Petroleum and coal deposits of Northeast India.

Suggested Readings:

1. Valdiya, K.S., (1998) *Dynamic Himalaya*, University Press, Hyderabad.
2. Summerfield, M.A. (2000) *Geomorphology and Global Tectonics*, Springer Verlag, Berlin.
3. Nandy, D.R, (2003) *Geodynamics of Northeastern India and the Adjoining Region*, ABC Publications, New Delhi.
4. Parasnis, D.S. (1975) *Principles of Applied Geophysics*, Chapman and Hall, London.
5. Sharma, P.V. (1986) *Geophysical Methods in Geology*, Elsevier, Amsterdam.
6. Smith, C. (2001) *Environmental Physics*. Routledge, London.
7. Keller, E.A. (1978) *Environmental Geology*. Bell & Howell, Washington D. C.
8. Subramaniam, V. (2001) *Textbook in Environmental Science*. Narosa International, New Delhi.
9. Chandra, D., Singh R.M., and Singh, M.P. (2000) *Textbook of Coal*, Tata Book Agency, Varanasi.
10. Holson, G.D. and Tiratsoo, E.N. (1985) *Introduction to Petroleum Geology*, Gulf Publication. Houston.
11. Durrance, E.M. (1986) *Radioactivity in Geology – Principles and application*, Ellis, Hoorwood.
12. Dahlkamp, F.J. (1993) *Uranium ore deposits*, Springer Verlag, Berlin.
13. Cunningham, W.P. and W.B. Saigo (2005) *Environmental Science*, McGraw Hill, New York.
14. Boyle, G., Bob Everett and J. Ramage (2003) *Energy System and Sustainability*, Oxford Univ. Press, New York.
15. Sudhakara Reddy, B & P. Balachandra (2006) *Energy, Environment and Development*, Narosa Publishing House Pvt. Ltd., New Delhi.
16. Websites of UNEP, IPCC, USEPA and MoEF, GOI.
17. Marinos, Paul G. (1997) *Engineering Geology and the Environment*, Taylor & Francis.

18. Gubbins, David and Emilio Herrero-Bervera (2007) *Encyclopedia of Geomagnetism and Paleomagnetism*, Springer
19. David D. Pollard and Raymond C. Fletcher (1986) *Fundamentals of Structural Geology***,** Cambridge University Press
20. Shearer, Peter M. (1999) *Introduction to Seismology***,** Cambridge University Press
21. Seth Stein and Michael Wysession (2002) *An Introduction to Seismology, Earthquakes, and Earth Structure*, Wiley-Blackwell
22. Billings, M P (1972) *Structural Geology* 3Rd Ed, Prentice Hall College Div
23. Darlene R. Stille, Roger Larson, Terrence E. Young, Jr. (2006) *Plate Tectonics: Earth's Moving Crust*, Compass Point Books
24. Valdiya, Khadg Singh (2004) *Himalaya: Emergence and Evolution*, Universities Press

ENV-C-302 Research Methods, Techniques and Statistical Analyses Credits- 4

Unit I: Definition of applied science and research. Classification of research. Critical appraisal of research studies, Planning research projects, Advance planning and its value, Methods of data collection and analysis, interpretation and presentation.

Unit II: Sampling techniques: Sampling of air, water and soil, sampling of plant and animal populations, concept of species area curve, concept of random and stratified sampling, Methods of Social Science research, PRA.

Unit III: Population and sample, frequency table, mean, mode, median, measure of dispersion, standard deviation, variance, correlation, regression and prediction, multivariate analysis. Test of significance- (Z & T test) variance in one and two sample cases. Test of equality of K– variance (Bartlett's test).

Unit IV: Basic principles of field experimentation: Randomization, Replication and Local Control. Lay out and analysis of data of completely Randomized block design, Latin square designs, Factorial design, Split plot and Strip plot designs.

Suggested Readings:

1. Chadda, A. (1989) *Agricultural Statistics in India*, Suman Book House, New Delhi.
2. Date, C. J. (1986). *An Introduction to database system*, Addision Wesley, U.K.
3. Dear, K.J.B., Mead, R and Rilay, J. (1987) *Statistical Tools for Agroforestry Research*, ICRAF, Kenya.
4. Medhi, J. (1992) *Statistical Methods*. Wiley Eastern, New Delhi.
5. Gurumani, N. (2006) *Research Methodology for Biological Sciences*, MJP Publishers, Chennai.
6. Vic Barnett (2006) *Environmental Statistics: Methods and Applications*, John Wiley and Sons, New Delhi.

ENV-C-303 Practical Credits- 4

1. Calculation of strain in rocks.
2. Study of structural features formed due to stress in rocks.
3. Study of properties of common rocks.
4. Study of coal, including peat, lignite, bitumen, oil shale.

5. Study of ore of atomic mineral.
6. Demonstration of seismometer and interpretation of seismograph.
7. Study of seismic zonation map of the world.
8. Study of map of a landslide hazard zone.
9. Calculation of the mean deviation, SD and standard error of mean.
10. Estimation of Test of significance.
11. Calculation of regression coefficient.

Suggested Readings:

1. Shryock, H.S. (1976) *The methods and Materials of Demography,* Academic Press, New York
2. Gurumani, N. (2006) *Research Methodology for Biological Sciences*, MJP Publishers, Chennai.
3. Chadda, A. (1989) *Agricultural Statistics in India,* Suman Book House, New Delhi.
4. Vogelsang, D. (1995) *Environmental Geophysics – A Practical guide,* Springer Verlag, Berlin.

ENV-O-304	Disaster Management	Credits- 4

Unit I: Introduction and Concept of disasters and hazards related to Earthquakes, Tsunami, Volcanic eruption, Cyclones, Floods, Drought, Landslides, Forest fires, Avalanches and Pest infestation. Prediction and perception of hazards and adjustments to hazardous activities; Rates of natural cycles and residence time.

Unit II: Landslide: causes, prevention and correction. Landslide hazard mitigation. Earthquakes: intensity and magnitude of earthquakes; geographic distribution of earthquake zones; precursors to the earthquakes, seismic waves, travel-time and location of epicentre; nature of destruction; ground subsidence; protection from earthquake hazards; do's and don'ts during earthquake; Tsunamis- causes and consequences.

Unit III: Floods: Causes, nature and frequency of flooding: nature and extent of flood hazard; urban floods, environmental effects of flooding; flood mitigation methods. Tropical cyclone- formation and consequences. Coastal erosion; sea level changes and its impact on coastal areas. Drought: Nature and effect on plant and animal systems. Study of pattern and mitigation of forest fires.

Unit IV: Geological and environmental investigations for the construction of dams, bridges, highways and tunnels. Impact of major geotechnical projects on the environment. Disaster Management: Capability-Vulnerability- risk- preparedness and mitigation- Disaster management cycle; Disaster Risk Reduction and Resilience; Disaster Management Act and Policy.

Suggested Readings:

1. Krynine, D.S. and Judd, W.R. (1998) *Principles of Engineering Geology*, CBS, New Delhi.
2. Smith, K. (1992) *Environmental Hazards,* Routledge, London.
3. Bell, F.G. (1999) *Geological Hazards,* Routledge, London.
4. Bryant, E. (1985) *Natural Hazards*, Cambridge University Press. London.
5. Nagarajan, R. (2001) *Lanslide Disaster – Assessment and Monitoring*, Anmol Publications, New Delhi.
6. Cutter, Susan L. (1999) *Environmental risks and hazards*, Prentice Hall of India, New Delhi.
7. Bill Mc Juire, Ian Mason and C. Killburn (2002) *Natural hazards and Environmental change*, Oxford University Press, New York.
8. Gupta, Harsh K. (2003) *Disaster Management*, Universities Press (India) Pvt. Ltd
9. Coppola, Damon P. (2006) *Introduction to International Disaster Management*, Butterworth-Heinemann

10. Jha, Madan Kumar (2010) *Natural and Anthropogenic Disasters: Vulnerability, Preparedness and Mitigation*, Springer
11. Glad,e Thomas, Malcolm G. Anderson, Michael J. Crozier (2005*) Landslide Hazard and Risk*, edited Springer
12. Singh, Surendra, Leszek Starkel, Hiambok Jones Syiemlieh (2008) *Environmental Changes and Geomorphic Hazards*, Bookwell.

ENV-O-305 Environmental Issues and Problems of North East India Credits- 2

Unit I: Population growth, urbanization, growth of vehicles and its impact on air quality. Changes in forest cover, biodiversity loss and conservation measures, issues and concerns related to sacred forests and sacred groves. Impact of introduction of high yielding varieties, use of fertilizers and pesticides, issues and problems associated with shifting agriculture; Industrialization: environmental impacts of oil refineries, cement plants, paper mills, wood based industries and tea industry.

Unit II: Environmental impacts of coal and lime stone mining, quarrying of sand from hills and rivers, Extraction of petroleum and natural gas; Environmental and socio-economic implications of mega hydro electric projects; Issues relating to conservation of Ramsar sites of north-east India: Loktak lake, Deepor beel, Impact of tourism, social conflicts and environment.

Suggested Readings:

1. Singh, O.P. (2006) *Environment and natural resources*, Regency Publications, New Delhi.
2. Tiwari, B.K. and C. Kumar (2008) *Forest Products of Meghala*ya, Regional centre, NAEB, Shillong.
3. Singh, O.P. (2005) *Mining Environment*, Regency Publications, New Delhi.
4. Ramakrishnan, P.S., K.G. Saxena S. Patnaik and S. Singh (2003) *Methodological issues in Mountain research*, Oxford & IBH Publishing, New Delhi.
5. Tiwari, B.K., S.K. Barik and R. S. Tripathi (1999) *Sacred forests of Meghalaya*, Regional Centre, NAEB, Shillong.
6. Ramakrishnan, P.S., A. N. Purohit, K.G. Saxena, K.S. Rao and R.K. Maikhuri (1996) *Conservation and management of biological resources in Himalaya*, Oxford & IBH Publishing, New Delhi.
7. Saxena, K. G., Luohui Liang and K. Rerkasem (2007) *Shifting agriculture in Asia*, BS MPS Dehradun
8. Ramakrishnan, P.S. (2000) *Mountain Biodiversity, Land Use Dynamics and Traditional Ecological Knowledge*, Oxford and IBH, New Delhi.

SEMESTER IV

ENV-C-401 Environmental Economics and Sociology Credits- 4

Unit I: Introduction to Environmental Economics and Natural Resource Accounting; Natural Goods and Services; Valuation methods of Natural Resources; Valuation of tangibles and intangibles; Accounting of Forest, Land and Water resources; Natural Resource Accounting and sustainable development; System of Environmental and Economic Accounting, and Green Accounting.

Unit II: Population growth of humans; Malthusian theory of population; factors affecting human population growth and distribution; Impact of human population growth on natural resources and environment, city and village ecosystem.

Unit III: Environmental sociology: concept of culture, inequality, gender and equity, interaction between society and environment, environmental problems in historical perspective, individual

interaction with environment and impact thereof, social movements influencing environmental protection, society and resources management, decision making.

Unit IV: Communication: definition, models, characteristics, process and approach, learning experience, principles and types, learning in groups, group defined, group size and characteristics, task and techniques: Snowball groups and Buzz group. Motivation: definition, models; Training- concept, type and steps required to be followed to train different level of functionaries.

Suggested Readings:

1. Botkin, Daniel B. (2011) *Environmental Science: Earth as a Living Planet*, John Wiley and Sons, New Delhi.
2. Markandya, A. *et al* (2006) *Environmental Accounting and Sustainability*, Edward Elgar Publishing Ltd. U.K.
3. Charles, P. and J.R. Vincent (2003) *Natural Resource Accounting and Economic Development: Theory and Practice*, Edward Elgar Publishing Ltd. U.K.
4. Haab, T. and Mc Connell K.E. (2003) *Valuing Environmental and Natural Resources*, Edward Elgar Publishing Ltd. U.K.
5. Harper, C. (1996) *Environment and Society*, Prentice Hall, Washington D.C.
6. Barry, J. (1999) *Environmental and Social theory*, Routledge, London.
7. Riley, E. Michelson, W.C. (Eds) (1998) *Hand Book of Environmental Sociology*, Westport Greenwood Press, USA.
8. Adame, M.E. (1987) *Agricultural Extension in Developing Countries*, Longman, London.
9. Sen Sarma, P.K. and Jha, L.K. (2008) *A manual of Forestry Extension education*, APH Pub. Corp., New Delhi.
10. Massimo Livi-Bacci (2012) *A Concise History of World Population* (V Ed.). Wiley-Blackwell
11. Yaukey, D., Anderton, D.L. and Landquist, J. H. (2007) *Demography: The Study of Human Population*, Wavelength Pres Inc. IL. USA
12. Miller Katherine (2004) *Communication Theories: Perspectives, Processes, and Contexts*, McGraw Hill, New York.
13. Stephen W. Littlejohn and Karen A. Foss (2007) *Theories of Human Communication*, Cengage Learning, New Delhi
14. King, Leslie and Deborah McCarthy (2009) *Environmental Sociology: From Analysis to Action*, (II Ed.), Rowman and Littlefield, USA.
15. Mayerfeld Michael Bell (2012) *An Invitation to Environmental Sociology*, (IV Ed.), Pine Forge Press, SAGE, Landon.

ENV-C-402 Forest Management and Biodiversity Conservation Credits- 4

Unit I: Management: definition, principles of forest management, objectives of forest management, Rotation: kinds of rotation, Land expectation value, Normal forest, Estimation of normal growing stock. Silviculture systems: definition, characteristics, scope and classification; Clear felling systems, Clear strip system. Alternate strip system: (methods of obtaining regeneration, advantages and disadvantages.

Unit II: Uniform system: definition, pattern of felling- seeding felling, secondary and final fellings, Regeneration period, Periodic block,: allotment of area to fixed/ permanent of floating periodic blocks, preparatory fellings, (examples , advantages and disadvantages). Indian Irregular Shelterwood system and Selection system: definition, methods of obtaining regeneration, conditions of application, pattern

of felling, advantages and disadvantages. Management of clump and non clump forming bamboo species), traditional forest management systems in northeast India.

Unit III: Biodiversity: Major categories, ecosystem diversity, species diversity, genetic diversity, natural biodiversity vs agricultural biodiversity, determinants of species diversity. Definitions: endemic, extinct, endangered, vulnerable, rare. Status of species diversity in India, distribution of biodiversity, hotspots. Biodiversity loss and strategies for conservation: Factors affecting biodiversity, ex-situ and in-situ conservation at the species and ecosystem levels. Protected areas: National parks, wildlife Sanctuaries and Biosphere Reserves. Traditional biodiversity conservation practices.

Unit IV: Value and significance of biodiversity: Tangible benefits- food, fiber, fodder, medicines, construction material. Intangibles- pollination, pest control, soil development and maintenance of soil fertility, soil and water conservation, nutrient cycling. Human-animal conflicts, existing conservation projects: Tiger, Rhino, Elephant, Turtles, Crocodiles, Birds; Coral reefs and Mangroves.

Suggested Readings:

1. Negi, S.S.(1985) Management of forests**,** M/S Bishen Singh Mahendrapal Singh,Dehradun
2. Maslekar, A.R. (2008) *A Handbook for foresters,* Bishen Singh Mahendra Pal Singh, Dehradun.
3. Khanna, L.S. (2004) *Theory and Practice of Indian Silviculture*, Khanna Bandhu, Dehra Dun.
4. Prakash, R and Khanna, L. S. (1983) *Theory and Practice of Silvicultural Systems,* Intl. Book Distributors, Dehradun.
5. Sharma,L.C.(1998*) Forest economics and management*, M/S Bishen Singh Mahendrapal Singh,Dehradun
6. A. Dutta (2001) Biodiversity and Ecosystem Conservation, Kalyani Publisher, Kolkata.
7. S.K. Agarwal *et al* (1996) *Biodiversity and Environment,* APH, Dehra Dun.
8. S.S. Negi (1993) *Biodiversity and its Conservation in India*, Indus Publications, New Delhi.
9. W.W. Collins and C.O. Qualset (1998) *Biodiversity in Agro-ecosystem*, CRC, Boston.
10. V.K. Krishnamurthy (2003) *Text Book of Biodiversity*, Science Publisher, Chennai.
11. P.S. Ramakrishnan (2000) *Mountain Biodiversity, Land Use Dynamics and Traditional Ecological Knowledge*, Oxford and IBH, New Delhi.
12. Ghosh, Ashish (2009) *Biodiversity Conservation,* APH Publications, New Delhi.
13. Ladle, Richard and Richard J. Ladle (2009) *Biodiversity and Conservation: Response to biodiversity loss*, Taylor and Francis

ENV-C-403 Practical **Credits- 4**

1. Inventorization of local NTPFs.
2. Market survey for forest products.
3. Rapid study of environmental impact of tourism.
4. Study of forest management systems (JFM, CFM and Sacred Groves).
5. Measurement of height and girth of trees.
6. Estimation of volume of logs.
7. Estimation of species diversity in aquatic and terrestrial ecosystems.
8. Study of floristic composition of a forest ecosystem.

Suggested Readings:

1. Charles, P. and J.R. Vincent (2003) *Natural Resource Accounting and Economic Development: Theory and Practice*, Edward Elgar Publishing Ltd. U.K.
2. Haab, T. and Mc Connell K.E. (2003) *Valuing Environmental and Natural Resources*, Edwrd Elgar Publishing Ltd. U.K.

3. Khanna, L.S. (2004) *Theory and Practice of Indian Silviculture*, Khanna Bandhu, Dehra Dun.
4. Khanna, L.S. (1985) *Forest Mensuration*, Intl. Book Distributors, Dehradun.
5. Ghosh, S.K. and Singh, R. (2003) *Social Forestry and Forest Management*, Global vision publication, Delhi.

ENV-C-404 Project work and Field work / Study Tour or Industrial exposure Credits- 6

(Project work will be assigned in the previous semester however will be evaluated in this semester)