UNIVERSITY OF KELANIYA

SRI LANKA

FACULTY OF SCIENCE

Revised Curriculum

of

BACHELOR OF SCIENCE DEGREE PROGRAMME IN ENVIRONMENTAL CONSERVATION AND MANAGEMENT

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BACHELOR OF SCIENCE (HONOURS) DEGREE PROGRAMME IN ENVIRONMENTAL CONSERVATION AND MANAGEMENT

2013/2014

Contents

1. Preamble

The Faculty of Science of the University of Kelaniya commenced the B.Sc. Degree Programmes (General and Special) in Environmental Conservation and Management since 2005/2006 academic year. The Department of Zoology and Environmental Management (formerly Department of Zoology) of the Faculty of Science mainly contributes to these deegree programmes.

In 2012, The Department of Zoology and Environmental Management acquired funds from the "Quality and Innovation Grant, Window 2 (QIG, W2) of the Higher Education for the 21st Centuary (HETC) Project" for improving the quality of teaching and learning process of the Environmental Conservation and Management Degree Programmes. As per the conditions of the proposal to the above grant, the curriculum including the course structure and the syllabi of the Environmental Conservation and Management Degree Programmes have been extensively revised.

Further, the qualifiers of the two degree programmes have also been revised as B.Sc. in Environmental Conservation and Management (B.Sc. in ENCM) and B.Sc. (Honours) in Environmental Conservation and Management (B.Sc. (Honours) in ENCM) as per the recommendation of the Sri Lanka Qualifications Framework (SLQF).

However the general rules, regulations and guidelines related to the degree programmes that are stated in the Student Hand Book of the Faculty of Science will remain unchanged with respect to the following aspects;

- The Notations of Course Units and Abbreviations Used,
- General Guideline for the Degree Programmes,
- Registration for Course Units,
- Changes of Course Units,
- Attendance,
- Assessment Procedure,
- Grading System,
- Repeating a Course Unit Examination,
- Grade Point Average
- Eligibility for the Award of the B.Sc. in ENCM Degree and Award of Classes
- Eligibility for the Award of the B.Sc. (Honours) in ENCM Degree and Award of Classes,
- Option of Reverting to the B. Sc. Degree, and
- Award of the Degree.

2. Graduate Profile of the B.Sc. in ENCM Degree programme

The ENCM Graduate of the University of Kelaniya is a socially responsible leader, team player, as well as a self-managed adaptable individual with positive attitudes who will be able to;

- Demonstrate knowledge and understanding of basic principles, concepts, systems, processes, issues, management tools and technologies in the field of ENCM,
- Collect, analyze and interpret qualitative and quantitative data on environment,
- Identify problems and propose solutions in the areas of ENCM,
- Develop arguments and make sound judgments in accordance with basic theories in the area of ENCM,
- Present relevant information, ideas and concepts effectively and efficiently,
- Engage in lifelong learning, acquire new competencies and undertake further training in the field of ENCM,
- Demonstrate ICT skills relevant to ENCM, and
- Exercise initiative in conserving and managing the environment with personal responsibility and accountability.

The ENCM graduates will be competent;

- To serve as managers, executives, administrators and educators, and
- Engage in self-employment in ENCM and allied fields.

3. Program Intended Learning Outcomes (PILOs) of the B.Sc. in ENCM Degree Programme

Upon successful completion of the ENCM Degree Program, a graduate will be able to demonstrate competencies in the following aspects;

A. Knowledge and Understanding (Cognitive skills)

- Describe environmental resources and natural environmental processes,
- Describe the biological diversity in the national, regional and global context,
- Explain the impacts of human intervention on environmental resources and measures for sustainable utilization of environmental resources, and
- Explain relevant concepts, tools and methods involved in environmental conservation and management.

B. Intellectual Skills

- Discuss the causes for environmental degradation in national, regional and global context,
- Assess the manner in which the developmental activities interfere with the environmental processes,
- Evaluate diverse environmental conservation and management practices and identify most appropriate strategies to address environmental issues in a given context, and
- Evaluate economics of development projects with respect to environmental aspects.

C. Practical Skills (Psychomotor skills)

- Conduct investigations on environmental issues with limited guidance,
- Collect, analyze and interpret environmental data in a logical and accurate manner,
- Apply appropriate environmental conservation and management methodologies to address environmental issues,
- Apply ICT including GIS and Remote Sensing in environmental conservation and management effectively, and
- Develop and conduct outreach activities on environmental conservation and management.

D. Transferable Skills

- Communicate and present information effectively,
- Self-disciplined in time management and activity planning,
- Operate effectively within a team, demonstrating team spirit and leadership skills,
- Adapt to changing situations,
- Work and learn independently,
- initiate activities and take personal responsibility for their own work, and
- Demonstrate competencies in general ICT skills.

E. Affective Domain (Atitudinal changes)

- Demonstrate positive attitudes and social responsibility, and
- Demonstrate self-motivation in real life activities.

4. Graduate Profile of the B.Sc. (Honours) in ENCM Degree programme

The ENCM (Honours) Graduate of the University of Kelaniya is a socially responsible leader, team player, as well as a self-managed adaptable professional with positive attitudes who will be able to;

- Demonstrate in-depth knowledge and understanding of principles, concepts, systems, processes, issues, management tools and technologies relevant to ENCM,
- Engage in independent learning using scholarly reviews and secondary sources of information,
- Demonstrate awareness on current developments in ENCM,
- Identify environmental issues, collect qualitative and quantitative data, analyze and interpret the results logically and propose appropriate solutions,
- Develop arguments and sustain them and make sound judgments in accordance with basic theories in the area of ENCM,
- Present relevant information, ideas and concepts effectively and efficiently,
- Use ICT effectively in ENCM,
- Apply management tools and technologies related to ENCM,
- Acquire new competencies and undertake further training in the field of ENCM,
- Conduct research in ENCM, and
- Exercise initiative in conserving and managing the environment with personal responsibility and accountability.

The ENCM Honours graduates will be competent;

- To serve as researchers, academics, consultants, managers, executives, administrators and policy planners, and
- Engage in self-employment in ENCM and allied fields.

5. Program Intended Learning Outcomes (PILOs) of the B.Sc. Honours in ENCM Degree programme

Upon successful completion of the B.Sc. Honours in ENCM degree Program, a graduate will be able to demonstrate competencies in the following aspects;

A. Knowledge and Understanding

- Describe environmental resources and natural environmental processes,
- Describe the biological diversity in national, regional and global contexts,
- Explain relevant concepts, tools and methods involved in environmental conservation and management,
- Explain the impacts of developmental activities on the environment, and
- Identify and compare the effectiveness of different solutions for environmental issues.

B. Intellectual Skills

- Plan environmental conservation and management methodologies to solve environmental issues,

- Analyze, interpret and discuss environmental health risk with respect to chemical risk assessment and management of environmental related diseases,
- Critically comment upon relevant concepts, tools and methods involved in environmental conservation and management,
- Critically analyze the impacts of human intervention on environmental resources and measures for sustainable utilization of environmental resources,
- Evaluate the effectiveness of different environmental conservation and management practices,
- Design appropriate methods and strategies to address environmental issues in real world situations, and
- Identify and propose guidelines and suitable methodologies to improve the quality of environmental management activities.

C. Practical Skills (Psychomotor skills)

- Conduct independent research with limited guidance regarding environmental conservation and management issues,
- Collect, analyze and interpret environmental data in an accurate manner using appropriate statistical methods and comprehend appropriate conclusions,
- Apply appropriate methodologies and tools including Geographical Information Systems and Remote Sensing in environmental conservation and management effectively,
- Develop and conduct outreach activities on environmental conservation and management, and
- Use appropriate environmental management methodologies to enhance developmental activities of the country.

D. Transferable Skills

- Communicate and present information effectively,
- Self-disciplined in time management and activity planning,
- Operate effectively within a team, demonstrating team building and leadership,
- Adapt to changing situations,
- Work and learn independently,
- Exercise initiative in many activities and take personal responsibility for their own work, and
- Demonstrate competencies in general ICT skills.

E. Affective Domain (Attitudinal changes)

- Demonstrate positive attitudes and social responsibility, and
- Demonstrate self-motivation in real life activities.

6. Course Structure

Year 1

	Course Code and Title	Status	Pre-requisite	Co-requisite
Year 1 Sem 1	ENCM 11512 Evolution of Earth and Biogeography	C	GCE A/L Biology	-
	ENCM 11522 Introduction to Environmental Management	C	GCE A/L Biology	-
	ENCM 11532 Hydrology and Meteorology	C	GCE A/L Biology	-
	ENCM 11543 Soil and Mineral Resources	C	GCE A/L Biology	-
	CHEM 11122 General Chemistry and Basic Analytical Chemistry	C	GCE A/L Chemistry	-
	CHEM 11141 Basic Chemical Analysis Laboratory	C	GCE A/L Chemistry	CHEM 11122
	ELTU 11042 English for Environmental Science	C	GCE A/L General English	-
	Total Number of Credits in Semester 1	**14**		
Year 1 Sem 2	ENCM 12553 Pollution and Environmental Health	C	ENCM 11522	-
	ENCM 12562 Sustainable Utilization of Energy Resources	C	ENCM 11522	-
	ENCM 12572 Forest Resources	C	ENCM 11522	-
	ZOOL 12523 Animal Diversity and Sri Lankan Fauna	C	GCE A/L Biology	ZOOL 12531
	ZOOL 12531 Animal Diversity and Sri Lankan Fauna Laboratory	C	GCE A/L Biology	ZOOL 12523
	CHEM 12152 Basic Inorganic Chemistry I	C	CHEM 11122	-
	CHEM 12162 Basic Organic Chemistry	C	CHEM 11122	-
	CHEM 12171 Introductory Organic Chemistry Laboratory	C	CHEM 11141	-
	Total Number of Credits in Semester 2	**16**		
	Credits at the end of Year 1	**30**		

C = Compulsory

Year 2

	Course Code and Title	Status	Pre-requisite	Co-requisite
Year 2 Sem 1	ENCM 21513 Principles of Geo-informatics	C	ENCM 11522	-
	ENCM 21522 Environmental Policies and Legislations	C	ENCM 11522	-
	ENCM 21533 Applied Ecology	C	ZOOL 12523	ENCM 21542
	ENCM 21542 Applied Ecology Laboratory	C	ZOOL 12531	ENCM 21533
	ENCM 21552 Parasites, Vectors and Environmental Health	C	ZOOL 12523	-
	ENCM 21562 Solid Waste Management	C	ENCM 12553	-
	CHEM 21122 Analytical Chemistry	C	CHEM 11122	-
	Total Number of Credits in Semester 1	**16**		
Year 2 Sem 2	ENCM 22572 Waste Water Management	C	ENCM 11522	-
	BOTA 22053 Floristic Resources in Sri Lanka and Management	C	ENCM 12572	-
	BOTA 22063 Plant Diversity	C	ENCM 12572	-
	CHEM 22171 Analytical Chemistry Laboratory	C	CHEM 21122	-
	MIBI 22554 Microbiology for Environmental Management	C	ENCM 12553	MIBI 22562
	MIBI 22562 Microbiology Laboratory for Environmental Management	C	ENCM 12553	MIBI 22554
	Total Number of Credits in Semester 2	**15**		
	Credits at the end of Year 2	**31**		

Year 3 – B. Sc in ENCM degree Programme

	Course Code and Title	Status	Pre-requisite	Co-requisite
Year 3 Sem 1	ENCM 31513 Environmental Economics	C[1]	ENCM 11522 & ENCM 12553	-
	ENCM 31522 Environmental Impact Assessment	C	ENCM 21533	-
	ENCM 31532 Environmental Monitoring	C	ENCM 21542	-
	ENCM 31543 Environment Management Systems and Green Technology	C	ENCM 11522 & ENCM 21522	-
	ENCM 31552 Hazardous Waste Management	C	ENCM 22572	-
	ENCM 33564 Environmental Project	C[1]	All level I & II ENCM course units	-
	CHEM 31132 Introduction to Environmental Chemistry	C	CHEM 11122	-
Year 3 Sem 2	ENCM 32572 Natural Disaster Management	O[1]	ENCM 11512 & ENCM 11532	-
	ENCM 32582 Urban Environment Management	O[1]	ENCM 11522	-
	ENCM 32592 Water Resources Management	C	ENCM 21533	-
	ENCM 32605 In-Plant Training	C[1]	All level I & II ENCM course units	-
	ZOOL 32563 Conservation Biology and Wildlife Management	C	ZOOL 12523 & ENCM 21533	-
	CHEM 32161 Environmental Chemistry Laboratory	C	CHEM 31132	-
	Credits at the end of Year 3	**31**		

O[1] : Students should accumulate credits for at least one optional course units offered in the third year.

C[1] : Not offered for the B. Sc. (Honours) in ENCM Degree programme.

Total of Credits at the end of the Year 3 = 30 + 31 + 31 = 92

Year 3 (Honours/ Part 1) - B. Sc. (Honours) in ENCM Degree programme

	Course Code and Title	Status	Pre-requisite	Co-requisite
Year 3 Sem 1	ENCM 31522 Environmental Impact Assessment	C	ENCM 21533	-
	ENCM 31532 Environmental Monitoring	C	ENCM 21542	-
	ENCM 31543 Environment Management Systems and Green Technology	C	ENCM 11522 & ENCM 21522	-
	ENCM 31552 Hazardous Waste Management	C	ENCM 22572	-
	ENCM 41512 Statistics for Environmental Management	C	ENCM 21542	-
	ENCM 41523 Forest Resources Management	C	ENCM 12572 & ENCM 21522	-
	ENCM 43532 Essay and Seminar on Special Topics in Environmental Management	C	ENCM 21522	-
	CHEM 31132 Introduction to Environmental Chemistry	C	CHEM 11122	-
Year 3 Sem 2	ENCM 32572 Natural Disaster Management	O^2	ENCM 11512 & ENCM 11532	-
	ENCM 32582 Urban Environment Management	O^2	ENCM 11522	-
	ENCM 32592 Water Resources Management	C	ENCM 21533	-
	ENCM 42542 Research Methodology and Scientific Writing	C	ENCM 41512	-
	ENCM 42553 Geo-informatics for Environmental Management	C	ENCM 21523	-
	ZOOL 32563 Conservation Biology and Wildlife Management	C	ENCM 21533	-
	CHEM 32161 Environmental Chemistry Laboratory	C	CHEM 31132	
	Credits at the end of Year 3 (Honours/Part 1)	**31**		

O^2 : Students should accumulate credits for at least one optional course units offered in the third year.

Year 4 (Honours/ Part I1) - B. Sc. (Honours) in ENCM Degree programme

	Course Code and Title	Status	Pre-requisite	Co-requisite
Year 4 Sem 1	ENCM 41564 Applications in Environmental Economics	C	ENCM 31543	-
	ENCM 41574 Ecological Interactions and Behavioural Ecology	C	ENCM 21542	-
	ENCM 41583 Reserve Design and Protected Area Management	C	ZOOL 32553	-
	ENCM 41592 Professional Placement	C	All level II & III ENCM course units	-
Year 4 Sem 2	ENCM 42604 Ecology and Management of Wetlands	C	ENCM 21533	-
	ENCM 42612 Social Responsibility in Environmental Management	C	ENCM 31522	-
	ENCM 42622 Air Quality Management	C	ENCM 31543	-
	ENCM 42632 Global Climate Change	C	ENCM 21533	-
	ENCM 42642 Marine and Coastal Resources Management	C	ENCM 21533	-
	ENCM 43654 Environmental Toxicology and Risk Assessment	C^2	ENCM 31532	-
	ENCM 43668 Research Project	C^2	ENCM 41512 & ENCM 42532	-
	Credits at the end of Year 4 (Honours/Part I1)	**37**		

C^2 : Offered throughout the year

Total of Credits at the end of Year 4 = 30 + 31 + 31 + 37 = 129

7. Course Units Offered by the Department of Zoology and Environmental Management.

(i) ENCM Coded Course Units

Year - 1

Course Code : ENCM 11512
Title : Evolution of Earth and Biogeography
Pre-requisite : G.C.E. A/L Biology
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- explain the origin and the diversification of earth,
- explain the origin and diversification of life forms,
- explain evolutionary concepts, evolutionary patterns and human evolution,
- describe basic concepts in biogeography,
- describe regional distribution of biota, and
- discuss the effect of climate change on biogeography.

Course content:
History of evolutionary thought and biological evolution, Population genetics and evolution, Variation, Mechanism of evolution, Natural selection, Speciation, Adaptive radiation, Types of evolution, Origin of earth, hydrosphere, lithosphere and atmosphere, Theories of origin of life on earth, Diversification of prehistoric life, Atmospheric changes after the origin of life, Plant and animal invasion into land, Human evolution, Extinction of life forms including mass extinctions. Biogeographic history of earth, Plate tectonics, seismic activities and continental drift, Biogeographic regions of the world with fauna and flora, Dispersal of species and species distribution in the world, Theory of Island Biogeography, Regional distribution of biota with special reference to Sri Lanka and endemicity.
Practical sessions on adaptive radiation of selected animals and cladistics.

Method of teaching and learning:
A combination of lectures, practical sessions, computer based learning, assignments, and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Raven, P. H. & G. B. Johnson (2010). Biology. 8th Edition. Tata McGraw-Hill Edition.
2. Reece, J. B., L. A. Urry, M. L. Cain., S. A. Wasserman., P. V. Minorsky & R. B. Jackson (2011). Campbell Biology, Global Edition. 9th Edition. Pearson Education Inc., San Francisco, CA.
3. MacDonald, G.M. (2003). Biogeography-space, time and life. John Wiley and Sons.

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Course Code : ENCM 11522
Title : Introduction to Environmental Management
Pre-requisite : G.C.E. A/L
Co-requisite : None
Status : Compulsory, Theory

Learning outcomes:
After completion of the course unit, the student will be able to;

- explain the degradation of the natural resources concurrent to the growth of the human population size,
- describe impacts of developmental activities on natural resources,
- explain the need for management and sustainable utilization of natural resources, and
- explain the environmental management principles.

Course content:
Human population expansion and need for technological advancement, Industrialization and Industrial revolution, Need for expansion, intensification and modernization of technology in agriculture and allied fields in food production, Deforestation, Environmental pollution, Intensification of the use of natural resources.

Impacts on natural resources by anthropogenic activities including aquaculture, agriculture, animal husbandry and other means of food production, Use of agrochemicals, Tourism expansion, Non-rehabilitation of sites of short term economic activities, Economic activities of short term benefits including IUU fishing and ghost fishing, Ornamental fish trade, Extraction of valuable faunal and floral resources with special reference to Sri Lanka, Reduced soil quality due to erosion and Global climatic change, Non-equitable exploitation and consumption of natural resources in different parts of the world.

Depletion of the quality and quantity of non-renewable and renewable natural resources, The need for environmental management, Concept of sustainable utilization and management of natural resources, Environmental management and precautionary principles, Environmental remediation, Restoration, Eco-agriculture.

Method of teaching and learning:
A combination of lectures, computer assisted learning, assignments and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended readings:

1. Dash, M. C. (2014). Concepts of Environmental Management for Sustainable Development. 1st edition, I K International Publishing House Pvt. Ltd.
2. Hyde P. & P. Reeve (2004). Essentials of Environmental Management. 2nd revised edition, IOSH Services Ltd.
3. NSF (2014). Natural Resources of Sri Lanka: conditions, trends and prospects.
4. Park, C. (2001). The Environment: Principles and Applications.2nd edition, Routledge; London.
5. Waters, B. (2013). Introduction to Environmental Management. Routledge, London.

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Course Code : ENCM 11532

Title : Hydrology and Meteorology
Pre-requisite : G.C.E. A/L Biology
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- explain the basic hydrological and meteorological processes,
- describe the layout of a meteorological station and explain the usage of different meteorological instruments in measuring weather parameters, and
- measure and estimate selected meteorological and hydrological parameters using standard techniques.

Course content:
Water cycle, Precipitation - different forms of precipitation, measurement of precipitation, mean annual rainfall, average rainfall over an area, missing precipitation data, interception; Infiltration, percolation and infiltration indices, Runoff and runoff estimation – rational method, Cook's method, Curve number method, Hydrograph analysis, Evaporation and evapotranspiration.

Introduction to meteorology; natural climatic changes; orientation of earth in the solar system-orbital shape, tilt/declination, precession of the earth, Climate of the earth in relation to geographical position (Latitude and longitude), Meteorological parameters of the atmosphere, Meteorological station, Energy balance of the earth, Global wind patterns and depressions, Cloud formation and cloud patterns, Asian monsoons.

Practical sessions on measurement of infiltration; Field study: stream flow measurement; Observation of Meteorological station and meteorological instruments, Measurement of selected meteorological parameters using standard techniques.

Method of teaching and learning:
A combination of lectures, practical sessions including field studies, computer based learning, assignments and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Das M.M. & M.D. Saikia (2009). Hydrology. PHI Learning Pvt. Ltd., India.
2. Lakshmi, V. (2001). Land surface Hydrology, Meteorology, and Climate: Observations and Modeling. John Wiley & Sons.
3. Karamouz, M. (2012). Hydrology and Hydroclimatology: Principles and Applications. CRC press.
4. Suresh, R. (2008). Watershed Hydrology. 2nd Edition. Standard Publishers Distributors, Delhi, India.

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Course Code **:** ENCM 11543

Title **:** Soil and Mineral Resources
Pre-requisite **:** G.C.E. A/L Biology
Co-requisite **:** None
Status **:** Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;
- explain types of mineral resources and their economic importance,
- describe mineral resource extraction and environmental impacts,
- describe the rock weathering and soil formation process,
- explain the physical, chemical and biological properties of soils,
- explain the process of soil erosion, estimate soil erosion and propose appropriate soil conservation measures, and
- demonstrate competencies in identifying rocks and minerals and quantifying physical and chemical properties of soils using standard procedures.

Course content:

Type of Rocks, classification of rocks; Rock formations and rock weathering; Geological map of Sri Lanka, Economically important global, regional and national mineral resources; Extraction of mineral resources and impacts on environment. Soil as a natural resource and types of soils, Characteristics and properties of soils (physical, chemical and biological); Soil-Water Relationships; Soil classification; Soil formation, Soil profile; Soil erosion and soil degradation, types of soil erosion, estimation of soil erosion; Soil conservation measures, Soil Fertility and Nutrient Management, Geological processes that affect soil and water quality.

Practical sessions on Soil analysis; rocks and minerals of Sri Lanka, Soil sampling and sampling equipment; Soil profile, soil color; soil moisture and moisture factor; Soil texture by feel and sieving, soil structure; Soil texture by hydrometer method; Soil texture by pipette method; Soil particle density, soil bulk density and porosity; Soil pH, EC, CEC, Organic matter content, Soil fertility.

Method of teaching and learning:

A combination of lectures, practical sessions, computer based learning, assignments and small group discussions.

Assessment:

In-course assessment and end of semester examination.

Recommended reading:

1. Brady, N. C. & R. R. Weil (2007). The Nature and Properties of Soils. 14th Edition. Prentice Hall.
2. Dubey, S.K. & A. Arora (2010). A Practical Book on Soil, Plant, Water and Fertilizer Analysis. S.R. Scientific, India.
3. Geological Atlas of Sri Lanka.
4. Morgan, R.P.C (2005).Soil Erosion and Conservation. Wiley-Blackwell.
5. NSF(2014). Natural Resources of Sri Lanka: conditions, trends and prospects.
6. Sarkar, D. & A. Haldar (2010). Physical and Chemical Methods in Soil Analysis. New Age International Pvt. Ltd.

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Course Code : ENCM 12553
Title : Pollution and Environmental Health
Pre-requisite : ENCM 11522
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:

After completion of the course unit, the student will be able to;

- describe the major types and causes for environmental pollution,
- explain the impacts of environmental pollution on ecosystem health, and
- demonstrate competencies in the application of appropriate control and management strategies to minimize the pollution impacts on ecosystems.

Course content:

An introduction to environmental pollution: pollution, pollutants, sources and types (point and area, primary and secondary), Atmospheric pollution: Types of air pollutants, Sources of air pollutants, Atmospheric effects of pollution: Ozone depletion, Global warming and Greenhouse effect, Acid deposition, Photochemical smog, Indoor air pollution, Thermal, odor and noise pollution, Impacts of air pollutants on vegetation including plant die back, materials, livestock and human health, Control and management of air pollution. Freshwater, brackish water, marine and groundwater pollution, types of aquatic pollutants, Sources, environmental effects, control and management strategies of following types of aquatic pollutants: sediments and suspended matter, nutrients and algal toxins, pesticides, Persistent Organic Pollutants, oil, human sewage, Thermal pollution, Radioactive material, Acid deposition, Heavy metals, Plastic waste, Monitoring of aquatic pollution, Water quality standards, Global and national case studies on aquatic pollution. Land

Degradation: Acidification, alkalization and salinization of land, Leaching requirement and other remedial measures, Water logging and reclamation of water logged fields, Soil compaction and remedial measures, Prevention of pollution by leachate. Case study on pollution issues in Sri Lanka.

Method of teaching and learning:
A combination of lectures, field studies, computer based learning, assignments, and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Godish, T. (2003). Air Quality. 4th Edition. Lewis Publishers. INC.
2. Goel, P. K. (2006). Water Pollution: Causes, Effects and Control.New Age International, India.
3. Harrison, R. M. (1996). Pollution, Causes, Effects and Control. 3rd Edition. The Royal Society of Chemistry, Thomas Graham House, Science Park, Cambridge.
4. Hill, M. K. (1997). Understanding Environmental Pollution. Cambridge University Press, Cambridge.
5. Mirsal, I. (2008). Soil Pollution: Origin, Monitoring & Remediation. Springer-Verlag Berlin Heidelberg.
6. Purohit, S. S. & B. Kakrani (2002). Air Environment and Pollution.Agrobios, India.

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Course Code **:** ENCM 12562
Title **:** Sustainable Utilization of Energy Resources
Pre-requisite **:** ENCM 11522
Co-requisite **:** None
Status **:** Compulsory, Theory

Learning outcomes:
After completion of the course unit, the student will be able to;

- describe different energy resources and energy generation,
- explain global and national energy consumption patterns and impacts of excessive energy consumption,
- appreciate energy management of households and industries, and
- discuss strategies for sustainable utilization of energy.

Course Content:
Introduction to energy resources: wind, solar, tidal, geo-thermal, petroleum, coal, natural gas, hydro, nuclear, biogas, dendro, Energy Generation: hydropower, fossil fuels, petroleum, coal, natural gas, biogas, energy from waste, Classification of energy resources, Energy consumption patterns in the world, and in Sri Lanka, Impacts of accelerated energy consumption, Sustainable utilization of Energy: Energy management for households , and Industries, Potential of using alternative energies in Sri Lanka, Brief introduction to Energy conservation concepts and tools: ISO 9001, alternative energy sources, Energy Audits, Green Building, Life Cycle Analysis, Case studies on sustainable utilization of energy, Site visit to a ISO 50001 certified industry and a green building.

Method of teaching and learning:
A combination of lectures, computer based learning, assignments and small group discussions.
Assessment:
In-course assessment and end of semester examination.

Recommended Reading

1. Energy conservation in the home (2014). Colorado State University, USA.
2. Galarraga, I., G. Eguino & M. Markandya (2013). A Handbook of Sustainable Energy. Edward Elgar publishing, UK.
3. Röser, D., A. Asikainen., K. Raulund-Rasmussen & I. Stupak (2008). Sustainable Use of Forest Biomass for Energy. Springer publishing, USA.
4. Twidell, J. & T. Weir (2003). Renewable Energy Resources. Taylor & Francis, USA. **********

Course Code : ENCM 12572
Title : Forest Resources
Pre-requisite : ENCM 11522
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- describe ecosystem functions in tropical forests,
- identify the major threats to sustainable utilization of forest resources,
- explain the provisions in the Forest Act in the management of forest resources in Sri Lanka, and
- demonstrate skills in forest measurements and inventorying.

Course content:
Introduction to tropical forests, Patterns in Tropical Forests (Structural Concepts and Diversity of Tropical Forests); Role of forests in biogeo-chemical cycling, Natural microbial processes (decomposition), Reproductive Biology of Plants: Growth, Physiology, Animal Plant Interactions: Ecological Guilds, Animals as pollinators, Animals as seed dispersers, Coevolution, Symbiotic associations, Disturbance Ecology (Large Scale Disturbances and Succession; Small Scale disturbance and Regeneration), Carbon sequestration, Major threats (local and global) on Forest resources, Governance of the Forest Resource in Sri Lanka: National forest policy and Forest Ordinance, Reduce Emission from Deforestation programme, Measuring individual trees (dbh, age, height, tree basal area), measuring stands (stand basal area, stocking density), Forest profile diagrams, Forest inventorying, (Practical sessions on forest measurements and inventorying.

Method of teaching and learning:
A combination of lectures, field studies, computer assisted learning, assignments and discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Jaboury, G. & S. Douglas (2010). Tropical Rain Forest Ecology, Diversity, and Conservation. Oxford Biology.
2. Kangas, A. & M. Maltamo (2006). Forest Inventory: Methodology and Application. Springer Publication, printed in Netherlands.
3. National Forest policy 1995 and Forest (amendment) Act No. 65 of 2009 of Sri Lanka.

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Year - 2

Course Code : ENCM 21513
Title : Principles of Geo-informatics
Pre-requisite : ENCM 11522
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, student will be able to;

- describe definitions, components of and map projections in GIS,
- identify spatial data sources and explain spatial data acquisition methods in GIS,
- describe data storing methods in GIS,
- describe remote sensing, GPS and web GIS and their applications, and
- analyze spatial problems using a GIS software.

Course content:
Introduction to GIS, Components of GIS, Spatial questions, GIS applications, Data output methods, Structure of spatial data models; Raster and vector data models, Mapping the spherical Earth (3D) into 2D using projection systems, Geo-referencing, Geographical data sources, Data acquisition methods such as aerial photogrammetry, remote sensing, GPS, Data processing methods, GIS operation methods, web GIS, Elements of remote sensing, Characteristics of satellite images; spatial, temporal, spectral and radiometric resolution, Electromagnetic Spectrum and characteristics of major bands, Atmospheric reactions with electromagnetic waves, Different target reactions with waves, spectral signature, GPS concept and applications.
Practical sessions on analysis of spatial problems using ArcGIS.

Method of teaching and learning:
A combination of lectures, practical sessions, computer based learning, assignments and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Burrough, P. A., & R. A. McDonnell (2011). Principles of Geographical Information Systems; Spatial Information Systems and Geostatistics. 2nd edition. Oxford University Press. UK.
2. Fu, P (2010). Web GIS: Principles &Applications. ESRI press, USA.
3. Gorr, W. L (2013). GIS tutorial 1; Basic workbook, 10.1 Edition. ESRI press, USA.
4. Heywood, I., S. Cornelius, & S. Carver (2013). An Introduction to Geographical Information Systems. 4th edition. Pearson education Ltd., UK.
5. Law, M (2013). Getting to know ArcGIS for desktop. ESRI press, USA.

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Course Code **:** ENCM 21522
Title **:** Environmental Policies and Legislations
Pre-requisite **:** ENCM 11522
Co-requisite **:** None
Status **:** Compulsory, Theory

Learning outcomes:
After completion of the course unit, the student will be able to;
- explain the environmental policy formulation process in Sri Lanka,
- evaluate environmental management policies in Sri Lanka,
- describe the environmental assessment and licensing processes in Sri Lanka,
- describe environmental conventions and protocols that address global environmental issues and discuss their applicability in Sri Lanka, and
- demonstrate competency in applying the provisions in relevant Acts and Ordinances in the management of environment in Sri Lanka.

Course content:
Introduction to environmental policy and environmental law, Policy formulation process in Sri Lanka, Environmental conservation and management policies in Sri Lanka: National Environmental Policy (draft), Constitutional provisions in environmental management, Provisions in the Penal Code and Code of Criminal Procedure; National Environmental Act, National Environmental Regulations and Orders, Flora and Fauna Protection Ordinance, Coast Conservation Act, System of granting approval for development projects and high polluting industries in Sri Lanka, Initial Environmental Examination and Environmental Impact Assessment (IEE and EIA), Environmental Protection licensing (EPL) process, Environmental standards, Environmental management under provincial administration, Legislation on local government, Other Acts and Statutes related to the protection of environment, Central administration and Delegation of power with special reference to environmental conventions and management, Case studies: court cases relevant to application of environmental laws, International conventions and protocols relevant to global environmental issues.

Method of teaching and learning:
A combination of lectures, case studies, computer based learning, assignments and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Constitution of the Democratic Socialist Republic of Sri Lanka of 1978 and amendments.
2. National Environmental Act No. 47 of 1980 of Sri Lanka and amendments.
3. Divan S. & A. Rosencranz (2002). Environmental Law and Policy in India, Cases, Materials and statutes. 2nd Edition. Oxford University press, UK.
4. Donald K (1997). Report of the Regional Symposium on the Role of Judiciary in Promoting the Rule of Law in the area of Sustainable Development. South Asia Co-operative Environmental Programme. Colombo, Sri Lanka.
5. Bernie P. W., A. E. Boyle & C. Redgwell (2009). International Law and the Environment. 3rd Edition, Oxford University Press, UK.
6. Global environmental conventions and protocols.
7. Acts and Ordinances relevant to environmental conservation and management in Sri Lanka.

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Course Code **:** ENCM 21533
Title **:** Applied Ecology
Pre-requisite **:** ZOOL 12523
Co-requisite **:** ENCM 21542
Status **:** Compulsory, Theory

Learning outcomes:
After completion of the course unit, the student will be able to;

- explain the basic structure and functioning of an ecosystem,
- explain the principles related to the structure and functioning of populations,
- discuss the dynamics of the global human population,
- explain the factors affecting community composition,
- discuss the global climate patterns and distribution of biomes, and
- discuss the ecological concepts related to the structure and functioning of terrestrial and aquatic ecosystems.

Course content:
Basic structure and functioning of an ecosystem including energy flow, nutrient cycling and ecosystem productivity, Population ecology; Population size, Density and patterns of population dispersion, Demography including life tables, Survivorship curves and Reproductive rates, Exponential, geometric and logistic models of population growth, Utilization of patchy resources, Opportunistic organisms and life history patterns including r-selection and K-selection, Factors affecting population growth, Mechanisms of density independent and density dependent population regulation, Population dynamics including stability and functions and population cycles, The global human population, Community ecology; Community composition, Diversity indices, Species area relationships, Ecotones, Keystone and Flagship species, Concept of habitat and niche, Effect of environmental factors on biota, Concepts in stream/river ecology including Longitudinal zonation, River continuum concept, Flood-pulse concept and Serial discontinuity concept, Global climate patterns and climate change, Terrestrial and aquatic biomes, Structure and functioning of terrestrial, freshwater, brackish water, and marine ecosystems. Life Tables and key factor analysis.

Method of teaching and learning:
A combination of lectures, computer based learning, self-studies, assignments and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Begon M., C. R. Townsend & J. L. Harper (2005). Ecology; from individuals to ecosystems. 4th Edition, Wiley-Blackwell.
2. Day, J. W., W. M. Kemp, Alejandro Yanez-Arancibia & B. C. Crump (2012). Estuarine Ecology, 2nd Edition, Wiley-Blackwell.
3. Dobson, M. & C. Frid (2008). Ecology of Aquatic Systems. 2nd edition, Oxford University Press.
4. Osborne, P. L. (2000). Tropical Ecosystems and Ecological Concepts. Cambridge University Press.
5. Raven, P. H. & G. B. Johnson (2010). Biology. 8th Edition. Tata McGraw-Hill Edition.
6. Reece, J. B., L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky & R. B. Jackson (2011). Biology - Campbell, 9th Edition. Pearson Education Inc.
7. Tait, R.V. & F. A. Dipper (2000). Elements of marine ecology. Butterworth-Heinemann, Oxford.

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Course Code **:** ENCM 21542
Title **:** Applied Ecology Laboratory
Pre-requisite **:** ZOOL 12531
Co-requisite **:** ENCM 21533
Status **:** Compulsory, Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- sample terrestrial and aquatic habitats using appropriate techniques,
- use basic ecological techniques for understanding ecosystem functioning,
- apply ecological indices to assess communities,
- assess the ecological adaptations of animals in relation to their habitats, and
- analyse, interpret and present ecological data in scientific manner.

Course content:
Sampling techniques for terrestrial, aerial, soil and aquatic animals; Study of soil ecosystems; Diversity indices; Estimation of the size of animal populations; Measurement of water quality; Limiting factors and their effect on animals; Identification of animals in the brackish water, Freshwater and marine ecosystems and their ecological adaptations; Construction of life tables and key factor analysis, Climatic diagrams, Demography in terrestrial habitats

Field studies on terrestrial, freshwater, brackish water and marine ecosystems.

Method of teaching and learning:
A combination of laboratory and field studies and computer based learning.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Brower, J. E., J. H. Zar, C. N. Von Ende (1997). Field and Laboratory methods for General Ecology. 4th Edition. McGraw-Hill, Boston.
2. Chalmers, N. & P. Parker (1996). Fieldwork and Statistics for Ecological Projects: The OU Project Guide, London.
3. Enger, E. D. & B. F. Smith (2012). Field laboratory exercises in environmental science, 7th edition. McGraw-Hill, New Jersey.
4. Krebs, C.J. (1999). Ecological Methodology, Addison-Welsey Educational Publishers, New York.

5. Magurran A. (2004). Measuring biological diversity, Wiley.
6. Southwood, T. R. E. & P. A. Henderson (2000). Ecological Methods, 3rd Edition, Wiley-Blackwell.

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Course Code **:** ENCM 21552
Title **:** Parasites, Vectors and Environmental Health
Pre-requisite **:** ZOOL 12523
Co-requisite **:** None
Status **:** Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- describe major public health problems associated with animal reservoirs, arthropod vectors and parasites in the environment,
- discuss the epidemiology of public health problems associated with parasites, animal reservoirs/arthropod vectors, and
- discuss the importance of managing the environment for prevention and management of public health issues related to animal reservoirs/arthropod vectors/parasites.

Course content:
Major public health problems associated with zoonotic and vector borne environmental diseases; Epidemiology of major zoonotic diseases in Sri Lanka; Cryptosporidiosis, Balantidiasis, Giardiasis; Epidemiology of major vector-borne diseases in Sri Lanka; Dengue, Malaria, Encephalitis, Filariasis; Vector surveillance; Management and prevention of zoonotic and arthropod-borne diseases, Impact of environmental changes on zoonotic and vector borne diseases, Emerging zoonotic diseases, Global trends and public health implications in emerging zoonoses, Practical sessions on identification of selected parasites and arthropod vectors associated with human health issues in Sri Lanka and vector surveillance.

Method of teaching and learning:
A combination of lectures, practical sessions including field studies, computer based learning, assignments, and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:
1. Eldridge, B.F. & Edman, J.D. (2004). Medical Entomology: A text book on public health and veterinary problems caused by arthropods. Kluwer Academic Publishers, London.
2. Friis, R.H. (2010). Essentials of Environmental Health. 2nd Edition (Essential Public Health).Jones & Bartlett Learning.
3. Robinson, W.H. (2005). Urban Insects and Arachnids: A Handbook of Urban Entomology. Cambridge University Press.

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Course Code **:** ENCM 21562
Title **:** Solid Waste Management
Pre-requisite **:** ENCM 12553
Co-requisite **:** None
Status **:** Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- discuss the issues related to disposal of solid waste and explore effective waste management strategies,

- discuss the applicability of waste to energy conversion techniques, and
- develop basic management plans for handling domestic, municipal, and industrial solid waste.

Course content:
Solid waste; generation, sources, types and composition, Physical, chemical and biological properties of solid waste, Environmental impact of solid waste, Storage, collection and transportation of solid waste, Domestic, municipal and industrial solid waste management techniques: physical transformation: component separation, volume reduction, size reduction, resource recovery, 3R/5R and 7R concepts, Treatment and energy recovery: biological transformations - aerobic degradation, Anaerobic degradation, Thermo chemical transformation: combustion, incineration, pyrolysis, gasification, Disposal of solid waste – open dumping, ocean dumping, sanitary landfills, sanitary landfill design considerations, operations, environmental monitoring, landfill gas recovery, Integrated solid waste management, case studies, Legal aspects of solid waste management.
Field studies on waste management techniques.

Method of teaching and learning:
A combination of lectures, field studies, computer based learning, assignments and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Bagchi, A. (2004). Design of Landfills and Integrated Solid Waste Management. 3rd Edition. Willey.
2. Chandrappa, R. & D.B. Das (2012). Solid Waste Management: Principles and Practice. Springer, Verlag Berlin Heidelberg.

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Course Code **:** ENCM 22572
Title **:** Waste Water Management
Pre-requisite **:** ENCM 11522
Co-requisite **:** None
Status **:** Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;
- explain different options for wastewater treatment,
- design basic wastewater treatment units,
- propose methods suitable to treat wastewater, and
- explain the possibilities of reuse of wastewater.

Course content:
Types of wastewater and constituents in wastewater, Problems of wastewater, Design of basic wastewater treatment units; Wastewater flow rates and loading, Physical unit operations, Chemical unit operations, Biological Treatment of Wastewater: Aerobic Processes, Suspended Growth Processes, Attached Growth Processes, Anaerobic Biological Wastewater Treatment Processes, Other wastewater treatment options including reverse osmosis, Sludge Treatment, Sewage treatment, Wastewater reuse, Effluent tolerance limits and discharge Standards, Field studies on wastewater treatment plants.

Method of teaching and learning:
A combination of lectures, computer assisted learning, assignments, and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Davis, M. (2013). Water and Wastewater Engineering, McGraw-Hill Science, India.
2. Karia, G. L. & R. A. Christian (2013). Waste Water Treatment: Concepts & Design Approaches, 2nd edition, PHI Learning Pvt. Ltd, New Delhi.
3. Mackenzie, D. & S. Masten (2013). Principles of Environmental Engineering & Science, McGraw-Hill Science.
4. Tchobanoglous, G., F. Burton & H. D. Stensel (2012). Wastewater Engineering: Treatment and Reuse, McGraw-Hill Science, India.

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Year - 3

Course Code **:** ENCM 31513
Title **:** Environmental Economics
Pre-requisite **:** ENCM 11522 & ENCM 12553
Co-requisite **:** None
Status : Compulsory, Theory
(Not offered for students following BSc (Honours) in ENCM Degree programme)

Learning outcomes:
After completion of the course unit, the student will be able to;

- explain basic theories and concepts of economics and environmental economics,
- determine optimal pollution levels and solutions for pollution externalities,
- make decisions on new development project approval by performing a cost benefit analysis, and
- assess environmental valuation techniques.

Course content:
Basic economic theory and concepts: Resources, Scarcity, Organization of the economic system; Nature of Demand and Supply Curve, Equilibrium in the market, Determinants of market demand, Elasticity of demand and supply; Production Economic Theory – Production function, Factor-product relationship, Factor-factor relationship; Theory of Cost – Short run and long run cost functions, Economics of scale; Theory of Price – different types of markets (perfectly competitive, monopoly, oligopoly, monopolistic competition).
Introduction to Environmental and Natural Resources Economics: scarcity, choice and opportunity cost, Basic ethics, value systems and the normative foundations of economics and other social systems, The requirements and equilibrium characteristics of a well-functioning competitive market, Market Failures in Environmental Economics (imperfect information, public goods, externalities). Economics of market allocation, open access resources, tragedy of commons The Marginal Damage Function, The Marginal Abatement Cost Curve.
Economics of pollution control: Basic concepts: fund and stock pollutants, allocation between generations, designing policy instruments for pollution control; pollution standards, charges and marketable pollution permits; evaluation of each instrument based on economic efficiency, inducements for technological advancements and transaction costs; Industrial pollution as an externality; solutions for externality problem.
Economic analysis of projects: Financial vs. economic analysis, criteria for comparing costs and benefits – Discounted Payback period, Net Present Value, Internal rate of return, Benefit Cost Ratio; advantages, disadvantages of each criteria; spreadsheet modeling of calculation of each criteria. Cost Benefit Analysis: basis, methodology; the need for extended cost benefit analysis, limitations of Cost Benefit Analysis. Environmental Valuation: importance of valuation, the concept of total economic value. Environmental valuation methods: Theory, main assumptions, detailed methodology and estimation and validation issues: Travel cost method, Contingent valuation method, Hedonic price method, Shadow project approach etc.

Method of teaching and learning:
A combination of lectures, field studies, computer based learning, assignments, and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Hussen, A.M. (2000). Principles of Environmental Economics: Economics, Ecology and Public Policy. Routledge, New York.
2. Karl, C., F. Ray & S. Oster (2013). Principles of Economics. 11th Edition.Pearson Education Limited, USA.
3. Tietenburg, T. (2003). Environmental and Natural Resource Economics. 6th Edition. Addison Wesley Longman, New York.

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Course Code **:** ENCM 31522
Title **:** Environmental Impact Assessment
Pre-requisite **:** ENCM 21543 / ZOOL 22543
Co-requisite **:** None
Status **:** Compulsory, Theory

Learning outcomes:

After completion of the course unit, the student will be able to;

- describe and discuss Environmental Impact Assessment process, and
- demonstrate competencies in planning and executing EIA process.

Course content:

Introduction to Environmental Impact Assessment (EIA); EIA and quality of life, Principles of EIA, History of EIA, The Nature of EIA, Purpose of EIA, Origin and development of EIA process and worldwide spread of EIA, Developmental projects, Environment and impacts; EIA procedures and managing EIA process, EIA methodologies: Optimization of resources, cost-benefit analysis, cost-effectiveness analysis, opportunity cost, 'the multiplier', contingent valuation, travel cost approach, Hedonic price technique, ecological evaluation, matrices and checklists, the multidisciplinary team, best professional judgment, Impact prediction, evaluation and mitigation, Principal stakeholders in EIA; developers, affected parties, regulators, facilitators, institutional interactions, Public consultation and participation in EIA process; EIA presentation, Monitoring and auditing, Problems associated with EIA process in developing countries and potential solutions, Issues related to scope of assessment, the nature of methods of assessment, the relative role of participants in the process, and the quality of assessments, Myths about EIAs, Incorporation of impacts and their mitigation into the process, Use of EIA as a decision making tool for achieving sustainable development; Improving the effectiveness of project assessment; Widening the scope of EIA (Strategic Environmental Assessment; SEA); Case studies.

Method of teaching and learning:

A combination of lectures, assignments, self-studies, computer based learning, and small group discussions.

Assessment:

Continuous assessment and end of semester examination.

Recommended reading:

1. Canter, L.W., (1996) Environmental Impact Assessment, Second Edition, McGraw Hill Publishing Company, Inc., New York.
2. CEA Report: Handbook on strategic Environmental Assessment (SEA). www.cea.lk/web/images/pdf/SEAGuideline.pdf
3. CEA (2013). EIA Procedure in Sri Lanka.
4. www.cea.lk/web/index.php/en/environmental-impat-assessment-eia-procedure-in-sri-lanka
5. EIA reports of various development projects.
6. Gilpin, A., (1995). Environmental Impact Assessment (EIA) –Cutting edge for the Twenty First Century, Cambridge University Press, Cambridge, England.
7. Vanclay, F., and Bronstein, D.A., (1995) Environmental and Social Impact Assessment, JohnWiley and Sons Ltd., Chichester, England.

8. Glasson, J., R. Therivel and A. Chadwick (1999) Introduction to Environmental Impact Assessment. University College London Publication, Tayler and Francis Group.
9. Zubair, L. (2001). EIA procedure: Challenges for Environmental Impact Assessment in Sri Lanka. Environmental Impact Assessment Review. 21:469-478.

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Course Code : ENCM 31532
Title : Environmental Monitoring
Pre-requisite : ENCM 21542
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- discuss applicability of different environmental monitoring approaches for environmental management,
- design monitoring programs relevant to key environmental issues, and
- demonstrate adequate competencies in analyses of selected environmental samples and present and interpret the results in a scientific manner.

Course content:
Importance of environmental monitoring for environmental management, data quality objectives, environmental data acquisition, scientifically reliable and legally defensible data; Applications of physico-chemical methods and bio monitoring methods, bio accumulators, bio indicators and biomarkers in environmental monitoring; Human bio monitoring methods; Design and execution of monitoring programmes relevant to key environmental issues, selection of priority parameters; Environmental sampling and sample handling; Quality assurance and quality control procedures.

Practical sessions on quality control and quality assurance procedures, Analysis of river water, well water and effluents using physico-chemical monitoring methods; Applications of selected bio monitoring approaches for monitoring environment, Case studies on designing environmental monitoring programs relevant to selected environmental issues in Sri Lanka.

Method of teaching and learning:
A combination of lectures, laboratory and field studies, computer based learning, assignments and discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Artiola, J. F., I. L. Pepper &, M.L, Brusseau (2004). Environmental Monitoring and Characterization. Elsevier Inc
2. Csuros, M. (1997). Environmental Sampling and Analysis: Lab manual. CRC press, New York.
3. Patnaik, P. (2010). Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil, Solid Wastes.2nd edition. CRC press, New York.
4. Wiersma, G.B. (2004). Environmental Monitoring. CRC Press, New York.
5. Zhang, C. (2007). Fundamentals of Environmental Sampling and Analysis. John Wiley and Sons, New Jersey.

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Course Code : ENCM 31543
Title : Environment Management Systems and Green Technology
Pre-requisite : ENCM 11522 & ENCM 21522
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- describe the elements of ISO 14001 environmental management system,
- demonstrate competencies to plan and implement ISO 14001,
- discuss the application of cleaner production strategies to minimize waste & to reduce cost, and
- discuss the applications of life cycle assessment and design for sustainability concepts in environmental management.

Course content:
Factors driving environmental initiatives in organizations, Introduction to environmental management systems, ISO 14001, documentation, procedure to obtain ISO certification, environmental auditing and gap analysis, impact, aspect register, implementation of ISO standards, Environmental quality standards; HACCP, TQM, derived discharge and emission and effluent standards, cleaner production; principles and application procedure, carbon and water footprints and their reduction, Life Cycle Assessment (LCA) of products, Life Cycle Screening (LCS), Design for the Sustainability (D4S), Green: products and technologies, energy, procurement, building and supply chain management, Chemical leasing and chemical care as strategies in environmental management.

Field studies: Factory visits to study implementation of environmental management systems, application of cleaner production techniques and green building concept. Conducting an environmental audit for a chosen production line in a selected factory.

Method of teaching and learning:
A combination of lectures, field studies, computer based learning, assignments, and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Klinger, K. (2001). Green Technologies: Concepts, Methodologies, Tools and Applications. PA, USA.
2. Lennart N., P. O. Persson., A. Ryden & A. Daroszka (2007). Cleaner Production: Technologies and Tools for Resource Efficient Production. The Baltic University Press, Uppsala.
3. Madrigal, A. (2011). Powering the Dream: The History and Promise of Green Technology. Da Capo press, 11 Cambridge Centre, Cambridge, UK.
4. Stephen, T & P. Ilona (2006). Environmental Management Systems: Understanding Organizational Drivers and Barriers. Earthscan, USA. **********

Course Code : ENCM 31552
Title : Hazardous Waste Management
Pre-requisite : ENCM 22572
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- state the characteristics of different types of hazardous waste,
- describe the treatment and disposal techniques,
- discuss the impacts of hazardous waste contamination, and

- develop basic management plans for handling domestic, municipal, industrial and medical/infectious hazardous waste.

Course content:
Hazardous Waste: definition and classification, sources, fate and transport of contaminants, effects, Current management practices: waste audits, pollution prevention, waste minimization, reuse and recycling, Treatment and disposal methods: Physical, chemical, physico-chemical, biological and thermal methods, Land disposal: site selection, liners, landfill stability, closure and post closure care, monitoring methods, surface impoundments, deep well injection, Legal aspects, Workplace management of hazardous materials and hazardous waste, Site remediation and remedial technologies, Guidelines for the management of scheduled waste, scrap tires, lead acid batteries (Sri Lankan context), Medical/ biomedical/ infectious waste management, Radioactive waste management, Case studies.

Method of teaching and learning:
A combination of lectures, field studies, computer based learning, assignments and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Blackman, W.C. (2001). Basic hazardous waste management. 3rd edition CRC Press.
2. LaGrega, M. D., P. L. Buckingham & J. C. Evans (2010). Hazardous Waste Management. Reissue edition, Waveland Press, INC.
3. www.cea.lk- publications

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Course Code **:** ENCM 33564
Title **:** Environmental Project
Pre-requisite **:** All level I & II ENCM course units
Co-requisite **:** None
Status **:** Compulsory, Practical
(Not offered for students following BSc (Honours)in ENCM Degree Programme)

Learning outcomes:
After completion of the course unit, the student will be able to;
- develop skills to apply the knowledge gained in the areas of environmental conservation and management,
- explore real world problems based on outreach activities and address environmental issues in Sri Lanka, and
- propose remedial and conservation measures to manage the problems identified.

Course content:

A short term case study on any aspect of environmental issue in Sri Lanka under the guidance of a senior academic staff member. The case study should focus on outreach activities, and is carried out by a small group of 3-4 students.

The case study should cover the following aspects; Identification of the environmental issue; Development of objectives of the case study with proper justifications; Designing methodologies and strategies with an appropriate time frame to achieve the objectives; Presentation of the proposal; Organizing outreach activitiesGathering of qualitative and quantitative data; Analysis of data using appropriate methods; Interpretation of the results, Drawing conclusions and Recommendations to manage the identified problem; Report writing and presentation in scientific manner.

Method of teaching and learning:
Literature survey, outreach activities, laboratory and/or field work, data analysis and interpretation and preparation of a case study report.

Assessment:
Continuous assessment during the case study and evaluation of the project proposal, case study report and the oral presentation at the end of the semester.

Recommended reading:
Relevant materials on the topic of the case study such as research papers published in journals and conference proceedings, text books, commissioned reports and other reliable sources.

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Course Code **:** ENCM 32572
Title **:** Natural Disaster Management
Pre-requisite **:** ENCM 11512 & ENCM 11532
Co-requisite **:** None
Status **:** Optional, Theory

Learning outcomes:
After completion of the course unit, student will be able to;

- describe elements/components of disaster management,
- assess risk management options in natural disasters,
- discuss structural and non-structural disaster mitigation measures, and
- discuss practical issues of disaster management.

Course content:
Introduction to natural disasters: scope and objectives of disaster management, Concepts and terms in disaster management; Natural disasters vs. Man-made disasters, Disaster victim, Disaster relief systems, Phases of disaster response, Phases of relief operations, Risk and vulnerability of natural disasters, Elements/components of disaster management; preparedness, Response, Recovery, Prevention, Mitigation of natural disasters, Disaster management system; disaster prediction, warning, management and relief, Technologies of disaster management; mapping, remote sensing, communication and information management, Issues of disaster management, Case studies.

Method of teaching and learning:
A combination of lectures, computer based learning, assignments, case studies and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Collins L. R. (2000). Disaster Management and Preparedness. CRC Press.
2. Singh R. B. (2006). Natural Hazards and Disaster Management: Vulnerability and Mitigation. Rawat publication.
3. Venkataraman L. & J. Schaake (2001). Surface Hydrology, Meteorology and Climate: Observations and Modeling, American Geographical Union**.**

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Course Code **:** ENCM 32582
Title **:** Urban Environment Management
Pre-requisite **:** ENCM 11522
Co-requisite **:** None
Status **:** Optional, Theory

Learning outcomes:
After completion of the course unit, the student will be able to;

- discuss the impacts of built environment,
- describe methods of land use planning and recommend appropriate designs, and
- demonstrate competencies in decision-making and problem-solving in urban environment management.

Course content:

Urbanization and urban growth, Urban resources and environmental problems, General scope of urban environmental management; Rural-urban migration determinants, impacts of built environment; The problems confronting Asian cities, urbanization and economic development relationship; Transportation (highways and road development projects) and Urban development; Technology oriented and people oriented management systems including ISO standardization; spatial planning, economic instruments, Urban and environmental policies for sustainable urbanization and cities; The Eco-city concept.

Urban Land use Planning and control, the conventional land use planning, ecological land use planning, and the concepts of urban planning, Planning theories and planning tools, and ecological urban Designs, Environmental and socioeconomic aspects of land use, Land use patterns, Structures and models, Land use planning systems, Land classification and evaluation, Land suitability and capability classes, Urban and rural land use, Land use decision making, Land policies, Land tenure and land administration.

Field studies on selected urban environmental planning approaches.

Method of teaching and learning:

A combination of lectures, field studies, computer based learning, assignments, and small group discussions.

Assessment:

In-course assessment and end of semester examination.

Recommended reading:

1. Hanaki, K. (2008). Urban Environmental Management and Technology. Springer.
2. Josef, L. (1999) Sustaining Cities: Environmental Planning and Management in Urban Design. McGraw Hill.
3. Maurya, S. D. (1988) Urban Environment Management: A Functional Study. Chugh Publications.

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Course Code **:** ENCM 32592
Title **:** Water Resources Management
Pre-requisite **:** ENCM 21533
Co-requisite **:** None
Status **:** Compulsory, Theory cum Practical

Learning outcomes:

After completion of the course unit, the student will be able to;

- explain and describe the principles of water resources planning and management,
- discuss the impacts of interventions on land and water resources,
- assess the key concepts for integrated water resources management, and
- analyze rainfall and river flows in decision making on water resources planning and management.

Course content:

Water allocation and utilization, Water resources utilization in agriculture, Measures to improve efficiency and sustainability of water use in agriculture, Water measurement in irrigation; Sectoral and holistic approach of water resource management, Principles and practice of water resources planning and management (Dublin principle, Integrated Water Resources Management); Water demand management and demand management tools; Bulk water allocation, Groundwater extraction and water Supply Wells, Aquifers and Groundwater Recharge Areas, Watershed Management as tool for water resources management, Water withdrawal from rivers and other freshwater sources and lower water levels in reservoirs, lakes, and ponds; Mass curve analysis, Modeling rainfall-runoff relationships; Conservation of freshwater and groundwater resource, techniques used in water conservation, Environmental flow; Impacts of mini hydropower projects; Impact of river basin development projects.

Practical sessions on rainfall frequency analysis; Application of computer models in water resources estimation and management; Modeling rainfall-runoff relationships.

Method of teaching and learning:
A combination of lectures, computer based learning, assignments and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Biswas, A. K., O. Varis & C. Tortajada (2005). Integrated Water Resources Management in South and South-East Asia.Oxford University Press.
2. Grafton, R.Q. & K. Hussey (2011). Water Resources Planning and Management, Cambridge University Press.
3. Sawvel, P.J. (2008). Water Resources Management (Introducing Issues with Opposing Viewpoints). Greenhaven.
4. Srinivasa, R. K. & A. Vasan (2010). Sustainable Water Resources Management and Impact of Climate Change.BS Publications, New Delhi, India.
5. Publications of the CapNet (http://www.cap-net.org).

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Course Code **:** ENCM 32605
Title **:** In-Plant Training
Pre-requisite **:** All level 1 and level II ENCM course units
Co-requisite **:** None
Status **:** Compulsory, Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- accustom successfully to the organizational structure in an industry/institute related to environmental conservation and management and function as an effective team member.

Course content:
The student will be placed in a selected industry/ institution where practical applications of environmental conservation and management are applied, and undertakes training to obtain experience at the professional working environment. During the training period, it is intended that the student develops inter-personal and self-management skills to adapt to a professional working environment while gaining experience on selected functioning aspects of the industry/institute. During the training it is also expected that the student learns the accepted safety, health and environmental (SHE) practices in the industry/institute, develops attitudes and the sense of responsibility towards the society, develop team work, organizational entrepreneurship and leadership skills, develop talents to face, manage and resolve issues related to the working environment with special reference to environmental conservation and management, adhere to the institutional regulations, undertake tasks within a prescribed time frame, and develop communication and interactive skills.

Method of teaching and learning:
Training under the supervision and guidance of a competent personnel in an industry or institution related to environmental conservation and management.

Assessment:
Evaluation of the progress report submitted by the trainer and the student's technical report and oral presentation on student's experience at the work place.

Recommended reading:
Reading and reference materials will be recommended/ provided by the relevant industry /institute where necessary.

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Year - 4

Course Code : ENCM 41512
Title : Statistics for Environmental Management
Pre-requisite : ENCM 21542
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- apply appropriate statistical methods for the analysis of numerical data relevant to environmental science,
- use appropriate software packages for analysis of experimental data, and
- interpret environmental data in a scientific manner.

Course content:
Introduction to scientific method and the statistical approach, Introduction to types of environmental data, Sample statistics and population parameters, Probability and cumulative density functions, Models of probability distributions including binomial distribution, hypergeometric distribution, Poisson distribution and normal distribution. Confidence intervals, Error-bound, Hypothesis testing. Chi-square test, Kolmogorov-Smirnov test, Product moment correlation, Simple linear regression, Probit analysis, One-way ANOVA, Two-way ANOVA. Multiple comparison procedures including Tukey's test, Scheffe's test. Non-parametric statistics including; Mann-Whitney U test, Kruskal Wallis test, Wilcoxon signed rank test, Rank correlation, Multivariate statistics including similarity matrix, cluster analysis, MDS and PCA.
Practical sessions on the use of statistical software packages for data analysis.

Method of teaching and learning:
A combination of lectures, computer based learning on the use of statistical software packages, assignments, self-studies, small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Fowler, J. & L. Cohen (1994). Practical Statistics for Field Biology: Wiley & Sons, Chichester.
2. Sokal, R. R. & F. Rohlf (1995). Biometry. W.H. Freeman and company, New York.
3. Zar, J. H. (1999). Biostatistical Methods. Prentice-Hall, New Jersey.

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Course Code : ENCM 41523
Title : Forest Resources Management
Pre-requisite : ENCM 12572 & ENCM 21522
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- discuss applicability of forest management techniques in commercial forest industry,
- prepare a forest management plan for a given context by applying appropriate forest management techniques, and
- describe the status of community and social forestry projects in Sri Lanka.

Course Content
Sustainable management of natural forests, Forest management in commercial and Industrial forestry; Forest Management techniques, Seed Collection and seed banks and Nursery Management Techniques; (Nursery design, seed bed preparations, seed treatments, maintenance, transportation), Factors in selecting tree species and sites, Ground preparation, Planting techniques, Stand tending techniques: Thinning, pruning, weeding, watering and fertilizer applications, Defining Rotation age, Industrial Harvesting Techniques, Silvicultural Techniques, Pests and diseases, Application of ecological concepts in forest management, Environmental impacts in forest management, Community and social forestry: case studies, Preparation of Forest Management plans.
Practical sessions on forest management plan preparation.

Method of teaching and learning:
A combination of lectures, field studies, computer assisted learning, assignments and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Bettinger, P., K. Boston., J. P. Siry & D. L. Grebner (2008). Forest Management and Planning, Academic Press, USA.
2. Günter, S., M. Weber, B. Stimm & R. Mosandl (2011). Silviculture in the Tropics, Springer, USA.
3. Julian E. & J. W. Turnbull (2004). Plantation Forestry in the Tropics: The Role, Silviculture, and Use of Planted Forests for Industrial Social, Environmental, and Agroforestry Purposes, Oxford University Press, UK.
4. Lawrence, S. D., K. Norman & J. P. Bettinger (2001). Forest Management: To Sustain Ecological, Economic, and Social Values. 4th Edition. Illinois, USA.

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Course Code **:** ENCM 43532
Title **:** Essay and Seminar on Special Topics in Environmental Management
Pre-requisite **:** ENCM 21522
Co-requisite **:** None
Status **:** Compulsory

Learning outcomes:
After completion of the course unit, the student will be able to;
- demonstrate a coherent overview of a given topic in environmental conservation and management,
- present the overview in the form of an essay, and
- defend the contents of the essay in the form of a seminar to the academic audience.

Course content:
A topic, which will be assigned at the beginning of the course.

Method of teaching and learning:
Self-studies including relevant literature survey and computer assisted learning.

Assessment:
Evaluation of the essay and seminar.

Recommended reading:
Reading material will be assigned at the beginning of the course and/ or should be found by the student.

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Course Code : ENCM 42542
Title : Research Methodology and Scientific Writing
Pre-requisite : ENCM 41512
Co-requisite : None
Status : Theory, Compulsory

Learning outcomes:
After completion of the course unit, the student will be able to;

- describe the sequential steps in the research process,
- explain a range of research methodologies used in scientific investigations and discuss the applicability of these methodologies in environmental science research,
- demonstrate competencies in using different sampling strategies in environmental investigations,
- explain the procedure of developing a research proposal for solving an identified research problem,
- identify the stipulated requirements for scientific writing of a dissertation, research papers, abstracts/extended abstracts for research conferences,
- quote references appropriately in the scientific documents based on stipulated requirements, and
- identify ethical issues in the context of research.

Course content:
Nature of scientific research: Inductive and deductive reasoning; scientific method; Sequential steps in the research process, Locating scientific literature using electronic search engines, Reviewing scientific literature, Formulating a research problem and postulating hypotheses; Conceptualizing a research design and data collection methods; Introduction to populations, samples, sampling units; Sampling techniques; simple random sampling, stratified sampling, systematic sampling and cluster sampling, determination of sampling size, Research designs based on number of contacts, reference period, and nature of investigation; Research methods in pure and applied sciences, descriptions, comparative studies, experiments modeling, surveys, case studies, meta-analysis; Experimental design; Complete Randomized Design and Randomized Block Design, Latin Square design.
Compiling a research proposal for solving the identified research problem, Scientific writing for dissemination of research findings: Academic writing, Formatting and Referencing requirements Effective presentation methods; Guidelines for writing a dissertation, Guidelines for writing a research paper, guidelines for preparation of abstracts and extended abstracts for presentations at research conferences/symposia.
Research ethics: Role and responsibilities of being a researcher, honesty and integrity; Ethical concerns related to the research process, Ethics of publication of research findings.

Method of teaching and learning:
A combination of lectures, computer based learning, assignments, self-studies, presentations and discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Creswell, J. W. (2009). Research Design. Sage Publications Inc. California.
2. Hofmann, A. H. (2009). Scientific writing and communication: Papers, proposals and presentations, Oxford University Press.
3. Kumar, R. (2005). Research Methodology, Pearson Education, Australia.

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Course Code : ENCM 42553
Title : Geo-informatics for Environmental Management
Pre-requisite : ENCM 21523
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- explain the theory of spatial analysis and discuss the applicability of spatial data models,
- describe the use of spatial entities to create a data model,
- apply image classification technique for data capturing in GIS,
- apply suitable spatial analysis methods to solve environmental problems, and
- assess the issues related to data analysis in GIS.

Course content:
Theory in spatial data analysis; measuring distances, perimeters and area in raster and vector data models, Queries, reclassification and buffering, Overlay, Surface interpolation, Analysis of surfaces; slope, aspect and visibility, Spatial data modelling; definition, data model and data structure, Raster data compaction techniques, Topological structuring of complex areas, Modelling surfaces; DTM; raster approach, data sources for DTMs, TIN; vector approach, Modeling networks, modelling the third dimension, modeling the fourth dimension-time, Analytical modelling in GIS; modelling physical and environmental process; hydrological modelling and Soil erosion modelling, Remote sensing; image classification, Vegetation indices.
Practical sessions on applications of ArcGIS in environmental management.
Method of teaching and learning:

A combination of lectures, practical sessions, computer based learning, case studies, assignments, and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Burrough, P. A., & R. A. McDonnell (2011). Principles of Geographical Information Systems; Spatial Information Systems and Geostatistics. 2nd edition. Oxford University Press. UK.
2. Fu, P, (2010). Web GIS: Principles &Applications. ESRI press, USA.
3. Gorr, W. L. (2013). GIS tutorial 1; Basic workbook, 10.1 Edition. ESRI press, USA.
4. Heywood, I., S. Cornelius & S. Carver (2013). An Introduction to Geographical Information Systems. 4th edition. Pearson education Ltd., UK.
5. Law, M. (2013). Getting to Know ArcGIS for Desktop. ESRI press, USA.

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Course Code : ENCM 41564
Title : Applications in Environmental Economics
Pre-requisite : ENCM 31543
Co-requisite : None
Status : Compulsory, Theory

Learning Outcome
After completion of the course unit, the student will be able to;

- explain basic theories and concepts of economics and environmental economics,
- determine optimal pollution levels and solutions for pollution externalities,
- make decisions on new development project approval by performing a cost benefit analysis,

- assess environmental valuation techniques,
- perform extended CBA in project approval, and
- incorporate environmental values into project analysis.

Course Content

Basic economic theory and concepts: Resources, Scarcity, Organization of the economic system; Nature of Demand and Supply Curve, Equilibrium in the market, Determinants of market demand, Elasticity of demand and supply; Production Economic Theory – Production function, Factor-product relationship, Factor-factor relationship; Theory of Cost – Short run and long run cost functions, Economics of scale; Theory of Price – different types of markets (perfectly competitive, monopoly, oligopoly, monopolistic competition). Introduction to Environmental and Natural Resources Economics: scarcity, choice and opportunity cost, Basic ethics, value systems and the normative foundations of economics and other social systems, The requirements and equilibrium characteristics of a well-functioning competitive market, Market Failures in Environmental Economics (imperfect information, public goods, externalities). Economics of market allocation, Open access resources, tragedy of commons, The Marginal Damage Function, The Marginal Abatement Cost Curve. Economics of pollution control: Basic concepts – (fund and stock pollutants, allocation between generations, Designing policy instruments for pollution control; pollution standards, charges and marketable pollution permits; Evaluation of each instrument based on economic efficiency, Inducements for technological advancements and transaction costs; Industrial pollution as an externality; solutions for externality problem. Economic analysis of projects: Financial vs. economic analysis, Criteria for comparing costs and benefits – Discounted Payback period, Net Present Value, Internal rate of return, Benefit Cost Ratio; Advantages, disadvantages of each criteria; Spreadsheet modeling of calculation of each criteria. Cost Benefit Analysis: basis, methodology; the need for extended cost benefit analysis, limitations of Cost Benefit Analysis. Environmental Valuation: importance of valuation, the concept of total economic value. Environmental valuation methods: Theory, main assumptions, detailed methodology and estimation and validation issues: Travel cost method, Contingent valuation method, Hedonic price method, Shadow project approach etc. Applications of extended cost benefit analysis of projects; Case studies in Transport, Energy, Industry and Environmental management sectors. Applications of Environmental valuation: The use of economic value in policy making, Case studies.

Method of teaching and learning:

A combination of lectures, computer assisted learning, assignments and discussions.

Assessment:

In-course assessment and end of semester examination.

Recommended Reading

1. C. Karl., F. Ray & S. Oster (2013). Principles of Economics, 11th Edition.Pearson Education Limited, USA.
2. Hussen, A.M. (2000). Principles of Environmental Economics: Economics, Ecology and Public Policy. Routledge, New York.
3. Tietenburg, T. (2003.) Environmental and Natural Resource Economics. 6th Edition. Addison Wesley Longman, New York.
4. Hanley, N., & C. L. Spash (2003). Cost Benefit Analysis and the Environment, Edward Elgar, USA.
5. Willis, K. G. & J. T. Corkindale, (eds.) (1995), Environmental valuation: new perspectives, CAB International, Wallingford, England.

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Course Code **:** ENCM 41574
Title **:** Ecological Interactions and Behavioural Ecology
Pre-requisite **:** ENCM 21542
Co-requisite **:** None
Status **:** Compulsory, Theory cum Practical

Learning outcomes:

After completion of the course unit, the student will be able to;

- determine the community structure using diversity indices,
- discuss the effect of dominant, keystone and foundation species on the community structure
- discuss the effect of biogeographic factors on the community structure,
- discuss the competition, predation, symbiotic relationships, pathogens and zoonotic diseases in animal communities,
- discuss the functional significance of foraging, territorial and mating behaviour,
- explain the social organization of aquatic mammals, canids and felids, elephants, primates and ungulates in relation to their ecology,
- demonstrate skills in analyzing food habits of mammals and birds in relation to their morphology,
- carry out ecological surveys in rivers/streams and rocky/sandy shore ecosystems, and
- demonstrate skills in studying play behaviour, aggression, anti-predatory behaviour and territorial behaviour of some animals in a scientific manner.

Course content:

Ecological Interactions: Community ecology; Habitat, niche and multidimensional niche theory. Diversity and trophic structure in communities; species diversity and analysis of community structure using diversity indices, Trophic structure of a community and limits on food chain length, Impact of dominant, keystone and foundation species on the community structure, Bottom-up and top-down control of food chains. Biogeographic factors affecting community diversity; latitudinal gradients, area effects and the Island Equilibrium Model.

Community interactions: Competition; types of competition, the competitive exclusion principle, temporal and spatial portioning of resource, Character displacement (morphological resource partitioning). Predation and herbivory; Predator-prey relationships including predator and prey strategies. Symbiotic community interactions; parasitism, mutualism, and commensalism. Ecology of disturbance and patch dynamics, Intermediate disturbance hypothesis. Ecological succession. Pathogens and zoonotic diseases on animal communities. Community assembly theory and ecology of habitat selection.

Behavioural Ecology: Functional significance of behaviour; Optimality theory and quantification of optimal behaviour through cost-benefit analysis, Measurement of function of behaviour. Foraging behaviour; Feeding tactics in animals including feeding at different trophic levels, modifying food supply, trapping and detecting food, tool use and co-operate hunting, Abundance and availability of food and search image formation. Ecology of reproduction; Mating behaviour, sexual selection and mate choice, Mating systems, Inclusive fitness, infanticide, altruism and kin selection, Parental care. Game theory. Social organization of aquatic mammals, canids and felids, elephants, primates and ungulates in relation to their ecology. A generalized model to explain the social organization of higher animals. Genetic basis and evolution of behaviour.

Practical sessions on: Study of food habits of mammals and birds in relation to their morphology, Field survey to study ecological interactions in a river/stream ecosystem, Field survey to study ecological interactions in a rocky shore intertidal ecosystem, Field study on the play behaviour of dogs, Laboratory study on the aggressive and anti-predatory behaviour of fishes, Territorial behaviour of dogs.

Method of teaching and learning:

A combination of lectures, laboratory and field practical sessions, computer based learning, self-studies, assignments and small group discussions.

Assessment:

In-course assessment and end of semester examination.

Recommended reading:

1. Alcock, J. (2005). Animal behaviour: An evolutionary approach. Sinaeur Associates Publishers, Massachusetts.
2. Hauer, E. F. & G. A. Lamberti (2007). Methods in Stream Ecology. Academic Press.
3. Krebs, J. R. & N.B. Davies (1993). Behavioural ecology. Blackwell.
4. Osborne, P. L. (2000). Tropical Ecosystems and Ecological Concepts. Cambridge University Press.
5. Raven, P. H. & G. B. Johnson (2010). Biology. 8th Edition. Tata McGraw-Hill Edition
6. Reece, J. B., L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky & R. B. Jackson (2011). Campbell Biology, Global Edition. 9th Edition. Pearson Education Inc.

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Course Code : ENCM 41583
Title : Reserve Design and Protected Area Management
Pre-requisite : ZOOL 32563
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- discuss the principles and concepts of reserve design and protected area management, and
- critically analyse the effectiveness of designation and designing of reserves and protected areas on the basis on distinctiveness, endangerment and utility.

Course content:
Introduction to Protected Areas (PAs); The origin and purpose of National Parks and Protected Areas; Roles and functions of Protected Areas; Global trends in establishment of PAs; Sri Lanka's PA network; Legislative and Institutional Framework for PA management in Sri Lanka; Setting Priorities: distinctiveness, endangerment and utility; Theoretical aspects: The Island Biogeography Theory; Protected area Gap Analysis; Protected Area Planning Approach; Site Planning and Design; Participatory Planning; Stakeholder Identification and Analysis; Tools in PRA/RRA; Development of PA Management Plan; Zoning methodology and developing Zoning Plans; Adaptive management, Participatory management, Co-management and Integrated management applications in PA management; Habitat management; Tourism in the Park Management Plan; Involving stakeholders; Tourism plan development and implementation; Tools for visitor management; Park Interpretation.

Method of teaching and learning:
A combination of lectures, laboratory and field practical sessions, computer based learning, self-studies, assignments, and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Bolen E. G. (2008). Wildlife Ecology and Management, 6th Edition. Prentice Hall, New Jersy.
2. Primack R. B. (2010). Essentials of Conservation Biology. 5th Edition. Sinauer Associates, Inc.
3. Van Dyke, F. (2008). Conservation Biology, Foundations, Concepts, Applications. 2nd Edition. Springer.

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Course Code : ENCM 41592
Title : Professional Placement
Pre-requisite : All level III ENCM course units
Co-requisite : None
Status : Compulsory, Practical

Learning outcomes:
After completion of the course unit, the student will be able to demonstrate;

- knowledge on the basic management procedures in a selected industry / institution,
- experience in selected functioning area of the industry / institution, and
- generic skills needed to work effectively in a professional working environment.

Course content:
The student will be placed in a selected industry/ institution where practical applications of environmental conservation and management are applied, and undertakes training to obtain experience at the professional working environment. It is

intended that the student develops inter-personal and self-management skills to adapt to a professional working environment while gaining experience on selected functioning aspects of the industry/institute during the training period.

Method of teaching and learning:
Training under the supervision and guidance of a competent personnel in an industry or institution related to environmental conservation and management.

Assessment:
Evaluation of the progress report submitted by the trainer and the student's technical report and oral presentation on student's experience at the work place.

Recommended reading:
Reading and reference materials will be recommended/ provided by the relevant industry /institute where necessary.

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Course Code **:** ENCM 42604
Title **:** Ecology and Management of Wetlands
Pre-requisite **:** ENCM 21533
Co-requisite **:** None
Status **:** Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit the student will be able to;

- discuss the values and functions of different types of wetlands,
- discuss the effects of biological and physico-chemical factors on wetland community development and wetland properties,
- identify potential threats to wetlands and propose appropriate wetland management strategies,
- discuss the importance of wetland restoration, constructed wetlands, and sustainable utilization of wetlands, and
- demonstrate skills in identifying wetlands for conservation, wise use of wetlands and wetland restoration.

Course contents:
Definition of wetlands, Wetland classification, Wetland hydrology, Wetland soils, Wetland vegetation and adaptations, Wetland biogeochemistry with special reference to the importance of N, C, S, P, Fe and Mn transformations in wetlands, Wetland zonation, Wetland functions, Threats to wetlands: Natural and anthropogenic impacts on wetlands, Factors affecting community development in wetlands: Biological diversity of wetlands, Rank abundance curves, Factors affecting animal and plant diversity in wetlands, species pool hypothesis, Hydrology as a factor controlling wetland properties, Wetland fertility and primary productivity, Effects of disturbances on wetlands, Effects of herbivory on wetlands.
Wetland restoration, Constructed wetlands: Types of constructed wetland systems for use in various landscapes, Hydrologic and ecological features of constructed wetlands, Design and optimization to treat a wide range of waste waters, Monitoring and assessment for water treatment efficiency, Potential uses of biomass produced in constructed wetlands, Case studies on wetland restoration projects and constructed wetlands, Wetland conservation and management, Sustainable use of wetlands.
Field studies on characteristics of selected wetlands and identification of potential threats and impacts.

Method of teaching and learning:
A combination of lectures, field studies, assignments, self-studies, computer based learning, and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Keddy, P. A. (2010). Wetland Ecology: Principles and Conservation. Cambridge University Press.
2. Mitsch, W. J. & J. G. Gosselink (2007).Wetlands. Wiley.
3. Selected current review papers published by reputed publishers.
4. Wetland site report series, Central Environmental Authority, Sri Lanka.

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Course Code **:** ENCM 42612
Title **:** Social Responsibility in Environmental Management
Pre-requisite **:** ENCM 31522
Co-requisite **:** None
Status **:** Compulsory, Theory

Learning outcomes:
After completion of this course unit, the students will be able to:

- demonstrate knowledge on principles of and tools for corporate social responsibility in environmental management.

Course content:
Definition of corporate social responsibility; economic responsibility, public responsibility, and social responsiveness; History and emergence of corporate social responsibility in environmental management; Human rights approach and justice approach in environmental management; Motivations of business for environmental management and corporate social responsibility; Role of government and various other stakeholders environmental management; Tools and Strategies for Environmental Management (Code of ethics, Sustainability reporting, pollution prevention, social and environmental accounting, eco-design, product stewardship etc.); Whistleblowing (i.e., an employee of a firm exposes organizational misconduct or wrongdoing to the public) as part of social responsibility in environmental management and its impact on institutional management; Organizational impacts of implementation of corporate social responsibility; Strategic implications of environmental management and corporate social responsibility for governance schemes on sustainability. The relevance corporate social responsibility to management aspect such as organization behaviour, strategy and operations.

Method of teaching and learning:
A combination of lectures, computer based learning, assignments and small group discussions.

Assessment:
In-course assessment, assignments, and end of semester examination.

Recommended reading:

1. Sekaran U. (2006) .Research Methods for Business. John Wiley & Sons Inc: New York.
2. Selected publications from Journal of Corporate Social Responsibility and Environmental Management, The Journal of Corporate Citizenship, Journal of Business Ethics.
3. Sheldon, C. & M. Yoxon (1999). Installing Environmental Management Systems, London: Earthscan.

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Course Code **:** ENCM 42622
Title **:** Air Quality Management
Pre-requisite **:** ENCM 31543
Co-requisite **:** None
Status **:** Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- explain the sinks and removal processes of atmospheric pollutants,
- describe the methods of air quality monitoring and assessment, and
- evaluate the strategies of air quality control and management.

Course content:
Ambient air pollution, Gaseous and particulate pollutants: sources, atmospheric reactions, sink processes, removal, Other types of pollutants, Effects on human and ecosystem health, Dispersion, atmospheric effects and air quality, Methods of air quality monitoring and assessment: sampling, samplers, analysis, emission assessments, modeling, biomonitoring methods, Control of air pollution: stationary source emission control - particulate control technology, Control of gaseous pollutants, Automobile emission control, Air quality regulations (Sri Lankan, regional and world) Sri Lankan and world standards for emissions, Control and management of thermal, odor and noise pollution, Control and management of indoor air pollution.

Field studies: vehicle emission testing (VET), Noise testing, use of lichens/mosses for air quality monitoring, air sampling.

Method of teaching and learning:
A combination of lectures, laboratory and field studies, computer assisted learning, assignments and discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Current review papers on air quality management published by reputed publishers.
2. Godish, T. (2003). Air Quality. 4th Edition. Lewis Publishers.INC.
3. Griffin, R. D. (2006). Principles of Air Quality Management, 2nd Edition.CRC Press Hester R. E. & R. M. Harrison (1997). Air Quality Management. The Royal Society of Chemistry, UK.
4. Purohit, S. S. & B. Kakrani (2002). Air Environment and Pollution. Agrobios, India.
5. Rao, M. N. & H. V. N. Rao (2003). Air Pollution, McGraw-Hill.

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Course Code **:** ENCM 42632
Title **:** Global Climate Change
Pre-requisite **:** ENCM 21533
Co-requisite **:** None
Status **:** Compulsory, Theory

Learning outcomes:
After completion of the course unit, student will be able to;

- explain factors influencing climate change,
- explain key indicators and impacts of climatic change,
- application of different tools to quantify climate change, and
- discuss mitigation and adaptation instruments and their responses to climate change.

Course content:
Life Energy and Climate, Climate Regulators, Natural and anthropogenic activities influencing regional and global climatic change of the earth, Direct Observations of Recent Climate Change, Paleoclimatic Perspectives on Climate Change, Past Climates - Natural Drivers, Panels, Protocols and a Common Misconception about Ozone, Impacts of climate change, Probabilities, Uncertainties and Units Used to Quantify Climate Change, Models as tools, Feedback Loops**,** Emission Scenarios**,** Projections of Future Changes in Climate, Global Projections for Regional Climate Change**,**

Climate Change Impacts, Instruments for Mitigation and Adaptation, Mitigation and Adaptation Responses, Climate change impacts and responses – Case studies.

Method of teaching and learning:
A combination of lectures, computer assisted learning, assignments and discussions.

Assessment:
In-course assessment and end of course examination.

Recommended reading:

1. CapNet, 2009. IWRM as a Tool for Adaptation to Climate Change Training Manual and Facilitator's Guide, CapNet. http://www.cap-net.org/documents/2014/06/iwrm-cc-training-manual.pdf
2. Dallas, N. (2008). Climate Change Basics. Mc Grow Hill.
3. Tomkiewicz, M. (2011). Climate Change, Mc Grow Hill.
4. IPCC, 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O. F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E.Hanson, Eds., Cambridge University Press.

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Course Code **:** ENCM 42642
Title **:** Marine and Coastal Resources Management
Pre-requisite **:** ENCM 21533
Co-requisite **:** None
Status **:** Compulsory, Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- discuss the ecological and economical importance of marine and coastal production systems,
- describe the major threats to marine and coastal production systems and the methods used to manage the threats,
- discuss the role of international conventions, government, NGOs and local coastal communities on the management and sustainable utilization of marine and coastal resources, and
- assess the integrated coastal zone management practices in selected coastal regions through field surveys.

Course content:
Critical appraisal of the marine and coastal production systems including the Open sea, Coral reefs, Mangroves, Sea grass beds, Estuaries and lagoons, Marshes, Sand dunes and, Associated terrestrial forests and their ecological and economic importance. Impacts of anthropogenic activities including Coastal tourism, Sewage outfalls, Oil spills, Aquaculture, Global warming, Maritime transport and ballast water disposal, Coral mining and over-fishing on coastal production systems. Natural events including Tsunamis and tidal waves on coastal production systems. Marine pollution Prevention Act of Sri Lanka, Use of remote sensing and mapping on the evaluation and assessment of coastal resources, Environmental impact assessment on marine and coastal systems, Participation and role of the government, NGOs and the coastal communities in the sustainable utilization, management and governance of coastal resources. Economics and environmental politics of coastal natural resources. Revenue-generation mechanisms in coastal production systems, Coastal erosion, Marine protected areas. Principles and practice of integrated coastal zone management (ICZM). Incentives for coastal resources management and conservation.

Field surveys and report preparation on the sustainable utilization, management and governance of coastal resources in selected coastal regions in Sri Lanka.

Method of teaching and learning:
A combination of lectures, field surveys, assignments, self-studies, computer based learning, and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Central environmental Authority, Sri Lanka (1994). Wetlands are no wastelands; A manual and strategy for conservation and development of wetlands. Wetlands conservation project, Central environmental Authority, Sri Lanka.
2. Clark, J. R. (1995). Coastal Zone Management Handbook. CRC press, 1st edition, 720 pages.
3. Clark, R. B. (2001). Marine Pollution, Oxford University Press, 5th edition, 248 pages.
4. Conservation management plan, Muthurajawela marsh and Negombo Lagoon (1994). Wetlands conservation project, Central environmental Authority, Sri Lanka.
5. Conservation management plan, Mundel lake and Puttalam corridor channel (1994). Wetlands conservation project, Central environmental Authority, Sri Lanka.
6. Dobson, M. & C. Frid (2009). Ecology of Aquatic Systems. Oxford University press. 2nd edition. 336 pages.
7. Frid, C. & M. Dobson (2013). Ecology of Aquatic Management. Oxford University Press. 2nd edition. 352 pages.
8. Kidd, S., A. Plater & C. Frid (2011). The Ecosystem Approach to Marine Planning and Management. Published by Routledge. 1st edition. 230 pages.
9. Tucker, C. S. & J. A. Hargreaves (2008). Environmental Best Management Practices for Aquaculture. Wiley-Blackwell, 1st edition. 592 pages.

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Course Code **:** ENCM 43654
Title **:** Environmental Toxicology and Risk Assessment
Pre-requisite **:** ENCM 31532
Co-requisite **:** none
Status **:** Compulsory, Theory cum practical

Learning outcomes:
After completion of the course unit, the student will be able to:

- critically discuss toxicological impacts of environmental contaminants on biota emphasizing health effects on humans,
- demonstrate competencies in specific techniques/tools used for assessing toxic effects of environmental contaminants, preparation of laboratory reports based on critical analysis of toxicological data in a scientific manner, and
- assess, evaluate and predict the human health risks and ecological health risks posed by environmental contaminants and hazardous situations for managing the environment.

Course content:
Introduction to Environmental Toxicology; Toxicokinetics and toxicodynamics; Absorption, distribution, accumulation and excretion of chemical contaminants and health effects on target tissue/organs; Metabolism of xenobiotics; phase 1 and phase 2 reactions; detoxification and bioactivation; Molecular mechanisms of toxic effects; Acute, and Chronic effects on organisms, long term effects: mutagenesis, carcinogenesis and teratogenesis; endocrine disruption; Environmental toxicology of selected groups of environmental contaminants: heavy metals, pesticides, polychlorinated biphenyls, dioxins and furans; cyanobacterial toxins; Environmental toxicology of engineered nano materials. Evaluation of acute and chronic toxicity, bioassays and biomarkers; Radiation and health risks; Occupational safety and health risks. Major elements of Risk assessment: hazard identification, exposure assessment, dose response assessment and risk characterization; Techniques and tools in human health risk assessment, Techniques and tools in ecological health risk assessment; probabilistic risk assessment methods, assessment factor methods, assessment of relative risks, Radiation risk assessment. Prospective and retrospective risk assessments; formulation of environmental quality standards based on risk assessments, Risk management and risk communication.

Practical sessions on: Evaluation of toxic effects of selected environmental contaminants; Bioassays and estimation of toxicity thresholds; Applications of risk assessment methodologies, prediction of hazardous concentrations and species protection levels based on species sensitivity distribution analysis.

Method of teaching and learning:
A combination of lectures, laboratory studies and preparation of scientific reports, computer based learning, assignments, seminars and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Landis, W. G., R. M. Sofield & M. Yu (2011). Introduction to Environmental Toxicology. CRC Press Boca Raton, Florida.
2. Klaassen, C. D., L.J. Cassarett & J. Doull (2013). Toxicology – The Basic Science of Poisons. 8th Edition. McGrew Hill.
3. Newman, M.C. (2010) Fundamentals of Ecotoxicology. 3rd Edition. CRC Press, New York.
4. Wright, D. A. & P. Welbourne (2002). Environmental Toxicology. Cambridge University Press.

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Course Code **:** ENCM 43668
Title **:** Research Project
Pre-requisite **:** ENCM 41512 & ENCM 42532
Co-requisite **:** None
Status **:** Compulsory, Practical

Learning outcomes:
After the completion of the course unit, the student will be able to;

- develop a research proposal on an identified research problem related to special field of environmental science,
- carry out a research project on a specific area of environmental science according to the scientific method,
- analyse experimental data using appropriate statistical tests and interpret results in a scientific manner, and
- present the research result in the form of dissertation and defend the findings to the academic audience.

Course content:
A short term research project based on scientific method that involves field and/or laboratory work in any of the following areas: Hydrology, Meteorology, Climate Change, Soil Management, Sustainable Utilization of Resources, Forest Management, Animal Diversity, Environmental Health, Ecology, Water Resources Management, Solid and Hazardous Waste Management, Conservation Biology and Wildlife Management, Natural Disaster Management, Environmental toxicology, Air Quality Management, Marine and Coastal Resources Management, Applications of GIS and Remote Sensing, Herpetology, Ornithology and Parasitology; Literature review; Development and presentation of a research proposal on the identified research problem; Preparation of the dissertation based on stipulated requirements; Oral presentation and defense of the research findings.

Method of teaching and learning:
Literature survey, research proposal preparation, laboratory and/or field work, data gathering, data analysis and interpretation, preparation of dissertation.

Assessment:
Dissertation, oral presentation and viva-voce examination.

Recommended reading:
Peer reviewed literature related to the assigned research topic.

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(ii) ZOOL Coded Course Units

Year – 1

Course Code : ZOOL 12523
Title : Animal Diversity and Sri Lankan Fauna
Pre-requisite : G.C.E. (A/L) Biology
Co-requisite : ZOOL 12531
Status : Compulsory, Theory

Learning outcomes:
After completion of the course unit, the student will be able to;

- describe principles of taxonomy,
- explain structural organization and diversity of animal kingdom, and
- identify and classify protists and animals with special reference to Sri Lankan fauna.

Course content:
Introduction to animal kingdom, Principles of taxonomy of animals, Structural organization and diversity of the following groups of Protists and animals with special reference to Sri Lankan fauna; Rhizopoda, Zoomastigophora, Apicomplexa, Ciliophora, Actinopoda and Foraminifera, Porifera , Cnidaria, Ctenophora, Platyhelminthes, Nematoda, minor phyla including Rotifera, Annelida, Arthropoda, Mollusca, Echinodermata, Hemichordata, Urochordata, Cephalochordata, Chordata including fishes, amphibians, reptiles, birds and mammals. Adaptive radiation of different groups of vertebrates.

Method of teaching and learning:
A combination of lectures, computer based learning, self-studies, assignments, tutorial and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Hickman, C., L. Roberts, S. Keen & A. Larson Jr. (2011). Animal Diversity, 6th Edition, McGraw-Hill.
2. Kotagama, S. & G. Ratnavira (2010). An illustrated guide to the birds of Sri Lanka. Published by the Field Ornithology Group of Sri Lanka, University of Colombo.
3. Raven, P. H. & G. B. Johnson (2010). Biology. 8th Edition. Tata McGraw-Hill Edition.
4. Reece, J. B., L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky & R. B. Jackson (2011). Biology – Campbell. Global Edition. 9th Edition. Pearson Education Inc.
5. Study Guide for ZOOL 12523: Animal Diversity. Department of Zoology, University of Kelaniya.

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Course Code : ZOOL 12531
Title : Animal Diversity and Sri Lankan Fauna Laboratory
Pre-requisite : G.C.E. (A/L) Biology
Co-requisite : ZOOL 12523
Status : Compulsory, Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- use taxonomic keys to identify animals to the lowest taxonomic group possible,
- construct dichotomous keys to identify animals to the lowest taxonomic group possible,
- identify animals to the lowest possible taxon examining morphological characteristics, and
- appreciate the diversity of Sri Lankan fauna.

Course content:
Examination of the prominent morphological features of representative organisms belonging to following taxa; Rhizopoda, Zoomastigophora, Apicomplexa, Ciliophora, Actinopoda, Foraminifera, Porifera , Cnidaria, Ctenophora, Platyhelminthes, Nematoda, Rotifera, Annelida, Onychophora, Arthropoda, Mollusca, Echinodermata, Hemichordata, Urochordata, Cephalochordata, Chordata including fish, amphibians, reptiles, birds and mammals.
Use of taxonomic keys for animal identification, Construction of dichotomous keys to identify selected groups of animals giving special reference to Sri Lankan fauna.

Method of teaching and learning:
A combination of laboratory and field practical sessions, computer based learning, self-studies, assignments and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. De Silva, A. (1990). A Colour Guide to the Snakes of Sri Lanka. Portishead Avon R. and A. Publication Limited.
2. De Silva, P. H. D. H. (1980). Snakes of Sri Lanka. Department of Government Printing, Colombo.
3. Dutta, S.K. & K. Mamamendra-Arachichi (1996). The Amphibian Fauna of Sri Lanka. Wild life Heritage Trust of Sri Lanka, Colombo.
4. Henry, G. M. (1978). A Guide to the birds of Ceylon. K.V.G. De Silva & Sons, Kandy.
5. Laboratory Manual for ZOOL 12531: Animal Diversity and Sri Lankan Fauna Laboratory, Department of Zoology, University of Kelaniya.
6. Pethiyagoda, R. (1991). Freshwater Fishes of Sri Lanka Wildlife Heritage Trust, Colombo.
7. Phillips, W. W. A. (1981). The Manual of Mammals of Sri Lanka. Volumes I-IV. Wildlife and Nature Protection Society of Sri Lanka, Colombo. Raven, P. H. & G. B. Johnson (2010). Biology. 8th Edition. Tata McGraw-Hill Edition.
8. Reece, J. B., L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky & R. B. Jackson (2011). Biology – Campbell. Global Edition. 9th Edition. Pearson Education Inc.

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Year – 3

Course Code **:** ZOOL 32563
Title **:** Conservation Biology and Wildlife Management
Pre-requisite **:** ZOOL 12523 & ZOOL 22543
Co-requisite **:** None
Status **:** Theory cum Practical

Learning outcomes:
After completion of the course unit, the student will be able to;

- explain the principles of conservation biology and aims of wildlife management,
- describe the issues associated with the biodiversity loss,
- prioritize conservation efforts using qualitative and quantitative techniques,
- evaluate habitats and recommend strategies for habitat management for target wildlife,
- suggest strategies for management of wildlife using population data and field experiments, and
- demonstrate skills in application of specific techniques used in wildlife conservation and management.

Course content:
Principles of Conservation Biology, Change of biological diversity with time, Species extinction and formation, IUCN categories for the conservation status of taxa, Threats to biological diversity, Habitat destruction, Habitat fragmentation, Over harvesting, Invasive species, Climate change, Problems of small populations, Measuring and comparing biodiversity, Abundance time series, Risk prediction, Genetic principles and rules in Conservation Biology, Conservation

at the species and population level, Conservation planning and priority selection, Management of endangered species, Conservation of plant animal mutualism, Conservation of pollinators, Conservation in human modified landscapes.

Introduction to wildlife Management, Aims of wildlife management, Wildlife management in Sri Lanka, Protected areas, Habitat management strategies, Wildlife and water, predators and predation, Hunting and trapping, Human-elephant conflict, elephant conservation, Management of crocodiles and marine turtles. Population analysis, Life tables, Patterns of population growth, Wildlife diseases, Wildlife surveys including animal capture/marking, surveys, aging and sexing and experiments, The role of society in conservation, *In-situ* and *ex-situ* conservation. International trade of wildlife and CITES, Ecotourism, Legal aspects, Flora and fauna protection ordinance in Sri Lanka and international efforts of wildlife management.
Two field studies at nature reserves.

Method of teaching and learning:
A combination of lectures, laboratory and field studies, assignments, self-studies, computer based learning, and small group discussions.

Assessment:
In-course assessment and end of semester examination.

Recommended reading:

1. Bolen, E. G. & W. Robinson (2002). Wildlife Ecology and Management, 5th edition, Benjamin Cummings, USA.
2. Flora and fauna protection ordinance in Sri Lanka.
3. Navjot, S. S. & E. R. Paul (2011). Conservation biology for all, Oxford University Press, New York.
4. Primack, R. B. (2010). Essentials of conservation biology, 5th edition. Sinauer Associates, Inc. Publishers Sunderland, Massachusetts U.S.A.
5. Silvy, N. J. (2002). The Wildlife Techniques Manual: Volume 1: Research. Volume 2: Management 2-vol. set. John Hopkins University Press.
6. Sinclair, A. R. E., J. M. Fryxell & G. Caughley (2005). Wildlife Ecology, Conservation and Management, 2nd Edition, Wiley-Blackwell.

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8. Course units offered by the Department of Botany

Year- 2

Course Code : BOTA 22053
Title : Floristic Resources in Sri Lanka and Management
Pre-requisite : BOTA 12014/ ENCM 12572
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:
By successful completion of this course, the student should be able to

- explain richness and conservation of flora and crop wild relatives of Sri Lanka,
- discuss significance and management of invasive flora,
- describe cropping systems and cultural practices used in sustainable organic agriculture and
- explain biological principles involved in organic agriculture.

Course contents:
Flora of Sri Lanka: floristic composition: endemic, exotic and indigenous flora and their uses. Relationships between floristic composition and climate. Conservational status and conservation methods of flora. Crop wild relatives and their potential uses. Exotic flora and invasive plants and their adverse impacts, management and potential uses.
Biological principles, and approaches used in production of bio fuels, bio fertilizer, green manure and agroforestry. Uses of botanicals, bio fuels, bio fertilizer, green manure, cover crops and organic solid waste in organic agriculture. Desired agronomic and cultural practices used for sustainable organic crop management.

Method of teaching and learning:
Lectures, hands on laboratory and field practicals and assignments

Assessment:
End of course written examination and continuous assessments

Recommended readings:

1. Ashton, M, Gunatilleke, S, Zoyza, N and Dassanayake. (1997). A Field Guide to the Common Trees and Shrubs of Sri Lanka. Wildlife Heritage Trust.
2. Ferando, M, Wijesundara, S and Ferando, S (2003) Orchids of Sri Lanka: a conservationist's companion. IUNC, Sri Lanka.
3. Sharma, A K (2004) A Handbook of Organic Farming. Agrobios, India.
4. Vlas, J (2008) Illustrated filed guide to the flowers of Sri Lanka. Mark booksellers, Kandy.
5. Wild, A (1993) Soils and the environment. Cambridge University press

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Course Code : BOTA 22063
Title : Plant Diversity
Pre-requisite : BOTA 12014/ ENCM 12572
Co-requisite : None
Status : Compulsory, Theory cum Practical

Learning outcomes:
At the end of this course unit, the student should be able to

- explain how plants have evolved and phylogenetic relationships amongst diverse groups of plants and
- demonstrate skills in identifying and distinguishing morphologically different groups of algae, bryophytes, pteridophytes, gymnosperms and angiosperms using their characteristic features.

Course contents:
Classification, origin and evolutionary relationships of autotrophic protists (algae) and plants, green alga as common ancestor of plants. Identification and illustration of morphological features of reproductive and vegetative structures of algae, bryophytes, seedless vascular plants and seed plants. Plants as pioneers of the terrestrial environment. Web based laboratory exercises to study the diversification of plants.

Method of teaching and learning:
Lectures, presentations, laboratory and field exercises, computer assisted learning and tutorials.

Assessment:
Continuous assessment and end of course examination.

Recommended reading:

1. Ernest, M G and Adriance, S Foster (1989). Morphology and Evolution of Vascular Plants. W H Freeman.
2. Purves, W K; Orians, G H; Heller, H C and Sadava, D (1998). Life: The Science of Biology. W H Freeman.
3. Raven, Peter H; Evert, Ray F and Eichhorn, S F (2005). Biology of Plants. Worth Publishers.
4. Perry, J W and Morton, D (1996). Photo Atlas for Biology. Wadsworth.
5. Sharma, O P (1993). Practical Botany. Pragati Prakashan.

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9. Course Units Offered by the Department of Chemistry

Year - 1

Course Code : CHEM 11122
Title : General Chemistry and Basic Analytical Chemistry
Pre-requisite : A/L Chemistry
Co-requisite : None
Status : Compulsory, Theory

Learning outcomes:
Upon successful completion of the course unit, the student should be able to;

- outline the historical development of atomic theory
- explain certain atomic properties using theories of atomic structure
- recognize various types of chemical bonding and apply the theories of bonding to predict properties of compounds
- apply basic concepts of solubility, precipitation, and titrations in chemical analysis

Course content:
Structure and bonding
History of atomic theory, modern view of atomic structure, periodic table, chemical bonding, molecular geometry, bonding theories (valence bond theory and molecular orbital theory), intermolecular forces.

Aqueous solution chemistry
Measurement and units, concentration Chemical equilibrium; Le Chatelier's principle
Gravimetry; Solubility and solubility product, mechanism of precipitation. Contamination of precipitates; co-precipitation and post precipitation. Purification of precipitates.

Titrimetry; **classification**, Acid-base titrations, acid base indicators, buffers. Complexometric titrations, ligands, indicators, types of EDTA titrations. Redox titrations; redox indicators, permanganometry, iodometry and iodimetry, bromometry, dichromate titrations. Precipitation titrations; methods of endpoint detection

Method of teaching and learning :
A combination of lectures and tutorial discussions.

Assessment :
Continuous assessment and/or end of course unit examination

Recommended reading :

1. Harris, D.C. (2010) *Quantitative Chemical Analysis,* Freeman
2. Brown, T.L; LeMay, H.E; Bursten, B.E; Murphy, C.J; (2009), *Chemistry: The central science*, Prentice Hall.
3. Lee, J.D. (2008) *Concise Inorganic Chemistry*, Blackwell

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Course Code **:** CHEM 11141
Title **:** Basic Chemical Analysis Laboratory
Pre-requisite **:** A/L Chemistry
Co-requisites **:** CHEM 11122
Status **:** Compulsory, Practical

Learning outcomes:
Upon successful completion of the course unit the student should be able to;

- adhere to safety rules and good laboratory practice at all times
- effectively use basic laboratory techniques for chemical analysis
- identify and separate cations and anions in inorganic compounds by standard chemical tests
- use titrimetric and gravimetric methods to quantify analytes in aqueous media.

Course content:
Laboratory safety, laboratory rules and regulations, handling of chemicals and glassware Basic laboratory techniques; filtration, preparation of solutions, dilution, sample preparation etc,
Qualitative analysis of basic cations and anions in inorganic compounds; group analysis by precipitation and identification of ions by specific reactions, flame tests,
Quantitative analysis of aqueous analytes; acid base titrations, redox titrations complexometric titrations and gravimetry

Method of teaching and learning:
A 3 hour laboratory class per week (15 weeks) Pre labs and assignments

Assessment :
Continuous assessment and end of course unit examination

Recommended reading:

1. Mendham, J; Denney, R.C.; Barnes, J.D.; (2002) *Vogel's Textbook of Quantitative Chemical Analysis*. Prentice Hall.
2. Svehal, G; (2001) *Vogel's Qualitative Inorganic Analysis,* Longmans

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Course Code : CHEM 12152
Title : Basic Inorganic Chemistry I
Pre-requisite : CHEM 11122
Co-requisite : None
Status : Compulsory, Theory

Learning outcomes:
Upon successful completion of the course unit, the student should be able to:

- explain the periodic trends of physical and chemical properties of the main group and *d* block elements
- compare chemistry of the main group elements with that of *d* block elements
- name coordination compounds systematically according to IUPAC nomenclature
- draw the structures of the different types of isomers of coordination compounds
- explain magnetic properties, colors, hybridizations, geometries, and distortions of coordination complexes using the bonding theories of coordination compounds.

Course content:
Main group and transition elements
Classification of elements, chemistry of s and p block elements; extraction, physical and chemical properties, periodicity of properties, compounds of s & p block elements and complex formation. Introduction to d and f-Block elements
Coordination chemistry
History, isomerism and nomenclature of coordination compounds, Lewis theory, valence bond theory, crystal field theory. Applications of crystal field theory; colors, magnetic properties etc., spectrochemical series, factors affecting the crystal field splitting, Jahn-Teller distortion, introduction of other bonding theories.

Method of teaching and learning:
A combination of lectures and tutorial discussions

Assessment:
Continuous assessment and/or end of course unit examination

Recommended reading :

1. Shriver, D. F., Atkins, P.W. and Langford, C.H., (2009) *Inorganic Chemistry*, Oxford.
2. Lee, J.D. (2008) *Concise Inorganic Chemistry*, Blackwell.
3. James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Okhil K. Medhi (2006) Iorganic Chemistry, 4th edition, Pearson.

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Course Code : CHEM 12162
Title : Basic Organic Chemistry
Pre-requisite : CHEM 11122
Co-requisite : None
Status : Compulsory, Theory

Learning outcomes:
Upon successful completion of the course unit, the student should be able to;

- draw the structures of isomers and conformers of organic molecules and assign absolute configurations of chiral centers of organic molecules.
- recognize key organic functional groups and their reactions
- predict and rationalize potential reaction pathways for selected organic reactions using kinetics and thermodynamics.
- transform one simple organic functional group to another, identify aromatic compounds, and rationalize their stability.

Stereochemistry
Isomerism in carbon compounds; structural isomers, stereoisomers, optical activity, measurement of optical activity, conformational isomers of cyclic and acyclic alkanes; chirality, R and S convention, Fisher projections, importance of chirality.
Reactions of organic compounds and chemistry of reaction intermediates carbocations, carbanions, radicals and mechanistic aspects of organic reactions (SN1, SN2, E1, E2, AdE and SE reactions) and selected reactions of aliphatic and aromatic compounds
Aromaticity and heterocyclic compounds
Aromatic character; application of Huckle rule, aromatic and antiaromatic compounds Introduction to heterocyclic aromatic compounds (pyrrole, pyridine, thiophene and furan)

Method of teaching and learning:
A combination of lectures and tutorial discussions

Assessment:
Continuous assessment and/or end of course unit examination

Recommended reading:

1. Solomons, T. W.G., (2003) Organic Chemistry, John Wiley
2. Brown, W.H. (1995) Organic Chemistry, Harcourt Brace.
3. McMurry, J. (1996) Organic Chemistry, Brooks & Cole
4. Acheson, R.M. (1977) An Introduction to the Chemistry of Heterocyclic Compounds,John WIley

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Course Code : CHEM 12171
Title : Introductory Organic Chemistry Laboratory
Pre-requisite : CHEM 11141
Co-requisite : CHEM 12162
Status : Compulsory, Practical

Learning outcomes:
Upon successful completion of the course unit, the student should be able to;
- adhere to safety rules governing an organic laboratory
- identify functional groups of unknown organic compounds by standard chemical tests
- apply techniques to separate, purify, derivatize and characterize organic compounds present in mixtures

Course content:
Safety aspects in an organic laboratory, Qualitative analysis of functional groups in organic compounds, solubility, purification and identification of functional groups in organic compounds, recrystallization, melting points, derivatization, separation of mixtures of organic compounds.

Method of teaching and learning:
A 3 hour laboratory class per week (15 weeks)

Assessment:
Continuous assessment and end of course unit examination

Recommended readings

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J., Smith, P.W.G., (1989) *Vogel's Textbook of Practical Organic Chemistry*, Logmans
2. Pavia, D.L., Lampman, G.M., Kriz, G.S., Engel, R.G., (1988) *Introduction to Organic Laboratory Techniques: A Small-Scale Approach*, Brooks Cole

3. Moting, J.R., Mofrrill, T.C., Hammond, C.N. and Neckers, D.C., (1999) *Experimental Organic Chemistry*, Freeman.
4. Williamson, K.L., (2002) *Macroscale and Microscale Organic Experiments*, Heath and Company.

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Year - 2

Course Code : CHEM 21122
Title : Analytical Chemistry
Pre-requisite : CHEM 11122
Co-requisite : None
Status : Compulsory, Theory

Learning outcomes:
Upon successful completion of the course unit, the student should be able to;

- adhere to safety rules governing an organic laboratory
- identify functional groups of unknown organic compounds by standard chemical tests
- apply techniques to separate, purify, derivatize and characterize organic compounds present in mixtures

Learning outcomes:
Upon successful completion of the course unit, the student should be able to:

- select the most appropriate sampling technique for a particular analytical experiment
- apply fundamentals of separation techniques (solvent extraction and chromatography), spectroscopy and electro analytical techniques for quantitative chemical analysis.

Course content:
Sampling and chemometrics
Sampling methods, data evaluation and statistical analysis: basic statistics, comparison and rejection of data, Instrument performance characteristics; Instrument calibration and signal detection.

Analytical spectroscopy
Emission, absorption, fluorescence and scattering processes of radiation, The Beer Lamberts law, Atomic emission and absorption spectroscopic, UV-visible spectrometry, fluorescence spectrometry, Techniques based on the light scattering principle; Nephelometry and turbidimetry.

Analytical electrochemistry
Potentiometry; reference electrodes, indicator electrodes, direct potentiometry, potentiometric titrations, ion selective electrodes. Voltammetry; classical polarography, Tast polarography, pulse polarography, stripping analysis, cyclic voltammetry and square-wave voltammetry. Amaperometric titrations. Coulometry; electrogravimetry, constant current and controlled potential coulometry.

Analytical separation
Methods based on solvent extraction. An introduction to chromatography; gas chromatography, liquid chromatography, high performance liquid chromatography, ion exchange chromatography, molecular exclusion chromatography and affinity chromatography.

Method of teaching and learning:
A combination of lectures and tutorial discussions

Assessment:
Continuous assessment and/or end of course unit examination

Recommended reading:
1. Rouessac, F., Rouessac, A., Chemical Analysis: Modern Instrumentation Methods and Techniques

2. Paul, M.S. Monk., (2001) *Fundamentals of Electroanalytical Chemistry,* Wiley.
3. Skoog, D.A., Donald M. W., James, F.H., (2013) *Fundamentals of Analytical Chemistry,* Saunders College Publishing.
4. Harris, D.C. (2010) *Quantitative Chemical Analysis,* Freeman

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Course Code : CHEM 22171
Title : Analytical Chemistry Laboratory
Pre-requisite : CHEM 21122
Co-requisite : None
Status : Compulsory, Practical

Learning outcomes:
Upon successful completion of the course unit, the student should be able to;

- perform an appropriate sampling technique prior to chemical analysis
- apply the best analytical technique for an unknown sample to be characterized chemically
- validate the analytical method and data obtained by chemometric techniques
- identify, differentiate and demonstrate the classical and instrumental methods of chemical analysis.

Course content:
Experiments based on sampling and data handling, gravimetric analysis of metals using homogeneous precipitation method, complexometric titration of metal mixtures. Experiments based on analytical spectrometry; atomic absorption spectrometry, flame photometry and colorimetry. Electroanalytical techniques; voltammetry, potentiometry, Gran titration using spread sheets and electrogravimetry, Application of analytical techniques in industrial samples; pigments, paints and coatings, dyes etc,

Method of teaching and learning:
A 3 hour laboratory class per week (15 weeks), Pre-labs and assignments.

Assessment:
Continuous assessment and end of course unit examination.

Recommended reading:

1. Skoog, D.A., James F.H., Nieman. T. A., (1998) *Principles of Instrumental Analysis,,* Harcourt Brace College Publishers
2. Skoog, D.A., Donald M. W., James, F.H., (2013) *Fundamentals of Analytical Chemistry,* Saunders College Publishing.
3. Harris, D.C., (2006) *Quantitative Chemical Analysis,* Freeman
4. Mendham, J., Denney, R.C.; Barnes, J.D., (2002) *Vogel's textbook of Quantitative Chemical analysis,* Prentice Hall.

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Year - 3

Course Code : CHEM 31132
Title : Introduction to Environmental Chemistry
Pre-requisite : CHEM 11122 / 21122
Co-requisite : CHEM 32161
Status : Compulsory, Theory

Learning outcomes:

Upon successful completion of the course unit, the student should be able to;

- explain the importance of the environmental chemistry,
- describe the fundamentals in atmospheric, aquatic and soil chemistry,
- identify and recognize sources, reactions and fate of chemical pollutants in the environment, and
- explain the importance of waste minimization and waste management.

Course content:

Atomospheric chemistry

Importance of atmosphere, components of atmosphere, chemical and photochemical reactions, air pollution and chemistry of air pollutants, enhanced greenhouse effect, photochemical smog, ozone layer depletion, acid rain, nuclear winter, minimization of air pollution.

Aquatic chemistry

Introduction, interactions between water and air, interactions between water and soil, chemical transformations, water quality, water pollution, waste water and waste water treatment

Soil chemistry

Introduction, classification of soil, Physical and chemical properties of soil, Soil nutrients and their availability, Soil analysis and its importance, Soil degradation and terrestrial Pollution, waste management and solid waste disposal

Method of teaching and learning:

A combination of lectures and tutorial discussions

Assessment:

Continuous assessment and/or end of course unit examination

Recommended reading:

1. Manahan, S. (2010) *Environmental Chemistry*, Lewis.
2. McBride, M. B. (1994) *Environmental Chemistry of soils*, Oxford.
3. Evangelou, V. P. (1998) *Environmental soil & water Chemistry. Principle and Applications*, John Wiley.
4. Harrison, R. M. (1999) *Understanding our Environment. An introduction to Environmental Chemistry and Pollution*, RSC.

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Course Code : CHEM 32161

Title : Environmental Chemistry Laboratory

Pre-requisite : CHEM 31132

Co-requisite : None

Status : Compulsory, Practical

Learning outcomes:

Upon successful completion of the course unit, the student should be able to;

- describe common sources of atmospheric, soil and water pollutants, and
- develop skills necessary to identify and quantify soil, water and air pollutants.

Course content:

Soil analysis; phosphates, total nitrogen, ammonia, water soluble chlorides, sulfate and metal ions, soil acidity, alkalinity, cation exchange capacity (CEC) and total organic matter. Water analysis; total solids, conductance, hardness, pH, COD, BOD, oil, grease, dyes, surfactants and other heavy metals. Air analysis; sampling and determination of the levels of NOx and other pollutants in the air. Analysis of Industrial samples

Method of teaching and learning:
A 3 hour laboratory class per week (15 weeks)

Assessment:
Continuous assessment and end of course unit examination

Recommended reading:

1. Fifield, F. F. and Hanes, P. J., (2000) *Environmental Analytical Chemistry*, Blackwell.
2. Kebbekus, B.B and Mitra, S., (2000) *Environment Chemical Analysis*, Chapman & Hall/CRC
3. Boehnke, D. N. and Delumyea, R.D., (2000) L*aboratory Experiments in Environmental Chemistry*, Printice Hall

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10. Course Units offered by the Department of Microbiology

Year - 2

Course Code **:** MIBI 22554
Title **:** Microbiology for Environmental Management
Pre-requisite **:** ENCM 12553
Co-requisite **:** MIBI 22562
Status **:** Compulsory, Theory

Learning outcomes:
At the completion of this course unit the students will be able to:

- Understand the origin of microorganisms, the role they played in the evolution of other organisms,
- Understand the nature and characteristics of microorganisms,
- Understand in detail the roles of microorganisms in the environment,
- Manipulate microorganisms for the sustainability of the environment,
- Manipulate microorganisms to increase agricultural productivity,
- Employ microorganisms in environment related industries, and
- Maintain environment related microbiological quality standards.

Course contents:
The place of microorganisms (Bacteria, Viruses, Fungi) in the biosphere and in evolution: The relationship between matter and life, the origin of organisms on earth. The microbial origin of higher organisms, Evolutionary relationship of microorganisms with other organisms. The properties of microorganisms that make them capable of living in diverse environments of the biosphere: The way their size, unicellular nature and cell structure, growth rate, motility, spore formation, capsule formation, production of extracellular enzymes, extracellular polysaccharides, presence of transport mechanisms, bio-film formation, enzymes destroying toxic forms of oxygen, virulence factors, etc., make bacteria ubiquitous in the biosphere. The way the metabolic diversity of bacteria makes them versatile in the environment: The presence of diverse methods of ATP synthesis. Photophosphorylation, Fermentation, Aerobic and anaerobic respiration). The ability to shift between one method and another. Diversity of carbon nutrition: Carbon autotrophy, Carbon heterotrophy. The role of carbon autotrophs (Phototrophs and Chemolithotrophs and certain Archaea) as primary producers of the biosphere. Some important microbial metabolic activities in the environment: Contribution to cycling of matter, Winogradsky column as a model of sulfur cycle, Extracellular enzymes and their role, Degradation of diverse substrates including xenobiotics, Long chain hydrocarbon degradation, Nitrification of soil and why aeration encourages it, Denitrification of soil and why aeration discourages it, Methylotrophy including Methanotrphy, Methanogenesis. Soil microbial health: Determination of Microbial Carbon Biomass, Rhizosphere microorganisms, Role of microorganisms in maintaining soil fertility, Soil borne plant pathogens. Environmental application of microorganisms: Purification of drinking water, Wastewater treatment, Solid Waste management, Acid mine drainage, Bioleaching, Bioremediation,

Enhancement of agricultural productivity by manipulating soil conditions, Manipulation of beneficial plant microbial interactions, Organic fertilizer, Composting. Water quality and microbiological quality of drinking water: Organic matter and nitrate contents in water, Indicator organisms in drinking water, Coliform testing, *Escherichia coli*, Water Quality standards. (Drinking, Bottled and Recreational waters).

Method of teaching and learning:
A combination of lectures, tutorials, Student Centered Learning.

Assessment:
Continuous assessment and end of the course unit examination.

Recommended reading:

1. General Microbiology, Hans G. Schlegal (Cambridge, 2003)
2. Environmental Microbiology by Ian L. Pepper, Charles P. Gerba, Terry J. Gentry (Academic Press, 2014)

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Course Code **:** MIBI 22562
Title **:** Microbiology Laboratory for Environmental Management
Pre-requisite **:** ENCM 12553
Co-requisite **:** MIBI 22554
Status **:** Compulsory, Practical

Learning outcomes:
By completion of this course unit, the students will be able to:

- Isolate microorganisms from environments,
- Handle microorganisms in the laboratory, and
- Monitor and manipulate microbial activities in the environment.

Course content:
Detection, isolation and observation of microorganisms, Aseptic techniques, Pasteurization, Methods of sterilization, Estimation of population size, Strategies for laboratory growth of different microorganisms, Anaerobic and microaerophilic growth, Characterization of Microorganisms, Morphological and biochemical methods of characterization, Coliform testing, Testing for *Escherichia coli* in water and solids (foods, etc.), Conditions that favour fermentation, aerobic and anaerobic respiration of facultative anaerobes, Environmental induction of microbial processes.

Method of teaching and learning:
Laboratory classes and demonstrations, Industry visits and assignments.

Assessment:
Continuous assessment and end of the course unit examination.

Recommended reading:

1. Harrigan, W.F (1998) Laboratory methods in food and dairy microbiology. Culinary and Hospitality Industry Publications Services.
2. Pepper, I.L. and Gerba, C.P. (1995) Environmental Microbiology: A Laboratory Manual. Harcourt Brace & Company.

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11. Course Units offered by the English Language Teaching Unit

Year - 1

Course Code : ELTU 11042
Title : English for Environmental Science
Pre-requisite : G.C.E. (A/L) General English
Co-requisite : None
Status : Compulsory, Theory

Learning outcomes:
After completion of the course unit, the student will be able to,

- communicate effectively in oral and written forms on topics related to environmental science in English medium.

Course content:
English vocabulary related to environmental science, academic style in writing, appropriate reference styles in academic writing, preparation of summaries of written and spoken materials related to environmental science, discussions on environment related materials, common errors in pronunciation and grammatical structures, effective questioning, answering and expressing opinions related to environmental science, effective writing of lecture notes, academic talks and effective presentations related to environmental science, effective reading of environment related materials; textbooks, newspapers and magazines, student centered English language learning activities: group discussions, language games, making impromptu speeches on provided images relevant to the discipline, listening comprehension activities using multimedia resources.

Method of teaching and learning:
A combination of interactive classroom sessions, computer assisted learning, guest lectures, workshops and presentations.

Assessment:
In-class assignments and end-of-semester examination.

Recommended readings:

1. Korshuk, E., I. Kryba, E. Savich, P. Solovyov & A. Tamarina (2003). English for Environmental Science. Minsk: Technoprint.
2. Swales, J. M., & C. B. Feak (2004). Academic writing for graduate students: Essential tasks and skills (Vol. 1). Ann Arbor, MI: University of Michigan Press.
3. Grussendorf, M. (2007). English for presentations. Oxford University Press.

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