POSTGRADUATE INSTITUTE OF SCIENCE
UNIVERSITY OF PERADENIYA

Master of Environmental Science Degree Programme (SLQF Level 9)

Master of Science (M.Sc.) in Environmental Science Degree Programme (SLQF Level 10)

1 INTRODUCTION

We live at a critical time of environmental change and deterioration which makes it important for everyone of us to realize and understand the environment in which we live, and to take whatever action we can to safeguard it. Various activities of the fast growing human population are mainly responsible for the environmental deterioration. Recently, the human population growth rate has increased dramatically. The world population which was only 2 billion in 1930 reached 6.6 billion by the end of June, 2007, and would probably double by 2050. Natural resources are getting depleted and degraded owing to agricultural and industrial utilization, with one-third of the world's natural resources consumed within the last twenty five years.

Besides using natural resources at an ever increasing rate, the growing human population overloads the fragile biosphere with thousands of synthetic chemicals polluting the environment. The accumulation of solid waste further aggravates this situation. Pollution, which changes the characteristics of the environment, increases as the human population increases. Also, as countries develop economically the per capita usage of resources, and hence the per capita contribution to pollution, increases. Technological development also tends to exacerbate the degree of pollution. Thus, the population increase in a developed country increases pollution levels much more than the same population increase in a developing country does. The inevitable result of pollution, whatever the source or type, is to place the environment under ever increasing stress, which seriously affects the humans and other organisms that live in it. Biodiversity is being depleted at an alarmingly fast rate. Besides the several thousand species that may have become extinct in the recent past, about 60,000 species are already in danger of extinction. Therefore, it is important for every one of us to make all attempts to reduce pollution, and for every country to restore, as much as possible, the polluted natural resources. Systematic and scientific resource utilization and management will become increasingly important in the future. Thus, there is a growing and urgent need for a deeper understanding of the environment.

The M.Sc. programme in Environmental Science is designed to provide this understanding to young science graduates, who would have to take up the responsibility of conservation and management of

environment in years to come, so that future generations would have a relatively safe environment to live in. The programme has a multidisciplinary approach and would draw expertise in different relevant disciplines to provide a good knowledge of important environmental issues.

The programme will deal with global environmental problems, such as global warming, ozone layer depletion, acid rain and photochemical smog, in general and those in Sri Lanka in particular. Sri Lanka, now that it has ratified a number of international conventions and formulated a number of national policies related to environment, such as the National Environmental Policy, needs personnel with a sound background in the disciplines involved, with specialized training in Environmental Science, to deal with problems involving environmental degradation, particularly with reference to pollution and its management. This is particularly so in the Ministry of Environment and the Central Environmental Authority, organizations that are mainly responsible for the formulation and implementation of the policies related to the environment in the country, and in the local government bodies. This M.Sc. programme is designed to provide that expertise as well.

2. OBJECTIVE OF THE PROGRAMME

The objective of the programme is to develop the candidate's knowledge skills necessary to meet the demands in the field of environmental sciences with a broad knowledge and practical experience of its constituent branches of study.

More specifically, at the completion of this programme postgraduants are expected to be able to develop the skills in geological envivirnment, climates changes, biodiversity, ild life management, air pollution, noise pollution, water pollution, hazardous waste management, environment management and environmental impact assessments, cleaner production, waste water management, solid waste management and industrial waste management etc. It is intended for those aspiring to become environmental scientists and managers and also for those who need to improve their skills and knowledge.

3. PROGRAMME ELIGIBILITY

Applicants for admission to the programme must have successfully completed a science-based B.Sc. degree, or any other equivalent qualification acceptable to the Postgraduate Institute of Science, University of Peradeniya, and its Board of Study in Environmental Science. The medium of instruction and examinations of the programme will be English. Therefore, candidates should possess an adequate knowledge in English language.

Candidates who meet minimum eligibility requirements mentoned above and successful at the general aptitude test and the interview. Employed candidates who are eligible for admission should produce evidence of leave granted to follow the programme and the letter of release from the relevant Heads of the Departments/Institutions.

4. PROGRAMME FEE

Category	Programme Fee	
	Master of Environmental Science degree programme	**M.Sc. in Environmental Science degree programme**
Local candidates	Rs. 250,000/-	Rs. 350,000/-
Foreign candidates	Rs. 500,000/-	Rs. 700,000/-

Students registered for the Master of Environmental Science degree programme shall pay the Programme fee in full or in two or in three installments. An additional payment of Rs. 100,000/- (or Rs. 200,000/- form foreign students) should be made at the end of the first year to continue for the M.Sc. in Environmental Science degree programme. Other payments including registration fee, medical fee, library subscription, examination fee and deposits (science and library) should be paid according to the procedure stipulated by the PGIS. (N.B. The Programme fees given above may be revised as per recommendation of the Board of Management of the PGIS.)

5. THE PROGRAMME STRUCTURE AND DURATION

This programme consists of three options for completion.

5.1 Masters Degree by Course Work (SLQF Level 9)

The Master of Environmental Science degree can be obtained by completing course work only (without conducting any research project).

Course work, comprising of theory courses, and laboratory and/or fieldwork, shall be conducted over a period of two semesters of 15 weeks each. The total duration of the degree, including examinations, shall be about 12 months. Satisfactory completion of a minimum of 30 credits of course work with a GPA of not less than 3.00 is required for the successful completion of the degree - SLQF Level 9 (Students who do not satisfy the above criteria but obtain a GPA in the range 2.75 to 2.99 for course work of 25 credits are eligible for the Postgraduate Diploma in Environmental Science - SLQF Level 8, and those who obtain a GPA in the range 2.75 to 2.99 for course work of 20 credits are eligible for Postgraduate Certificate - SLQF Level 7).

5.2 Masters Degree (SLQF Level 10)

In addition to Masters Degree with course work (5.1), the Masters Degree (Research) requires a research project. The duration of the entire programme shall be 24 months inclusive of 5.1. Completion of all the requirements of 5.1 with a GPA of not less than 3.00 is a prerequisite for the Masters Degree (Research). The research project for this degree should be conducted on full-time basis, and completed during the second year. The research component is allocated 30 credits, totalling 60 credits for the entire programme. After successful completion of the research project, the student shall be eligible for the award of the M.Sc. in Environmental Science degree - SLQF Level 10 (Students who do not complete

the research project within the stipulated time period shall be awarded the Master of Environmental Science degree - SLQF Level 9).

5.3 Extension of the programme for M.Phil. (SLQF Level 11) or Ph.D. (SLQF Level 12)

After conducting research for a period of six months in the M.Sc. degree (research) programme, students who have demonstrated exceptional progress may apply for upgrading the degree status to M.Phil. The student should continue the research project and any additional research work/assignments recommended by the PGIS for a total of two years (60 credits of research) to qualify for the award of the M.Phil. degree (SLQF Level 11).

During the second year of research, students who have demonstrated exceptional and continuous progress may apply for upgrading the degree status from M.Phil. to Ph.D. The student should continue the research project and any additional research work/assignments recommended by the PGIS for another year on full-time basis (additional 30 credits) to qualify for the award of the Ph.D. degree (SLQF Level 12).

PROGRAMME SUMMARY

Master of Environmental Science Degree Programme (SLQF Level 9)
Master of Science (M.Sc.) in Environmental Science Degree Programme (SLQF Level 10)

Course Code	Course	Lecture hrs.	Practical/ Field Work hrs.	No. of credits
Preliminary Courses				
ENS 401	Introductory Biology	20	20	2
ENS 402	Bio-Statistics	20	20	2
Semester I				
Compulsory Courses				
ENS 511	Planet Earth: Geological Environment	24	12	2
ENS 512	Biosphere Organization and Functioning: Ecosystems and Populations	24	12	2
ENS 513	Biodiversity, Human Population Dynamics and Man's Impact on Environment	24	12	2
ENS 514	Air and Sound Pollution, Atmosphere and Climate	24	12	2
ENS 515	Water Resources and Water Pollution	24	12	2
ENS 516	Land Pollution and Solid and Hazardous Waste Management	24	12	2
ENS 522	Environment Management and Sustainable Development	24	12	2
ENS 523	Legal Protection of Environment	15	–	1
ENS 533	Industrial Waste Management	21	18	2
ENS 534	Environment Monitoring and Sampling Techniques	15	30	2
ENS 540	Cleaner Production	15	-	1
ENS 551	Research Methodology and Scientific Writing	15		1
ENS 599	Independence Study**[1]	500 notional hrs.		5

		Total		**26**
Optional Courses				
ENS 531	Energy Resources, Use, Concepts and Alternatives	30	–	2
ENS 532	Agriculture and Toxic Chemicals	24	12	2
ENS 535	Wetlands and Their Exploitation	21	18	2
ENS 536	Marine Resources and Marine Pollution	21	18	2
ENS 537	Environmental Geology & Health	24	12	2
ENS 539	Environment and Farming Practices	21	18	2
SLQF Level 10 - Research Work				
ENS 699	Research Project **[2]	3000 notional hrs. (one year)		30

Students are required to obtain 4 credits from among the optional courses.
**[1] *Compulsory for Master of Environmental Science (SLQF Level 9)*
**[2] *Compulsory for M.Sc. in Environemental Science (SLQF Level 10)*

The course work shall offer all compulsory modules (26 credits) and optional courses of his/her choice for another four (04) credits out of tweleve (12) credits offered. Course work will be conducted over two semesters during weekends. ENS 401 is compulsory for those without a biology background, while ENS 402 is compulsory for those without a biostatistics background. The preliminary courses are not considered in computing the GPA. Prior to taking the compulsory courses and optional courses, a student shall successfully complete the preliminary courses and pass the respective examinations. Those who have done biology (or zoology and botany) or biostatistics at the undergraduate level may be exempted from the respective preliminary courses.

6. PROGRAMME CONTENTS (details of Course modules)

Code	ENS 401
Title	Introductory Biology
Credits	2 credits
Compulsory/Optional	Preliminary
Pre-requisites	None
Aims	To introduce biological principles for non-biological students of the programme
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: 1. Describe the basic concepts of plant-animal classification systems 2. Identify important plant and animal species 3. Describe the basic physiological functioning of plants and animal bodies
Time Allocation	20 lecture hours + 20 practical hours
Content	Plant kingdom and plant classification; Animal kingdom and animal classification; Binomial nomenclature; Important plant taxa and Phytosociology; Important animal phyla such as Protozoa, Cnidaria, Platyhelminthes, Annelida, Arthropoda, Mollusca, Echinodermata, and Chordata; Classes of vertebrates; Class Mammalia and its various orders; Fossils and extinct animals; Organ systems of animals; Elements of genetics, embryology, organic evolution and zoogeography.
Recommended Texts	**Graham, L.E., Graham, J.M. Wilcox, L.W. (2006).** *Plant Biology (2nd edition).* Pearson Education Inc., New Jersey, USA **Taylor, D.J., Stout, G.W., Green, N.P.O. and Soper, R. (2008).** *Biological Science (3rd edition).* Cambridge University Press. Cambridge, UK. **Campbell, N.A., Reece, J.B., Urry, L.A., Cain, M.L., Wasserman, S.A., Minorsky, P.V., Jackson, R.B. (2008).** *Biology (8th edition).* Pearson Education Inc., New Jersey, USA

Assessment Criteria

Continuous Assessments	Mid-Semester	Final Examination
20%	30%	50%

Code	ENS 402
Title	Bio-Statistics
Credits	2 credits
Compulsory/Optional	Preliminary
Prerquisites	none
Aims	To introduce basic principles in statististics of the programme
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: 1. Describe the basic concepts of basic statistics 2. Identify important software packages relavent to statistics 3. Describe the basic environmental data analyses
Time Allocation	20 lecture hours + 20 practical hours
Content	Need and Purpose of sampling; Estimates and parameters; Precision of estimates; Methods for sampling locations and times; Simple and stratified random sampling; Systematic sampling; Sample size determination; Sampling Theory: Sampling distributions of Means, Difference of means, Proportion, Variances; Scale of measurement of data; Hypotheses testing: Point estimates an confidence interval estimates, Difference of means, Proportions, Variances; Type I and Type II Errors; Parametric tests (Concerning Means, Proportions and Variances); Nonparametric tests; Analysis of count data and contingency tables; Design of experiments; Analysis of variance for single factor and factorial experiments; Mean comparison
Recommended Texts	Pranab Kumar Banerjee (2011). Introduction to Bio-Statistics

Assessment Criteria

Continuous Assessments	**Practical Test**	**Final Examination**
20%	30%	50%

Code	ENS 511
Title	Geological Environment
Credits	2 Credits
Compulsory/Optional	Compulsory
Prerquisites	None
Aims	To familiarise students in earth processes and earth materials
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: 1. Describe main earth processes 2. Describe the structure of the earth and how it is determined 3. Explain the compositions of earth materials 4. Describe the weathering process and formation of soil profiles 5. Explain applications of groundwater exploration in crystalline terrains 6. Explain earth hazards, mainly earthquakes, tsunami and landslides and their prediction and controls
Time Allocation	24 hours lectures + 6 hours practical + 6 hours field work
Content	Earth in the Solar System; Structure of the Earth; Lithosphere and its composition; Plate tectonics; History of Earth and Geologic time; Rocks and minerals and weathering processes; Soil profiles; Hydrosphere: Earth's water resources and its applications; Groundwater exploration; Landslides and Earthquakes their prediction and control
Recommended Texts	Cooray, P.G. (1984). The Geology in Sri Lanka. National Museum, Colombo, pp.340. E.W. Spencer, 1988.Introduction to structure of the earth, Billy P. Glass, 1982. Introduction to planetary geology, Yasamanov, N.A..1990. Modern Geology, Secord, James A.1998. Principles of Geology Walton Williams C., (1970) Groundwater resources evaluation, McGraw Hill Book Co., New York. Panabokke, C.R. (2008). Groundwater Conditions in Sri Lanka – a Geomorphic Perspective, National Science Foundation publ., pp.144. Landslides, Publications in National Building Research Organization

Assessment Criteria

Field/practial Assessments	Mid-Semester	Final Examination
20%	30%	50%

Code	ENS 512
Title	Biosphere Organization and Functioning: Ecosystems and Populations
Credits	2 Credits
Compulsory/Optional	Compulsory
Prerquisites	None
Aims	To introduce major ecological concepts and facts pertaining to ecosystems and populations.
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: • Describe major ecological concepts and facts pertaining to ecosystems and populations • Describe major ecosystems in Sri Lanka and the world. • Describe major concepts in population ecology and their uses.
Time Allocation	24 hours lectures + 12 hours practical/Field work
Content	Biosphere structure; Biogeographic regions and major biomes; Bio-species, populations and communities; Ecosystem structure; Habitat and niche; Trophic levels and Food webs; Productivity; Adaptation of species to their habitats and available resources; Limiting factors and ranges of tolerance; Population Ecology: Age structure; Survivorship curves and life-tables, Population growth and carrying capacity, Population dispersal and regulation, Life history strategies, Interaction among organisms, Species richness; Natural and man-made ecosystems; Mature and immature ecosystems; Major natural ecosystems of the world (aquatic and terrestrial); Major ecosystems of Sri Lanka.
Recommended Texts	Krebs, C.J. 2001. *Ecology*. 5th Edn. Benjamin Cummings, San Francisco, CA. Odum, E.P. and Barrent, G.W. 2005. *Fundamentals of Ecology*. 5th Edn. Brooks/Cole, Belmont, CA.

Assessment Criteria

Field Assessments	Mid-Semester	Final Examination
20%	20%	60%

Code	ENS 513
Title	Biosphere Organization and Functioning: Ecosystems and Populations
Credits	2 Credits
Compulsory/Optional	Compulsory
Prerquisites	None
Aims	To introduce the concept of biodiversity, its importance, and current impacts on biodiversity
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: • Describe the concept of biodiversity. • Comment on the importance of biodiversity. • Describe biodiversity hotspots. • Comment on endemic, endangered, and threatened species with special reference to Sri Lanka. • Identify current threats to biodiversity. • Describe past, present, and future trends in the world's population.
Time Allocation	24 hours lectures + 12 hours practical/Field work
Content	Biodiversity and its present decline; Biodiversity in the past; Biodiversity hotspots; Indigenous and exotic species; Endemic, Endangered and Threatened species; IUCN Red List of threatened species; Keystone and Umbrella species; Viability of populations and species extinction; Habitat fragmentation and biodiversity loss; Sri Lankan biodiversity; Establishment and management of reserves and protected areas; *in-situ* and *ex-situ* conservation; Biodiversity and nature protection in Sri Lanka; people-wildlife conflict in Sri Lanka. Human population dynamics; Man's position and his impact on earth; Overpopulation and environmental degradation; Worldwide population trends; Land use; Urbanization.
Recommended Texts	Krebs, C.J. 2009. *Ecology: The Experimental Analysis of Distribution and Abundance.* 6th Ed. Benjamin Cummings, San Francisco, California. Leveque, C. And Mounlou, J. 2004. *Biodiversity.* John Wiley & Sons, Ltd., West Sussex, England.

Assessment Criteria

Continuous Assessments	Mid-Semester	Final Examination
10% of final grade (usually one assignment based on a field trip)	20% of final grade	70% of final grade

Code	ENS 514
Title	Air and Sound Pollution, Atmosphere and climate
Credits	2 credits
Compulsory/Optional	Compulsory
Prerquisites	None
Aims	To identify the surface air pollutants (ozone, nitrogen dioxide, carbon monoxide, sulphur dioxide, size- and species-resolved particulate matter), noise pollutants and its main characteristics
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: 1. Identify some ingredients and causes of air pollution 2. Identify some effects and solutions of air pollution 3. Describe some actions they can personally do to improve air quality Trace the beginnings of pollution by humans 4. Explain how stratospheric and tropospheric ozone is formed 5. Explain the action take by the EPA to reduce groundlevel ozone 6. Identify present day federal laws and agencies that deal with the pollution 7. Assess the extent of noise pollution 8. Describe how our atmosphere was formed and change in the climate of Sri Lanka
Time Allocation	Air Pollution (15 hrs L+ 6 hrs field visit) Noise Pollution (6 hrs L + 6 hours practical session) Atmosphere 3 hrs L
Content	Classification and sources of air pollutants. Primary and secondary air pollutants, Photochemical smog. Effects of air pollution on plants, materials and human health. Air quality standards and Air quality modelling.Urban air pollution: Air pollution trends in Sri Lanka. Monitoring air pollution: Automated monitoring, active, passive and bio-monitoring. Indoor air pollution. Global warming and climatic change.Kyoto Protocol; cleaner development mechanism and carbon trading. Ozone layer depletion and its mitigation. Acid rain and its effects on ecosystems. Sound and noise; Loudness; Measurement of noise levels; Decibel scale; Effects of noise including physiological and psychological effects; Noise control criteria and approaches for noise control; Noise control in industry; Sound screens and their effect on atmospheric dispersion of pollutants; Public policy and legislation on noise control Composition and structure of Atmosphere; Earth's radiation balance; Wind structure; Effects of orography; Dynamic equilibrium within the atmosphere, biosphere and hydrosphere; Climate of Sri Lanka
Recommended Texts	Jeremy Colls. 2002. Air Pollution. Edition: 2nd. Contributors:, Spon Press. London. Daniel Vallero, 2014. .Fundamentals of Air Pollution (Fifth Edition), Elsevier, Donaald E. Hall, 1988. Basic Acoustics, John Wiley & Sons, UK, Elizabeth Kolbert 2006. Field Notes from a Catastrophe: Man, Nature, and Climate Change, Bloomsbury USA, pp240

Assessment Criteria

Practial Assessments	**Mid-Semester**	**Final Examination**
20%	30%	50%

Code	ENS 515
Title	Water Resources and Water Pollution
Credits	*2 credits*
Compulsory/Optional	**Compulsory**
Prerquisites	**None**
Aims	Knowledge of the point and non-point sources for water pollution and its environmental impacts
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: 1. Identify point and non-point sources for water pollution 2. Identify some organic pollutants 3. Describe Biological oxygen demand, Chemical Oxygen Demand 4. Explain how Groundwater pollution is occurred 5. Explain the Effects of water pollution on biota 6. Identify water purification & water treatments methods 7. Identify water quality parameters and standards
Time Allocation	24 hours Lectures + 12 hours Practical
Content	Aquatic environment,; Properties of freshwater and sea water; Lotic and lentic waters; Man-made lakes and other aquatic facilities; Water pollutants; Types and sources of organic pollutants; Eutrophication and Algal toxins; Bioaccumualtion and biological magnification,Biological oxygen demand, Chemical Oxygen Demand; Run-off from agriculture; Seepage from mine tailings and land-fill operations; Groundwater pollution; Thermal pollution; Effects of water pollution on biota; Indicator organisms; chemical and ecological water pollution control, Water purification & water treatments; Sewage treatment; Water quality parameters and standards
Recommended Texts	P. K. Goel (2016) Water Pollution: Causes, Effects and Control New Age International, 418 pages

Assessment Criteria

Practical Assessment	**Final Examination**
34%	66%

Code	ENS 516
Title	Land Pollution and Management of Solid and Hazardous Waste
Credits	*2 credits*
Compulsory/Optional	**Compulsory**
Prerquisites	**None**
Aims	To identify the land pollution and study how to manage the solid and radiation wastes in sustainable manner
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: (1) familiarise with environmental pollution related to solid and hazardous waste (2) familiarise with treatment technology and management aspects of solid and hazardous waste (3) identify the radiation impacts on the radioactive wastes and their disposal.
Time Allocation	24 hours Lectures + 12 hours Practical/Field work
Content	Soil and land pollution; Accumulation of solid waste; Solid waste cycles; Microbiology involved in the methods of solid waste disposal, composting and sanitary land filling; Economic, aesthetic and environmental problems pertaining to solid waste disposal; Thermal incineration; Toxic effects; Recycling; Energy from refuse and sewage. Industrial pollution control; Management of solid wastes, and other types of wastes such as biomedical, chemical and hazardous waste; Waste water treatment (of both domestic and industrial waste water); Domestic waste management; Agricultural wastes as a source of raw materials; Natural and man-made radiation; Measurement of radiation, Radiation dose, Biological effects of radiation; Radioactive wastes and their disposal.
Recommended Texts	Gilbert M. Masters and Wendell P. Ela (2007). Introduction to Environmental Engineering and Science (3rd Edition) ISBN-13: 978-0131481930 ISBN-10: 0131481932

Assessment Criteria

Practical Assessment	**Mid-Semester**	**Final Examination**
20%	30%	50%

Code	ENS 522
Title	Environmental Management and Sustainable Development
Credits	*2 credits*
Compulsory/Optional	Compulsory
Prerquisites	none
Aims	Management of an environment in a comprehensive, systematic, planned and documented manner, which includes the planning and resources for developing, implementing and maintaining policy for environmental protection.
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: (1) learn the basic principles and role of the environment management (2) get to know the management approach and concepts to sustainable development (3) identify the life cycle analysis, design for sustainability, eco labelling and green procurement, greening the supply chain (4) understand the corporate social responsibility certification standards (5) learn the procedures in environment impact assessment
Time Allocation	27 hours Lectures + 6 hour practical assignment/Field work
Content	Basic principles of management; Role of Environmental management and its ramification on general management, Road leading to Sustainable development and environmental time line (1962 to 2013 key activities on environment pollution control), Resources Consumption in society and metrics to identify and calculate over consumption (Footprints- Ecological Footprint, Carbon Footprint, Water Footprint, Social Foot print and Ecological rucksack); Management Approaches and concepts to Sustainable Development (Pollution Prevention, Eco efficiency, Cleaner Production/RECP, Green productivity, Sound Chemicals Management. Chemical Leasing, Green Reporting Initiative/National Green Reporting system, Sustainable Consumption and Production, green economy, green growth, greening Industries, green Chemistry, green engineering and blue economy); Continuation of Management approaches and concepts to SD Tools for Facilitating Sustainable Development (Life Cycle Analysis, Design for Sustainability, Eco labelling and Green Procurement, Greening the supply chain, De-materialization, Closing the loop, Bio Mimicry); Environmental management Planning and Stakeholder engagement including nearby communities, Corporate Social Responsibility Certification standards (ISO 14001 , Eco Management and Audit Scheme and ISO 50001); Resource development and Environmental Impact Assessment (EIA) in Sri Lanka.
Recommended Texts	1. Sroufe, Robert ((2003). "Effects of Environmental Management Systems on Environmental Management Practices and Operations." Production and Operations Management. 12-3: 416-431. 2. Melnyk, Steven A., Robert P. Sroufe, and Roger Calantone. "Assessing the Impact of Environmental Management Systems on Corporate and Environmental Performance." 3. El-Gayar, Omar; Fritz, Brian D. (2006). "Environmental Management Information Systems (EMIS) for Sustainable Development: A Conceptual Overview". Communications of the Association for Information Systems. Association for Information Systems. **17**. ISSN 1529-3181

Assessment Criteria

Field Assessments	Mid-Semester	Final Examination
20%	30%	50%

Code	ENS 523
Title	Legal Protection of Environment
Credits	*1 credit*
Compulsory/Optional	**Compulsory**
Prerquisites	**None**
Aims	Describing the network of treaties, statutes, regulations, common and customary laws addressing the effects of human activity on the natural environment.
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: (1) learn the law of environment protect in different administrative bodies (2) learn the legal protection licencing scheme (3) understand the international conventions and protocols related to environment (4) learn the environmental ethics
Time Allocation	15 hours lectures
Content	Environmental policy, Constitutional provisions for environmental protection and management; Environmental protection by the Provincial Councils; Principles and concepts of environmental law; Practice and enforcement of environmental law in Sri Lanka; Introduction to the Act and Statutes related to environment conservation and management. Legal instruments in environmental protection with special reference to Environmental Protection Licensing (EPL) Scheme, Load based license fee concept etc. Public participation in environmental policy-making; International conventions and protocols related to environment; Environmental ethics; Environmental education; Environmental watchdogs.
Recommended Texts	Nation environmental Act Wildlife protection act Judges and Environmental Law (a handbook for Sri Lanka Judiciary), 2009. Environmental Foundation Ltd.

Assessment Criteria

Mid-Semester	**Final Examination**
40%	60%

Code	ENS 531
Title	Energy Resources, Use, Concepts and Alternatives
Credits	2 Credit2
Compulsory/Optional	Optional
Prerquisites	None
Aims	
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: (1)
Time Allocation	30 hours Lectures
Content	Energy development and consumption; Fossil fuels; Fossil fuel deposits and their depletion Biogas; Use of solar, wind, geothermal and ocean energy (both wave and thermal); Conservation of energy; Hydro and Thermal power plants and environmental pollution; Thermal pollution; Energy transportation; Fuels for the future; Nuclear energy its advantages and problems; Constraints on efficient energy usage imposed by thermodynamics; Environmental impact of energy use.
Recommended Texts	

Assessment Criteria

Mid-Semester	**Final Examination**
40%	60%

Code	ENS 532
Title	Agriculture and Toxicology
Credits	2 credits
Compulsory/Optional	Optional
Prerquisites	**none**
Aims	
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: (1)
Time Allocation	24 hours lectures + 12 hours practical
Content	Food resources and World food problem; Agriculture and its impact on the environment and man (Irrigation, Mechanization, Chemical fertilizers, Pesticides, High yielding varieties, GM foods); Under-utilized food and feed sources; Crop disasters; Effects of grazing patterns, wood-gathering and farming practice on the natural ecology; Economic factors in pest control; Improper use of pesticides and laws relating to use of pesticides; Alternatives to synthetic pesticides; Natural pest control methods; Biochemical, toxicological and other health effects of toxic chemicals on humans and other animals; Carcinogenic and mutagenic effects of chemicals; Acute toxicity; Sublethal effects; Synergetic effects; Tolerances; Transformations; Environmental factors affecting toxicity; Control and treatment of environmental toxicity.
Recommended Texts	

Assessment Criteria

Conninuous Assessments	**Mid-Semester**	**Final Examination**
20%	30%	50%

Code	ENS 533
Title	Industrial Waste Management
Credits	2 Credits
Compulsory/Optional	Compulsory
Prerquisites	None
Aims	To learn ongoing planning and plan implementation process to meet current and future needs for the service area based on the state's adopted hierarchy of waste management strategies.
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: (1) to assess the activities involved for the proposed and determine the type, nature and estimated volumes of waste to be generated; (2) to identify any potential environmental impacts from the generation of waste at the site; (3) to recommend appropriate waste handling and disposal measures / routings in accordance with the current legislative and administrative requirements; and (4) to categorise waste material where practicable (inert material / waste fractions) for disposal considerations i.e. public filling areas / landfill.
Time Allocation	21 hours lectures + 18 hours practical
Content	Special constraints of microbiological systems; Fermentor & Bioreactor design; Sterilizer design; Wastewater treatment (Ponds, Activated sludge, etc.). Physical Treatment Processes (Screening, sedimentation, etc.); Theory of Air Pollution Control (Particle/gas dynamics); Design and specification of Air Pollution Control Systems (Mechanical collectors, filters, scrubbers, electrostatic precipitators); "Air quality management" and 'Best available Technology' approaches: US and UK experience. Waste as a resource; Cleaner Production Technology and Membrane Technology; Hazardous waste techniques and management; Sludge treatment and disposal.
Recommended Texts	Chandrappa, R. and Das, D.B., (2012).*Solid waste management principles and practice*, Springer Publication.

Assessment Criteria

Practical Assinment	**Final Examination**
40%	**60%**

Code	ENS 534
Title	Environmental Monitoring and Sampling techniques
Credits	*2 credits*
Compulsory/Optional	Compulsory
Prerquisites	none
Aims	The overall objective of the course is to prepare a site-specific field data collection program that includes environmental sampling for air, surface water, groundwater, and soils.
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: **(1)** identify accident release of chemicals by the industry 2) To identify ground water contamination around an abandoned chemical factory. f) To determine if apples from a sprayed orchard are contaminated with pesticides.
Time Allocation	15 hours lectures + 30 hours practical sessions
Content	Sampling and the effective choice of a monitoring site; Monitoring in conjunction with modelling to minimise waste and cost of environmental monitoring; Low-cost tools. Measurement of atmospheric parameters; temperature, wind speed and direction, inversion height, etc.; Air quality monitoring: sampling preservation, monitoring techniques and methodology (analysis of carbon monoxide, nitrogen oxides, sulphur dioxides, hydrocarbons, particulate matter). Measurement of water parameters; Sampling, preservation, monitoring techniques and methodology (determination of pH, conductivity, oxygen, anions and cations, fertilizer and pesticide residues, microorganisms), Instrumentation and methods of analysis using advanced techniques such as atomic spectroscopy; electro-analytical methods; Neutron activation analysis; X-ray fluorescence; Gas and liquid chromatography; Ion chromatography
Recommended Texts	

Assessment Criteria

Practical Assessment	**Final Examination**
50%	50%

Code	ENS 535
Title	Wetlands and Their Exploitation
Credits	2 Credita
Compulsory/Optional	Optional
Prerquisites	None
Aims	
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: (1)
Time Allocation	21 hours lectures + 18 hours practical
Content	(*2 credits*) World Wetlands; Riverine, Lacustrine, Reservoir, Estuarine, Swampy and Coastal habitats; Wetlands and Wildlife; Threats to wetlands and Conservation of wetland flora and fauna of Sri Lanka; Environmental and health problems arising from wetland farming practices and wetland pollution; Irrigation systems and environmental problems associated with them; Salinization and desertification; Ancient and Recent Irrigation Systems of Sri Lanka; Multi-purpose reservoirs and their environmental impact; Water-based tourism and its environmental effects; Reclamation of wetlands; Wetlands and Fisheries; Capture and Culture fisheries, Socio-economy of people dependent on wetlands.
Recommended Texts	

Assessment Criteria

Conninuous Assessments	**Mid-Semester**	**Final Examination**
20%	30%	50%

Code	ENS 536
Title	Marine Resources and Marine Pollution
Credits	2
Compulsory/Optional	optional
Prerquisites	none
Aims	To apply the knowledge of ocean bathymetry and its dynamics to comprehend mechanisms of marine pollution and marine resource distribution and formation
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: (1) learn how the oceans are formed, behaviour of sea water and marine sedimentation (2) learn the marine flora and fauna (3) study the marine resources (4) learn maritime boundaries amd the law of sea
Time Allocation	21 hours lectures + 18 hours practical sessions
Content	Ocean Bathymetry, Formation of ocean basins, Properties and structures of Sea Water, Marine Sedimentation, Wind and Ocean Circulation, Waves, Tides, the Dynamic of Shoreline, Coastal and Marine Habitats, Biological Productivity, Marine Flora and Fauna, Marine Mineral/Petroleum Resources, Maritime Boundaries and Marine pollution
Recommended Texts	Invitation to Oceanography Paul R. Pinet

Assessment Criteria

Conninuous Assessments	**Mid-Semester**	**Final Examination**
20%	30%	50%

Code	ENS 537
Title	Environmental Geology & Health
Credits	**2**
Compulsory/Optional	**optional**
Prerquisites	**none**
Aims	In this course unit, you will learn about the branch of science known as environmental geology. It is a highly important scientific field that impacts the daily life of every living thing on Earth.
Intended learning outcomes	At the end of the successful completion of the course, students will be able to: (1) diffentiate the biogeochemical cycles and anthropgenic impacts on them (2) identify the mobility of elements that influenced the human health (3) identify the geological environments that aggevate the human health
Time Allocation	24 hours lectures + 12 hours practical sessions
Content	Understanding geological change, Fundamental Concepts of biogeochemical cycles, processes controlling biogeochemical cycles and anthropogenic impacts on them, Natural Environment; Geologic factors that may impact upon human life or way of life, revolution of geological materials from past to present, Environmental problems and possible alternative solutions to such problems, Mobility of metals in geologic environment; Significance of enrichment in major elements, trace elements, and heavy metals and its geological impact, Asbestos and its impacts, Acid sulphate soils and its impacts in environment, Water-borne diseases; chronic renal failure, Urbanization and disease.
Recommended Texts	Keller, Edwards (2011). Environmental Geology, 9th Edition, pearson publications James Reichard, Edgar Spencer (2013). Environmental Geology

Assessment Criteria

Conninuous Assessments	**Mid-Semester**	**Final Examination**
20%	30%	50%

Code	ENS 540
Title	Cleaner Production
Credits	**1**
Compulsory/Optional	**compulsory**
Prerquisites	**none**
Aims	
Intended learning outcomes	At the end of the successful completion of the course, students will be able to learn: 1. The precautionary approach - potential polluters must prove that a substance or activity will do no harm; 2. The preventive approach - preventing pollution at the source rather than after it has been created; 3. Democratic control - workers, consumers, and communities all have access to information and are involved in decision-making; 4. Integrated and holistic approach - addressing all material, energy and water flows using life-cycle analyses
Time Allocation	15 hours lectures
Content	Cleaner Production and its advantages; Waste audit procedure: pre-assessment, material balance, synthesis, Economic evaluation of alternatives. Waste audit; process data, environmental data, financial data; Searching for cleaner production options, waste reduction options and action plan, databases, selected examples, life cycle assessment; Calculations for actual examples, ISO 14000 and its implementation.
Recommended Texts	ISO 14001:2004, Environmental Management Systems-Specification With Guidance for Use ISO 14004:2004, Environmental Management Systems-General Guidelines on Principles, Systems and Supporting Techniques ISO 14010:1996, Guidelines for Environmental Auditing-General Principles ISO 14011:1996, Guidelines for Environmental Auditing-Audit Procedures-Auditing of Environmental Management Systems

Assessment Criteria

Conninuous Assessments	**Mid-Semester**	**Final Examination**
20%	30%	50%

Course code	ENS 599
Course title	Independent Study
Credits	05
Compulsory/optional	Compulsory
Prerequisites	ENS 551, which can be taken concurrently
Time allocation	500 notional hrs.
Aims	Aims: The overall aim is to familiarize the student with concepts and methods involved in scientific research **Specific aims:** 1. To explain the scientific process in the conduct of research. 2. To develop skills to write a review paper and a scientific research proposal. 3. To develop skills to make a presentation. 4. To master the application of statistical methods on quantitative scientific data.
Intended learning outcomes	At the end of the successful completion of the course, students will be able to, 1. Explain the scientific method. 2. Conduct an independent review of literature on a selected topic in the area of Analytical Chemistry. 3. Write a formal scientific report conforming to the guidelines provided. 4. Transfer the knowledge gained through (2) and (3) above in the form of a presentation. 5. Complete a research proposal conforming to the guidelines provided. 6. Perform statistical analysis of quantitative data.
Content	*Review paper*: Review of literature; Development of the review paper in concise and professional manner and logical presentation of results that have been reported, writing the abstract, compilation of the list of references. *Proposal writing*: Interpretation and critical evaluation of results of published research; Formulation of a research problem: Concise literature review, justification, time frame, identification of resources, budgeting, etc. *Project*: Collection and statistical analysis of data on a topic associated with the review paper. *Seminar*: Presentation of literature and data collected on a given topic; Preparation of an abstract, preparation of slides.

ssessment criteria

Component	% marks
Review paper	20
Proposal writing	10
Project	40
Seminar	30

Recommended Texts:

1. Backwell, J., Martin, J. (2011) A Scientific Approach to Scientific Writing, Springer.

2. Postgraduate Institute of Science (2016) Guidelines for Writing M.Sc. Project Report/M.Phil. Thesis/Ph.D. Thesis
3. Priyantha, N (2015) Measurements and Errors in Chemical Analysis, Science Education Unit, University of Peradeniya.

Course code	ENS 699
Course title	Research Project
Credits	30
Compulsory/optional	Compulsory
Prerequisites	ENS 551; GPA of 3.00 at SLQF Exit Level 9
Time allocation	3000 notional hrs. (one year)
Aims	Aims: The overall aim is to prepare the student to conduct a research independently. **Specific aims:** 1. To train students to apply scientific method in scientific research. 2. To train students to generate researchable hypotheses. 3. To train students to plan, design and conduct scientific research. 4. To gather reliable scientific data, analyse, and interpret. 5. To develop skills in scientific writing.
Intended learning outcomes	At the end of the successful completion of the course, students will be able to, 1. Apply the scientific method. 2. Design a research project. 3. Complete a research project. 4. Describe ethical issues in scientific research 5. Explain the patenting process in research 6. Make presentations at national/international conferences. 7. Produce a thesis conforming to the requirements of the PGIS. 8. Write manuscripts for publication in refereed journals.
Content	The students will conduct sufficient amount of laboratory/field work on a chosen research topic under the guidance provided by an assigned supervisor/s, make a presentation of research findings at a national/international conference, and produce a thesis.

Assessment criteria

Continuous assessment	End-semester examination
30%	Oral examination (20%) Thesis (40%) Conference presentation (10%)

7. PROGRAMME EVALUATION

This programme is subjected to the rules and regulations of the PGIS. These rules and regulations and the programme syllabus may be changed by the PGIS at its discretion.

Evaluation of Course work

Based on the scheme given below, the overall performance of a student in a given course shall be evaluated by the respective instructor(s) and a grade shall be assigned.

Evaluation Scheme

- For all courses a minimum of 80% attendance is expected.
- The evaluation of each course (except independent study and research project) shall be based on within course and end of course examinations, and assignments. The weightage of marks given below can generally be used as a guideline in the computation of the final grade.

End of course examination	50 - 60%
Continuous assessments (mid-semester examination, assignments, etc.)	40 - 50%

- Courses with laboratory and/or fieldwork shall be evaluated, where applicable, on a continuous assessment basis.
- The minimum grade a student should achieve to pass a course is C.
- Students will be informed of the evaluation scheme by the instructor at the beginning of a given course.

Grade Points and Grade Point Average (GPA)

The Grade Point Average (GPA) will be computed using the grades earned for core courses and optional courses, taken for credit. Preliminary courses, industrial training, research project and seminar will be evaluated on a pass/fail basis.

On completion of the end of course examination, the instructor(s) is/are required to hand over the grades of a given course to the programme coordinator who will assign the Grade Points using the following table:

Grade	Grade Point
A+	4.0
A	4.0
A^-	3.7
B^+	3.3
B	3.0
B^-	2.7
C^+	2.3
C	2.0
E	0.0

The Grade Point Average (GPA) will be computed using the formula:

$$GPA = \frac{\Sigma\, c_i g_i}{\Sigma\, c_i},$$

where c_i = number of credit units for the i^{th} course, and
g_i = grade point for the i^{th} course

Make-up Examinations

'Make-up' examinations may be given only to students who fail to sit a particular examination due to medical or other valid reasons acceptable to the PGIS.

Repeat Courses

If a student fails a course or wishes to improve his/her previous grade in a course, he/she shall repeat the course and course examinations at the next available opportunity. However, he/she may be exempted from repeating the course, and repeat only the course examinations if recommended by the teacher-in-charge or M.Sc. Programme Coordinator. The student may repeat the same course or a substituted (new) optional course in place of the original course. A student is allowed to repeat five (05) credits of coursework free-of-charge. The maximum number of credits a candidate is allowed to repeat is fifteen (15). The maximum grade, a candidate could obtain at a repeat attempt is a 'B' and he/she is allowed to repeat a given course only on two (02) subsequent occasions.

Evaluation of Research Project

Research project will be evaluated on the basis of a written report (M.Sc. project report) and oral presentation (see Section 6.0 of the PGIS Handbook for the format of the project report).

8. TEACHING PANEL

	Name, qualifications and affiliation/Address	Area of Specialization
1.	Dr. L.R.A.K. Banadara *B.Sc.* (*Perad.*), *PhD.* (*Perad.*) Dept. of Physics, UOP	Physics, radiation
2.	Prof. G.W.A.R. Fernando *B.Sc.* (*Perad.*), *M.Phil.* (*Perad.*), *Ph.D.* (*Mainz*) Dept. of Physics, OUSL	Geology and geochemistry
3.	Dr. G.B.B. Herath *B.Sc.* (*Eng.*) *(Perad), Ph.D.* (*Japan*) Dept. of Civil Engineering, UOP	Environmental Engineering
4.	Prof. O.A. Ileperuma *B.Sc.* (*Cey.*), *Ph.D.* (*Arizona*) Dept. of Chemistry, UOP	Organometallic Chemistry; Environmental Chemistry
5.	Dr. K.B.S.N. Jinadasa *B.Sc.* (*Eng.*) *(Perad),* M.Sc. (Singapore), Ph.D.(Saitama) Dept. of Civil Engineering, UOP	Environmental Engineering,solid-waste management
6.	Dr. C.S. Kalpage *B. Sc, (Eng.) (Perad),P.hD. (Birmingham, UK)* Department of Chemical Engineering, UOP	Chemical Engineering
7.	Prof. B.S.B. Karunaratne *B.Sc.* (*Cey.*), *Ph.D.* (*Warwick*) Dept. of Physics, UOP	Ceramics; Phyiscs
8.	Dr. D.G.G. P. Karunaratne *B.Sc. Eng* (*Perad.*), *Ph.D* (*Lisben*) Dept. of Chemical Engineering, UOP	Cleaner Production, chemical engineering
9.	Prof. M. Meegaskumbura *B.Sc.* (*Perad.*), *Ph.D.* (*Boston*) Department of Molecular Biology & Biotechnology, UOP	Molecular Biology
10.	Dr. (Ms). K.G.N. Nanayakkara *B. Sc. (Eng.) (Perad), PhD (NUS)* Department of Civil Engineering, UOP	Environmental Engineering
11.	Prof. M.M.A.N. Navaratne *B.Sc.(Perad.), M.S. (Hawaii), Ph.D. (Hawaii)* Dept. of Chemistry, UOP	Analytical Chemistry; Bioinorganic Chemistry
12.	Prof. H.M.T.G.A. Pitawala *B.Sc.* (*Perad.*), *M.Phil.* (*Perad.*), *Ph.D.* (*Mainz*) Dept. of Geology, UOP	Geochemistry
13.	Prof. G.A D. Perera *B.Sc.* (*Perad.*), *D.Phil.* (*Oxon*) Dept. of Botany, UOP	Ecology
14.	Prof. H.M.D.N. Priyantha *B.Sc.(Perad.), Ph.D. (Hawaii)* Dept. of Chemistry, UOP	Electrochemistry; Analytical Chemistry

15.	Mrs. G.M.P.R. Weeerakoon, *B. Sc, (Eng.) (Perad), M.Sc. (New Castle)* Department of Civil Engineering, UOP	Civil Engineering
17.	Dr. R.L. Wijayawardena *B.Sc.* (*Perad.*), *M.Sc., Ph.D.* (*Suny*) Dept. of Physics, UOP.	Nuclear Physics
16.	Mr. Chaminda Wijesundara *B.Sc.* (*Perad.*), *M.Sc. (Perad), M.Phil. (Perad)* Department of Zoology, UOP	Bird Ecology; Wildlife Ecology
17.	Dr. S.K. Yatigammana,. *B.Sc.* (*Perad.*), *M.Sc.* (*Perad.*), *Ph.D.* (*Queens*) Dept. of Zoology, Univ. of Peradeniya	Limnology; Environmental Science

OUTSIDE EXPERTS

1.	Mr D.L. Jagath. C. Gunawardena *LLB (Col), PG Diploma in Agriculture* No. 15/4, Stanley Thilkaratne Mawatha, Nugegoda	Enviornmental Law
2.	Dr. H.A.G. Jayatissa *B.Sc.* (*Perad.*), *M.Sc.* (*Germany*), *Ph.D.* (*Germany*) National Building Research Organization, Colombo 5	Landslides, Geological Hazards
3.	Eng. Mr. Sena Peiris *B Sc, (Eng.) (Perad), PG Diploma in Industrial Engineering (NIBM), MBA* 251/30, National Cleaner Production Centre,Kirula Road, Narahenpita	Cleaner Production
4.	Prof. Nalin P Ratnayake *B.Sc. (Perd.), M.Sc. (Shimane), PhD (Hokkaido)* Department of Earth Resource Engineering University of Moratuwa	Oceanography
5.	Dr. M.S. Vithanage *B. Sc.(Sab), M.Sc. (Perad), PhD (Copenhagen)* National Institute of Fundamanetal Studies, Kandy	Environmental chemistry
6.	Mr W.A.D.D. Wijesooriya *B.Sc.* (*Kel*), *M.Sc , ITC* (*The Netherlands*) Waragroda Road, Kelaniya,	Environmental Management
7.	Dr. D.S.A. Wijesundara Research Professor National Institute of Fundamental Studies, Hantana Rd., Kandy *B.Sc (Sp) (Perad), MPhil (Perad), PhD (NY)*	Plant Science

9. PROGRAMME COORDINATORS

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