DEPARTMENT OF AGRICULTURE & ENVIRONMENTAL SCIENCES

SCHOOL OF SCIENCE

NOIDA INTERNATIONAL UNIVERSITY

COURSE CURRICULUM FOR UNDERGRADUATE STUDIES UNDER CHOICE BASED CREDIT SYSTEM

FOR

B.Sc. (Hons.)

Environmental Science

PREAMBLE

The course curriculum for undergraduate studies under choice based credit system (CBCS) for B.Sc. in Environmental Science (Hons.) presented in this document follows the nationwide exercise undertaken by the University Grants Commission as part of curriculum restructuring initiative. **Noida International University** is offering B.Sc. Environmental Sciences a 3 year graduation Programme, the course curriculum presented here is largely based on the draft syllabus being prepared for UGC. Besides, Department of Environmental Studies had formulated an undergraduate syllabus for Environmental Science during 2011-2012 which was useful to start with. The curriculum at that time was framed after numerous formal and informal meetings were held with colleagues from various colleges, who helped with crucial inputs as to the content of the courses. The course curriculum contained in the following pages, therefore, represents a continuous effort of present and past deliberations with university and college teachers. This curriculum, however, varies from the one we prepared in 2011-2012 keeping in view the UGC curriculum requirements under CBCS. A part of the preface you are reading also forms part of the Preamble to the Course Curriculum under submission to UGC. There is bound to be repetition, which hopefully will not be construed otherwise.

The course curriculum is both inclusive and interdisciplinary and draws content from different allied disciplines. Ideally, an undergraduate programme in environmental science should equally focus equally on theory and practice so that students are able to pick up necessary skills enabling them to find gainful employment in the job market. Therefore, a number of skill-based courses have been identified and made a part of the curriculum. Various core courses have been made appealing from a practitioner's point of view. Hopefully, a student with a B.Sc. Environmental Science (Hons.) degree, should be equipped to meet the requirements of job market. Also, there is sufficient content for those who wish to continue academic life at the university beyond undergraduate level. While balancing the two, due care was taken to maintain necessary academic rigor and depth in the course content so that the learning outcomes from these courses will lead to intellectual growth of a student.

The need for an honours course in Environmental Sciences is necessitated by the acceptability of the subject by young students and also from the point of view of job market opportunity it proffers them as compared to those from pure academic disciplines. A latent demand for the subject exists in our country and we must meet the aspirations of young students. It is also expected that Environmental Science graduates, in the long run, will also significantly contribute to the vision of '***zero defect, zero effect***' policy initiative of Government of India.

As mentioned earlier, the course curriculum presented in the following pages conform to the general CBCS scheme, semester schedule, evaluation criteria and course credit structure of UGC. B.Sc. Environmental Science (Hons.) programme, like all other undergraduate courses shall comprise of 140 credits spread over twenty six (26) papers to be completed in three years/six semesters. The credits will be distributed as follows: 14 papers constituting Core Courses, 8 papers comprising Elective Courses, and 4 papers of Ability Enhancement Courses of which two are Skill Enhancement Courses.

CORE MODULE SYLLABUS FOR ENVIRONMENTAL STUDIES FOR UNDER GRADUATE COURSES OF ALL BRANCHES OF HIGHER EDUCATION

Vision

The importance of environmental science and environmental studies cannot be disputed. The need for sustainable development is a key to the future of mankind. Continuing problems of pollution, loss of forget, solid waste disposal, degradation of environment, issues like economic productivity and national security, Global warming, the depletion of ozone layer and loss of biodiversity have made everyone aware of environmental issues. The United Nations Conference on Environment and Development held in Rio de Janerio in 1992 and world Summit on Sustainable Development at Johannesburg in 2002 have drawn the attention of people around the globe to the deteriorating condition of our environment. It is clear that no citizen of the earth can afford to be ignorant of environment issues. Environmental management has captured the attention of health care managers. Managing environmental hazards has become very important. Human beings have been interested in ecology since the beginning of civilization. Even our ancient scriptures have emphasized about practices and values of environmental conservation. It is now even more critical than ever before for mankind as a whole to have a clear understanding of environmental concerns and to follow sustainable development practices. India is rich in biodiversity which provides various resources for people. It is also basis for biotechnology. Only about 1.7 million living organisms have been described and named globally. Still many more remain to be identified and described. Attempts are made to conserve them in ex-situ and in-situ situations. Intellectual property rights (IPRs) have become important in a biodiversity-rich country like India to protect microbes, plants and animals that have useful genetic properties. Destruction of habitats, over-use of energy resource and environmental pollution have been found to be responsible for the loss of a large number of life-forms. It is feared that a large proportion of life on earth may get wiped out in the near future. Inspite of the deteriorating status of the environment, study of environment have so far not received adequate attention in our academic programmes. Recognizing this, the Hon'ble Supreme Court directed the UGC to introduce a basic course on environment at every level in college education. Accordingly, the matter was considered by UGC and it was decided that a six months compulsory core module course in environmental studies may be prepared and compulsorily implemented in all the University/Colleges of India. The experts committee appointed by the UGC has looked into all the pertinent questions, issues and other relevant matters. This was followed by framing of the core module syllabus for environmental studies for undergraduate courses of all branches of Higher Education. We are deeply conscious that there are bound to be gaps between the ideal and real. Genuine endeavor is required to minimize the gaps by intellectual and material inputs. The success of this course will depend on the initiative and drive of the teachers and the receptive students.

Bachelor in Environment Science (Hons.)
Courses/Papers Sequence

COURSE	CREDITS Theory+ Practical
Core Courses - Theory (14 Papers)	14×4=56
Core Course - Practical/Tutorial*	14×2=28
II. Elective Courses (8 Papers)	
A1. Discipline Specific Electives - Theory (4 Papers)	4×4=16
A2. Discipline Specific Electives Practical/Tutorial* - (4 Papers)	4×2=8
B1. Generic Electives/Interdisciplinary - Theory (4 Papers)	4×4=16
B2. Generic Electives/Interdisciplinary - Practical/Tutorial* (4 Papers)	4×2=8
III. Ability Enhancement Courses	
1. Ability Enhancement Compulsory Courses (AECC) - (2 Papers of 2 Credits each) Environment Science & English/MIL Communication)	2×2=4
2. Skill Enhancement Courses (SEC) (2 Papers of 4 Credits each)	2×4=8
Total Credits	**144**

B.Sc. (Hons.)

Environmental Sciences Ist Sem

Sl.No.	Course Code	Subject	Period			Evaluation Scheme					
						Sessional Exam			External Exam	Subject Total	
			L	T	P	CA	TA	Total			
1	**ATUG 107**	INTRODUCTORY BIOLOGY	3	0	0	20	20	40	60	100	3
2	**STUEVS/ C01**	BIOINSTRUMENTATION	3	0	0	20	20	40	60	100	4
3	**STUGCS 1/C01**	PROGRAMMING IN **C**	3	0	0	20	20	40	60	100	4
4	**STUEVS/ C02**	ELEMENTARY CELL BIOLOGY	3	0	0	20	20	40	60	100	4
5	**AECC1**	ENVIRONMENTAL SCIENCES (EVS)	2	0	0	20	20	40	60	100	2
Practical											
1	**ATUG 107**	INTRODUCTORY BIOLOGY	0	0	2			25	25	50	2
2	**STUEVS/ C01**	BIOINSTRUMENTATION **(BI)**	0	0	2			25	25	50	2
3	**STUGCS 1/C01**	PROGRAMMING IN **C (PC)**	0	0	2			25	25	50	2
4	**STUEVS/ C02**	ELEMENTARY CELL BIOLOGY (ECB)	0	0	2			25	25	50	2
Total										750	2 4

BIO INSTRUMENTATION (STUEVS/C01)

L	T	P
4	0	2

Course Name: Bio Instrumentation **Course Code: STUEVS/C01**

Course Credit Hour: 4 hrs **Total Contact hour:** 60 hrs

Course Objective:

The students learn the physical principles of structure-function relationships in biological macromolecules such as proteins and nucleic acids, as well as the various approaches, techniques and instrumentation associated with structural biology.

Course Description:

This course presents the principles and applications of Biotechnology explaining the biomolecules and applications of biophysical methods. Students will be able to justify the need for buffers, describe how buffers are prepared, and calculate the amount of buffering agent needed when making a particular bufferOn successful completion of the course the students will be aware of Microscopic techniques, Electro physiological methods, Biomolecules structure determination using X-Ray diffraction.

Course Contents:

Unit I: General Biophysical methods: Measurement of pH, pOH, Buffer action, Isoelectric focusing.

Unit II: Separation & Identification of Materials: concept of Chromatography (Partition Chromatography, Paper Chromatography, Adsorption Chromatography, TLC, GLC, Ion Exchange Chromatography, Gel Chromatography, HPLC, Affinity Chromatography); Electrophoresis (Gel Electrophoresis, Paper Electrophoresis).

Unit III: Centrifugation: Basic Principle of Centrifugation, Instrumentation of Ultracentrifuge (Preparative, Analytical), Factors affecting Sedimentation velocity, Standard Sedimentation Coefficient, Centrifugation of associating systems, Rate-Zonal centrifugation, sedimentation euilibrium Centrifugation.

Unit IV: Microscopy: Light microscopy, Bright & Dark Field microscopy, Fluorescence microscopy, Phase Contrast microscopy, TEM, SEM.

Unit V: X-Ray Crystallography: X-ray diffraction, Bragg equation, Reciprocal lattice, Miller indices & Unit cell, Concept of different crystal structure, determination of crystal structure (concept of rotating crystal method, powder method). **Spectroscopy:** Basic concepts, principle, working, care & maintenance and applications of Raman Spectroscopy, NMR Spectroscopy and Absorption Spectroscopy.

Course Learning Outcomes (CLOs):

CLO-1: Enable the student to get sufficient knowledge in principles and applications of bio instruments.

CLO-2. To enable the students to learn the immuno techniques and radio labelling techniques.

CLO-3. To differentiate and analyze the biomedical signal sources.

CLO4. Describe the Basic concept of microscopic techniques such as Light microscopy, Bright & Dark Field microscopy, Fluorescence microscopy, Phase Contrast microscopy, TEM, SEM.

CLO5. Explain the basic principle and application of X-Ray Crystallography and spectroscopy.

Text Books:

- Cromwell, L. and Weibell, F.J. and Pfeiffer, E.A., Biomedical Instrumentation and Measurement, Dorling Kingsley (2006) 2nd ed.
- Carr, J.J. and Brown, J.M., Introduction to Biomedical Equipment Technology, Prentice Hall (2000) 4th ed.
- Wilson K and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. 7th Ed., Cambridge University Press.

Reference Books:

- Geddes, L.A., and Baker, L.E., Principles of Applied Biomedical Instrumentation, Wiley InterScience (1989) 3rd ed.
- Khandpur, R.S., Handbook of Biomedical Instrumentation, McGraw Hill (2003) 2nd ed.
- Webster, J.G., Medical Instrumentation Application and Design, John Wiley (2007) 3rd ed.
- Biophysical Techniques By Iain Campbell • 2012, 9780199642144, 0199642141, QUP Oxford.

Online links for study & reference materials:

https://microbenotes.com/category/instrumentation/

https://lecturenotes.in/download/material/18824-note-of-bioinstrumentation-by-nithya-biotech.

http://biomedikal.in/2009/12/lecture-notes-on-biomedical-instrumentation/

ELEMENTARY CELL BIOLOGY (STUEVS/C02)

L	T	P
4	0	2

Course Name: Elementary Cell Biology **Course Code: STUEVS/C02**

Course Credit Hour: 4 hrs **Total Contact hour:** 60 hrs

Course Objective:

To provide students the knowledge about cellular content, organization, structures and functions. To impart basic understanding of development biology and interaction of cell with environment.

Course Description:

It is an introductory cell biology course. Topics include the structure of the cell and cell components, both eukaryotic and prokaryotic. The processes of DNA replication and gene expression including protein processing and routing. Photosynthesis, respiration, and chemotrophy as means of energy production. The cell cycle and its regulation. These topics will be covered in one semester having four-hour lectures and one two-hour laboratory work per week.

Course Contents:

Unit I: Basics of Cell Biology (Structure & Function): Discovery of cell and Cell Theory; Comparison between plant and animal cells; Cell wall; Plasma membrane; Modification of plasma membrane and intracellular junctions; Cytoskeleton; Protoplasm; Mitochondria; Chloroplast; ER; Golgi complex; Lysosome, endosome and microbodies; Ribosome; Centriole; Nucleus; Chemical components of a cell; Catalysis and use of energy by cells.

Unit II: Biogenesis of Cellular organelles: Biosynthesis of mitochondria, chloroplast, ER, Golgi complex; Biosynthetic process in ER and Golgi apparatus; Protein synthesis and folding in the cytoplasm; Degradation of cellular components.

Unit III: Chromosomes: Chemical composition, structural organization of chromatids, centromeres, telomeres, chromatin, nucleosome organization, eu- and heterochromatin, special chromosomes (e.g. polytene and lampbrush chromosomes), banding patterns in human chromosomes.

Unit IV: Membrane Structure & Transport: Models of membrane structure, Membrane lipids, proteins and carbohydrates; Solute transport by Simple diffusion, Facilitated diffusion and Active transport; Cell adhesion

Unit V: Cell Cycle: An overview of cell cycle; Mitosis and meiosis; Components of cell cycle control system; Programmed cell death (Apoptosis), intrinsic & extrinsic pathways of cell death, Apoptosis in relation with Cancer, Viral disease (AIDS) & Organ transplant.

Course Learning Outcomes (CLOs):

After completion of the course, students will have a basic understanding of cell biology and will be able to demonstrate/explain:

CLO 1: To differentiate between animal as well as plant cells, to recognize and identify the function(s) of the following: centrioles, chromatin, Golgi apparatus, lysosome, microfilaments, microtubules, mitochondrion, nucleus, peroxisome, plasma membrane, rough and smooth endoplasmic reticulum, and ribosomes. An understanding of the ability of enzymes to facilitate chemical reactions. Explain how catalysts, including enzymes, affect and are affected by the chemical reactions in which they participate.

CLO 2: Protein sorting and transport of protein. Understanding of the biochemical processes of photosynthesis, glycolysis, citric acid cycle, and oxidative phosphorylation. Define cellular respiration and identify the cellular locations of the various stages of cellular respiration. Distinguish between the light reactions and the Calvin cycle of photosynthesis.

CLO 3: Chemical composition of nucleic acids (DNA/RNA). Structural Organization of DNA, chromatids, chromosome. Describe the various types of chromosomes on the basis of centromeric position. Chromosomal banding patterns and its application.

CLO 4: Cellular membrane structure and function. Various models of cellular membrane. Composition of cellular membranes. Transport across membrane by simple diffusion, facilitated diffusion and Active transport. Interaction between cells through cell adhesion molecules.

CLO 5: An understanding of how cells grow and divide. Describe the major events of each of the stages of the cell cycle (interphase, G1, G2, S, mitosis, prophase, prometaphase, metaphase, anaphase, telophase, mitotic phase, and cytokinesis). Cell Death and various process associated with cell death.

Text Books:

- Jeff Hardin, Gregory Bertoni, Lewis J. Kleinsmith, Wayne M. Becker. Becker's World of the Cell, 8th edition, Benajmin Cummings, 9780321689634, 0321689631, (2012).
- EDP De Robertis and EMF De Robertis. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, 9780781734936, 0781734932, (2006)

Reference Books:

- Gerald Karp, Cell and Molecular Biology: Concepts and Experiments, 6th edition, John Wiley & Sons. Inc, 9780470483374, 0470483377 (2010)
- G.M. Cooper, and R.E. Hausman. The Cell: A Molecular Approach. 5th Edition. ASM Press 780878931064, 0878931066 (2009)

Online links for study and reference materials:

- http://www.open2study.com/cellbiology
- https://nptel.ac.in/courses/102103012/
- Cell Biology - Course (swayam2.ac.in)

ENVIRONMENTAL SCIENCES- EVS (AECC1)

L	T	P
2	0	0

Course Name: Environmental Sciences **Course Code:** AECC1

Course Credit Hour: 2 hrs **Total Contact hour:** 30 hrs

Course Objective:

It is intended to impart basic undergraduate-level knowledge in the area of Environmental Sciences. People working in industries or elsewhere essentially require the knowledge of environmental science to enable them to work and produce the most efficient, economical and eco-friendly finished products.

Course Contents:

Unit I: Natural Resources: Forest resources: Use and over-exploitation, deforestation, case studies. Timberextraction, mining, dams and their effects on forests and tribal people, (b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water,dams-benefits and problems. (c) Mineral resources: Use and exploitation, environmentaleffects of extracting and using mineral resources, case studies. (d) Food resources: Worldfood problems, changes caused by agriculture and overgrazing, effects of modernagriculture, fertilizer-pesticide problems, water logging salinity, case studies. (e) Energyresources: Growing energy needs, renewable and non- renewable energy sources, use ofalternate energy sources (f) Land resources: Land as a resource, landdegradation, man induced landslides, soil erosion and desertification.

Unit II: Ecosystems: Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumersand decomposers, Energy flow in the ecosystem, Ecological succession, Food chains, foodwebs and ecological pyramids, Introduction, types, characteristic features, structure andfunction of the following ecosystem :- (a) Forest ecosystem, (b) Grassland ecosystem, (c)Desert ecosystem, (d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Unit III: Biodiversity and its conservation: Introduction – Definition: genetic, species and ecosystem diversity, Biogeographical classification of India, Value of biodiversity: consumptive use, productive use, social ethical, aesthetic and option values. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, Endangered and endemic species of India, Conservation of biodiversity : In-situ and Ex situ conservation of biodiversity.

Unit VI: Environmental Pollution: Definition, Causes, effects and control measures of: (a) Air pollution, (b) Water pollution,(c) Soil pollution, (d) Marine pollution (e) Noise pollution, (f) Thermal pollution, (g) Nuclearhazards. Human health risks; Solid waste management: Control measures of urban and industrial waste. Pollution case studies.

Unit V: Environmental Policies & Practices: Sustainability and sustainable development; Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture; Environment Laws: Environment Protection Act; Air and Water Wildlife Protection Act; Forest Conservation Act.; Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context.

Course Learning Outcomes (CLOs):

CLO1. Understand the basic concept immune system and its importance.

CLO2. Discuss Structure, Functions and Properties of different type of Immune Cells and immune organs.

CLO3. Describe the Basic characteristics of an antigen and Structure, Types, Functions and Properties of antibodies.

CLO4. Explain the Major Histocompatibility Complex I & II molecules, basics of Components of the Complement system.

CLO5. Discuss the basic concept of Generation of Immune Response, in particular Generation of Humoral Immune and Cell Mediated Immune Response.

Text Books:

- S.C. Sharma & M.P. Poonia, Environmental Studies, Khanna Publishing House, New Delhi.
- C.N. R. Rao, Understanding Chemistry, Universities Press (India) Pvt. Ltd., 2011
- Reuse, Mc-Graw Hill Education India Pvt. Ltd., New York, 2007, ISBN:978-07-062099
- Odum, E.P., Odum, H.T. & Andrews, J. 1971. Fundamentals of Ecology. Philadelphia: Saunders.

Reference Books:

- O.P. Gupta, Elements of Environmental Pollution Control, Khanna Publishing House, New Delhi
- Rao, C. S., Environmental Pollution Control and Engineering, New Age International Publication, 2007, ISBN: 81-224-1835-X.
- Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2011. Environmental and Pollution Science. Academic press, 2011.

Course Code: ATUG-107 **Course Name:** Introductory Biology

Course Credit Hour: 1 Hr **Total Contact Hour: 10 hours**

Course Objective:

The student will be able to explain the characteristics of living things and the levels of life. Students will understand how life has certain characteristics and begins at a molecular level.

Course Description:

Introductory Biology is a general biology course for nonmajors and provides an overview of the structure and function of living organisms. Topics covered in this course include essential information about characteristics of life, the scientific method, cell structure and function, genetics, microbiology, and comparative biology. Students will take from this course an understanding of the basic concepts in biology and role of plants and animals in agriculture.

Unit-1 **(3 hours)**

Introduction to the living world, diversity and characteristics of life, origin of life, Evolution and Eugenics.

Unit-2 **(3 hours)**

Binomial nomenclature and classification Cell and cell division. Morphology of flowing plants. Seed and seed germination.

Unit-3 **(4 hours)**

Plant systematic- viz; Brassicaceae, Fabaceae and Poaceae. Role of animals in agriculture.

Course Learning Outcomes (CLOs):

On completion of the course the students will be

CO-1: Describe elements of the scientific study of living things.

CO-2: Discuss cells, including their elements, organization, and membranes. CO-3: Describe how scientists classify and systematize the study of plants.

Text Books:

P. S Dhami, G. Chopra and H. N. Srivastava (2020). A text book of Biology. Pradeep Publications.

Reference Books:

Handbook of Biology (2014). Arihant Publications

B. Sc. (Hons.) Environmental Sciences
II Semester

Sl. No.	Subect Code	Subject				Sessional Exam			External Exam	Subject Total	Credit Hours
			L	T	P	CA	TA	Total			
1	**EVS-201**	Water & Water Resources	3	0	0	20	20	40	60	100	4
2	**EVS - 202**	Land & Soil Conservation & Management	3	0	0	20	20	40	60	100	3
3	**EVS - 203**	Bio Diversity Conservation & Ecosystem Services	3	0	0	20	20	40	60	100	4
4	**STUGC/C03**	Elements & Properties	3	0	0	20	20	40	60	100	4
5	**AECC 2**	Technical communication	2	0	0	20	20	40	60	100	2
Practical											
1	EVSP - 202	Land & Soil Conservation & Management	0	0	2			25	25	50	2
2	**SPUGC/C03**	ENVIRONMENTAL CHEMISTRY	0	0	2			25	25	50	2
3	**EVSP - 203**	Bio Diversity Conservation & Ecosystem Services	0	0	2			25	25	50	2
Total										600	23

EVS - 201	Water & Water Resources	L	T	P
		3	0	0

Unit 1: Introduction

Sources & types of water; hydrological cycle; precipitation, runoff, infiltration, evaporation, evapo-transpiration; classification of water resources.

Unit 2: Properties of water

Physical: temperature, colour, odour, total dissolved solids and total suspended solids; Chemical: major inorganic and organic constituents, dissolved gases, DO, COD, BOD, acidity and alkalinity, electrical conductivity, sodium adsorption ratio; Biological: phytoplankton, phytobenthos, zooplankton, macro-invertebrates and microbes.

Unit 3: Surface & subsurface water

Introduction to surface & ground water; surface & ground water pollution; water table; vertical distribution of water; formation & properties of aquifers; techniques for ground water recharge; river structure and patterns; watershed and drainage basins; importance of watershed and watershed management; rain water harvesting in urban settings.

Unit 4: Wetlands & their management

Definition of a wetland; types of wetlands (fresh water and marine); ecological significance of wetlands; threats to wetlands; wetland conservation and management; Ramsar Convention, 1971; major wetlands of India.

Unit 5: Marine resource management

Marine resources; commercial use of marine resources; threats to marine ecosystems and resources; marine ecosystem and resource management (planning approach, construction techniques and monitoring of coastal zones).

Unit 6: Water resource in India

Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources; water quality standards in India; hot spots of surface water; role of state in water resources management.

Unit 7: Water resources conflicts

Water resources and sharing problems, case studies on Kaveri and Krishna river water disputes; Multi-purpose river valley projects in India and their environmental and social impacts; case studies of dams - Narmada and Tehri dam – social and ecological losses versus economic benefits; International conflicts on water sharing between India and her neighbours; agreements to resolve these conflicts.

Unit 8: Major laws and treaties

National water policy; water pollution (control & prevention) Act 1972; Indus water treaty; Ganges water treaty; Teesta water treaty; National river linking plan; ecological & economic impacts.

EVS - 202 **Land & Soil Conservation & Management** **L T P**

3 0 2

Unit 1: Introduction

Land as a resource, soil health; ecological and economic importance of soil; types and causes of soil degradation; impact of soil loss and soil degradation on agriculture and food security; need for soil conservation and restoration of soil fertility.

Unit 2: Fundamentals of soil science

Soil formation; classification of soil; soil architecture; physical properties of soil; soil texture; soil water holding capacity; soil temperature; soil colloids; soil acidity and alkalinity; soil salinity and sodicity; soil organic matter; micronutrients of soil; nitrogen, sulphur, potassium and phosphorus economy of soil; soil biodiversity; soil taxonomy maps.

Unit 3: Soil degradation - causes

Soil resistance and resilience; nature and types of soil erosion; non-erosive and erosive soil degradation; losses of soil moisture and its regulation; nutrient depletion; soil pollution due to mining and mineral extraction, industrial and urban development, toxic organic chemicals, and organic contaminants in soils; fertilizers and fertilizer management; recycling of soil nutrients.

Unit 4: Land use changes and land degradation

Land resources: types and evaluation; biological and physical phenomena in land degradation; visual indicators of land degradation; drivers of land degradation - deforestation, desertification; habitat loss, loss of biodiversity; range land degradation; land salinization; human population pressure, poverty, socio-economic and institutional factors; drivers of land use and land cover change in major geographic zones and biodiverse regions with particular reference to the Himalaya and the Western Ghats.

Unit 5: Costs of land degradation

Economic valuation of land degradation; onsite and offsite costs of land degradation; loss of ecosystem services; effects on farming communities; effects on food security; effects on nutrient cycles; future effects of soil degradation; emerging threats of land degradation to developing countries.

Unit 6: Controlling land degradation

Sustainable land use planning; role of databases and data analysis in landuse planning control and management; land tenure and land policy; legal, institutional and sociological factors; participatory land degradation assessment; integrating land degradation assessment into conservation.

STUGC/C03 ELEMENTS AND PROPERTIES

L	T	P
4	0	2

Inorganic Chemistry

Unit 1:

Periodic trends and properties: Size, Ionization Energy, Electron Affinity, Electronegativity, Lattice and Hydration Energies, Use of redox potential and reaction feasibility.

Unit 2:

Chemistry of *s* and *p*-block elements: Alkali and alkaline earth metals: Hydrides and Complexation tendencies. Structural features of hydrides, halides, oxides and oxyacids.

Unit 3:

Chemistry of *d*-block elements: Salient features, characteristic properties of 3*d*-elements with reference to oxidation states, colour, magnetic behaviour, and complex formation tendency.

Physical Chemistry

Unit 4:

Gaseous State: Kinetic theory of gases, ideal gas laws based on kinetic theory. Collision in a gas- mean free path, collision diameter, collision number. Behaviour of real gases - the van der Waal's equation. Critical phenomena - critical constants of a gas and their determination, the van der Waals equation and critical state, Principle of corresponding states.

Unit 5:

Liquid State: Surface tension of liquids - capillary action, experimental determination of surface tension, temperature effect on surface tension. Viscosity of liquids, experimental determination of viscosity coefficient, its variation with temperature.

Recommended Books:

1. *Basic Inorganic Chemistry*, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995), John Wiley & Sons, New York.
2. *Concise Inorganic Chemistry*, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
3. *Physical Chemistry*, P. Atkins and J. De Paul, 8th Edition (2006), International Student Edition, Oxford University Press.
4. *Physical Chemistry*, P. C. Rakshit, 5th Edition (1988), 4th Reprint (1997), Sarat Book House, Calcutta.
5. *Principles of Physical Chemistry*, B. R. Puri, L. R. Sharma, and M. S. Pathania**,** 37th Edition (1998), Shoban Lal Nagin Chand & Co., Jalandhar.
6. *Physical Chemistry*, K. J. Laidler and J. M. Meiser, 3rd Edition, Houghton Mifflin Comp., New York, International Edition (1999)

EVS - 205 Bio Diversity Conservation & Eco System Services **L T P**

3 0 2

Unit-I

Introduction to classification of animal kingdom. Diversity of insects, nematodes, fishes, birds, reptile and other mammals. Animal food and fisheries. Role of animal and insects in pollination and seed dispersal. Economic importance of wild life.

Unit-II

Factors for decline of biological diversity. Approaches for conservation of biological diversity. Protection of wild flora, fauna and natural habitats. Concept of threatened species. Threatened and endangered animals of India.

Unit-III

Food, timber and medicinal plants non-timber forest produce. Importance of tropical rain forests and wetlands. Wild life sanctuaries, National Parks and Biosphere Reserve. Concept of genetic diversity, gene and germ-plasm banks.

Unit-IV

Biodiversity convention. International and national efforts to conserve biodiversity. Socio-cultural aspects of biodiversity. Biotechnological needs for biodiversity conservation. Traditional knowledge and biodiversity conservation.

Suggesting Reading:

1. Chandel, K.P.S., Shukla, G. And Sharma, N. (1996). Biodiversity in Medicinal and Aromatic Plants in India Conservation and Utilization, National Bureau of Plant Genetic Resources, New Delhi.
2. Council of Scientific and Industrial Research (1986). The Useful Plants of India Publication and Information Directorate, CSIR, New Delhi.
3. Nair, M.N.B. et. al. (Eds.) (1998). Sustainable Management of Non-wood Forest Products. Faculty of Forestry, University Putra. Malaysia. 434 004 PM Serdong, Selangor, Malaysia.
4. Soule, M.E. (ed.) (1986). Conservation Biology. The Science of Scarcity and Diversity. Sinaur Associates, Inc., Sunderland, Massachusetts.
5. Singh, J.S., Singh, S.P. and Gupta, S.R. 2006. Ecology, Environment and Resource Conservation, Anamaya Publishers, New Delhi.

AECC2 Technical Communication L T P

2 0 0

TECHNICAL COMMUNICATION

Course Code: TC I

L	T	P
2	0	0

Objective: The objective of the first semester course is to introduce the basics of communication language and gradually develop a module to exhilarate the command over the language and its acquisition.

Unit- 1: Introduction to professional communication

- Definition of communication
- Types of communication
- Channels of communication
- Barriers to communication
- General and Technical Communication

Unit-2 English language on global forum

- Language as tool of communication
- English language in global business environment
- Cultural variables

Unit -3 Group communication

- Group Discussion
- Role of moderators
- Objectives of GD
- Types of GD
- Participation in GD

Unit- 4 Active listening and oral abilities enhancement

- Introduction to principal components of spoken English – Transcription, Word accent, Intonation, weak Form in English.
- Listening to speeches, news bulletins viewing T.V programmes etc.
- Practicing (a) role play activities, b) short dialogues (c)Group discussion (d)Debates (e)Speeches

Unit -5 Review of Basic English grammar

- Sentence sense
- Case

B. Sc. (Hons.) Environmental Sciences
SEMESTER III

						Sessional Exam			External Exam	Subject Total	Credit Hours
			L	T	P	CA	TA	Total			
1	EVS-301	cology & Ecosystems	4	0	0	20	20	40	60	100	4
2	EVS - 302	Environmental Biotechnology	3	0	0	20	20	40	60	100	4
3	EVS - 303	Atmosphere & Global Climate Change	3	0	0	20	20	40	60	100	3
4	STUGC/C07	Environmental Chemistry	3	0	0	20	20	40	60	100	4
5	ATUG-306	Environmental Studies & Disaster Management	4	0	0	20	20	40	60	100	2
Practical											
1	EVSP - 308	Environmental Biotechnology	0	0	2			25	25	50	2
2	EVSP - 307	Ecology & Ecosystems	0	0	1			25	25	50	1
3	EVS - 304	Environmental Chemistry	0	0	2			25	25	50	2
Total										750	23

EVS = 307 ECOLOGY & ECOSYSTEMS **L T P**
3 0 1

Unit 1: Introduction

Basic concepts and definitions: ecology, landscape, habitat, ecozones, biosphere, ecosystems, ecosystem stability, resistance and resilience; autecology; synecology; major terrestrial biomes.

Unit 2: Ecology of individuals

Ecological amplitude; Liebig's Law of the Minimum; Shelford's Law of Tolerance; phenotypic plasticity; ecotypes; ecoclines; acclimation; ecological niche; types of niche: Eltonian niche, Hutchinsonian niche, fundamental niche, realized niche; niche breadth; niche partitioning; niche differentiation; thermoregulation; strategies of adaptation in plants and animals.

Unit 3: Ecology of population

Concept of population and meta-population; r- and K-selection; characteristics of population: density, dispersion, natality, mortality, life tables, survivorship curves, age structure; population growth: geometric, exponential, logistic, density-dependent; limits to population growth; deterministic and stochastic models of population dynamics; rudreal, competitive and stress-tolerance strategies.

Unit 4: Ecology of communities

Discrete versus continuum community view; community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; species interactions: mutualism, symbiotic relationships, commensalism, amensalism, protocooperation, predation, competition, parasitism, mimicry, herbivory; ecological succession: primary and secondary successions, models and types of successions, climax community concepts, examples of succession.

Unit 5: Ecosystem ecology

Types of ecosystem: forest, grassland, lentic, lotic, estuarine, marine, desert, wetlands; ecosystem structure and function; abiotic and biotic components of ecosystem; ecosystem boundary; ecosystem function; ecosystem metabolism; primary production and models of energy flow; secondary production and trophic efficiency; ecosystem connections: food chain, food web; detritus pathway of energy flow and decomposition processes; ecological efficiencies; ecological pyramids: pyramids of number, biomass, and energy.

Unit 6: Biogeochemical cycles and nutrient cycling

Carbon cycle; nitrogen cycle; phosphorus cycle; sulphur cycle; hydrological cycle; nutrient cycle models; ecosystem input of nutrients; biotic accumulation; ecosystem losses; nutrient supply and uptake; role of mycorrhizae; decomposition and nutrient release; nutrient use efficiency; nutrient budget; nutrient conservation strategies.

Unit 7: Biological invasions

Concept of exotics and invasives; natural spread versus man-induced invasions; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways; impacts of invasion on ecosystem and communities; invasive

ecogenomics – role of polyploidy and genome size in determining invasiveness; economic costs of biological invasion

EVS - 308	ENVIRONMENTAL BIO TECHNOLOGY	L	T	P
		3	0	2

Unit 1: The Structure and Function of DNA, RNA and Protein

DNA: structural forms and their characteristics (B, A, C, D, T, Z); physical properties: UV absorption spectra, denaturation and renaturation kinetics; biological significance of different forms; Synthesis.

RNA: structural forms and their characteristics (rRNA, mRNA, tRNA; SnRNA, Si RNA, miRNA, hnRNA); biological significance of different types of RNA; synthesis.

Protein: hierarchical structure (primary, secondary, tertiary, quaternary), types of amino acids; post-translational modifications and their significance; synthesis; types and their role: structural, functional (enzymes).

Central dogma of biology; genetic material prokaryotes, viruses, eukaryotes and organelles; mobile DNA; chromosomal organization (euchromatin, heterochromatin - constitutive and facultative heterochromatin).

Unit 2: Recombinant DNA

Technology

Recombinant DNA: origin and current status; steps of preparation; toolkit of enzymes for manipulation of DNA: restriction enzymes, polymerases (DNA/RNA polymerases, transferase, reverse transcriptase), other DNA modifying enzymes (nucleases, ligase, phosphatases, polynucleotide kinase); genomic and cDNA libraries: construction, screening and uses; cloning and expression vectors (plasmids, bacteriophage, phagmids, cosmids, artificial chromosomes; nucleic acid microarrays

Unit 3: Ecological restoration and bioremediation

Wastewater treatment: anaerobic, aerobic process, methanogenesis, bioreactors, cell and protein (enzyme) immobilization techniques; treatment schemes for waste water: dairy, distillery, tannery, sugar, antibiotic industries; solid waste treatment: sources and management (composting, vermiculture and methane production, landfill. hazardous waste treatment); specific bioremediation technologies: land farming, prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, constructed wetlands, use of bioreactors for bioremediation; phytoremediation; remediation of degraded ecosystems; advantages and disadvantages; degradation of xenobiotics in environment, decay behavior and degradative plasmids, hydrocarbons, substituted hydrocarbons, oil pollution, surfactants, pesticides, heavy metals degradative pathways.

Unit 4: Ecologically safe products and processes

PGPR bacteria: biofertilizers, microbial insecticides and pesticides, bio-control of plant pathogen, Integrated

pest management; development of stress tolerant plants, biofuel; mining and metal biotechnology: microbial transformation, accumulation and concentration of metals, metal leaching, extraction; exploitation of microbes in copper and uranium extraction.

EVS - 309 ATMOSPHERE & GLOBAL CLIMATE CHANGE **L T P**

3 0 0

Unit 1: Introduction

Evolution and development of Earth's atmosphere; atmospheric structure and composition; significance of atmosphere in making the Earth, the only biosphere; Milankovitch cycles.

Unit 2: Global energy balance

Earth's energy balance; energy transfers in atmosphere; Earth's radiation budget; green house gases (GHGs); greenhouse effect; global conveyor belt.

Unit 3: Atmospheric circulation

Movement of air masses; atmosphere and climate; air and sea interaction; southern oscillation; western disturbances; *El Nino* and *La Nina*; tropical cyclone; Indian monsoon and its development, changing monsoon in Holocene in the Indian subcontinent, its impact on agriculture and Indus valley civilization; effect of urbanization on micro climate; Asian brown clouds.

Unit 4: Meteorology and atmospheric stability

Meteorological parameters (temp, RH, wind speed and direction, precipitation); atmospheric stability and mixing heights; temperature inversion; plume behavior; Gaussian plume model.

Unit 5: Atmospheric chemistry

Chemistry of atmospheric particles and gases; smog – types and processes; photochemical processes; ions and radicals in atmosphere; acid-base reactions in atmosphere; atmospheric water; role of hydroxyl and hydroperoxyl radicals in atmosphere.

Unit 6: Global warming and climate change

Earth's climate through ages; trends of global warming and climate change; drivers of global warming and the potential of different green house gases (GHGs) causing the climate change; atmospheric windows; impact of climate change on atmosphere, weather patterns, sea level rise, agricultural productivity and biological responses - range shift of species, CO_2 fertilization and agriculture; impact on economy and spread of human diseases.

Unit 7: Ozone layer depletion

Ozone layer or ozone shield; importance of ozone layer; ozone layer depletion and causes; Chapman cycle; process of spring time ozone depletion over Antarctica; ozone depleting substances (ODS); effects of ozone depletion; mitigation measures and international protocols.

Unit 8: Climate change and policy

Environmental policy debate; International agreements; Montreal protocol 1987; Kyoto protocol 1997;

Convention on Climate Change; carbon credit and carbon trading; clean development mechanism.

Course Code: ATUG-306

Course Name: Environmental Studies & Disaster Management

Course Credit Hour: 3 **Total Contact Hour: 30 hr**

Course Description:

Through interdisciplinary academic courses, internships, experiential, and co-curricular activities our students become passionate stewards of the environment, scholars in sustainability and environmental management, and experts in environmental studies. With a focus on environmental justice, students develop critical-thinking skills, analyze real- world problems, and understand the power of narrative to create sustainable solutions for local and global communities.

Course Contents:

UNIT-1

Introduction to Environment: Definition, Components of Environment, Relationship between different components, Man Environment relationship, Impact of Technology on the environment, Environmental Degradation, Sustainable Development, Environmental Education.

Ecology & Ecosystems: Introduction: Ecology- Objectives and Classification, Concepts of an ecosystem- structure & function of ecosystem, Components of ecosystem- Producers, Consumers, Decomposers,

Energy flow in the ecosystem - Ecological succession. - Food chains, food webs and ecological pyramids. - Introduction, types, characteristic features, structure and function of the following ecosystem:

a. Forest ecosystem
b. Grassland ecosystem
c. Desert ecosystem
d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries) Bio-Geo- Chemical Cycles- Hydrological Cycle, Carbon cycle, Oxygen Cycle, Nitrogen Cycle, Sulfur Cycle

Environmental Pollution:

Air Pollution: Composition of air, Structure of atmosphere, Ambient Air Quality Standards, Classification of air pollutants, Sources of common air pollutants like SPM, SO2, NOX – Natural & Anthropogenic Sources, Effects of common air pollutants, Air Pollution Episodes

Noise Pollution: Introduction, Sound and Noise measurements, Sources of Noise Pollution, Ambient noise levels, Effects of noise pollution, Noise pollution control measures.

Water Pollution: Introduction – Water Quality Standards, Sources of Water Pollution, Classification of water pollutants, Effects of water pollutants, Eutrophication, Water Pollution Episodes

Current Environmental Global Issues: Global Warming and Green Houses Effect, Acid Rain, Depletion of Ozone Layer

Energy Resources: Renewable &Nonrenewable Resources: Renewable Resources, Nonrenewable Resources, Destruction versus Conservation.
Energy Resources: Energy Resources - Indian Scenario , Conventional Energy Sources & its problems, non-conventional energy sources- Advantages and its Limitations.

UNIT-2

Types of Disaster Introduction, Types of Natural Disasters, Accidental Disasters, Impact of Disasters on Trade and International Trade.

Natural Disasters: Introduction, Earthquakes, Hurricanes, Tornadoes, Floods, Drought, Tsunami, Volcanoes, Cyclones and Storms, Forest Fires, Severe Heat Waves, Landslides and Avalanches, Epidemics and Insect Infestations
Technological and Social Disasters: Introduction, Types of Technological Hazards, Hazardous Materials, Social Disasters, Political and Crowd Disasters,War and Terrorism

Disaster Management: Components of Disaster Management, Government's Role in Disaster Management through Control of Information, Actors in Disaster Management, Organizing Relief measures at National and Local Level, Psychological Issues, Carrying Out Rehabilitation Work, Government Response in Disaster
Course Learning Outcomes (CLOs):

CLO-1 Understand the natural environment and its relationships with human activities.

CLO-2 Characterize and analyze human impacts on the environment.

CLO-3 Integrate facts, concepts, and methods from multiple disciplines and apply to environmental problems

CLO-4 Capacity to integrate knowledge and to analyse, evaluate and manage the different public health aspects of disaster events at a local and global levels

CLO-5 Capacity to obtain, analyse, and communicate information on risks, relief needs and lessons learned from earlier disasters in order to formulate strategies for mitigation in future scenarios.

Text books:
Basics of Environmental Studies by Dr. N. S. Varandani, Books India Publications
Disaster Management by MukeshDhunna, Vayu Education of India, Delhi Publication
Reference books:
Environmental Studies by R. Rajagopalan, Oxford University Press Publication
Environmental Science by Richard T Wright & Bernard J Nebel, Prentice Hall India Publication
Environmental Science by Daniel B Botkin& Edward A Keller, Wiley Publications

STUGC/C07 ENVIRONMENTAL CHEMISTRY L T P

4 0 2

Unit 1:
Fundamentals of environmental

Atomic structure, electronic configuration, periodic properties of elements (ionization potential, electron affinity and electronegativity), types of chemical bonds (ionic, covalent, coordinate and hydrogen bonds); mole concept, molarity and normality, quantitative volumetric analysis. Thermodynamic system; types of chemical reactions; acids, bases and salts, solubility products; solutes and solvents; redox reactions, concepts of pH and pE, electrochemistry, Nernst equation, electrochemical cells. Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, organic functional groups, polarity of the functional groups, synthesis of xenobiotic compounds like pesticides and dyes, synthetic polymers.

Unit 2: Atmospheric chemistry

Composition of atmosphere; photochemical reactions in atmosphere; smog formation, types of smog (sulphur smog and photochemical smog), aerosols; chemistry of acid rain, case studies; reactions of NO_2 and SO_2; free radicals and ozone layer depletion, role of CFCs in ozone depletion.

Unit 3: Water chemistry

Chemical and physical properties of water; alkalinity and acidity of water, hardness of water, calculation of total hardness; solubility of metals, complex formation and chelation; colloidal particles; heavy metals in water.

Unit 4: Soil chemistry

Soil composition; relation between organic carbon and organic matter, inorganic and organic components in soil; soil humus; cation and anion exchange reactions in soil; N, P & K & phenolic compounds in soil.

EVS - 401 SYSTEMATICS & BIOGEOGRAPHY

L	T	P
4	0	0

Unit 1: Concept and systematics approaches

Definition of systematics; taxonomic identification; keys; field inventory; herbarium; museum; botanical gardens; taxonomic literature; nomenclature; evidence from anatomy, palynology, ultrastructure, cytology, phyto-chemistry, numerical and molecular methods; taxonomy databases.

Unit 2: Taxonomic hierarchy

Concept of taxa (species, genus, family, order, class, phylum, kingdom); concept of species (taxonomic, typological, biological, evolutionary, phylogenetic); categories and taxonomic hierarchy.

Unit 3: Nomenclature and systems of classification

Principles and rules (International Code of Botanical and Zoological Nomenclature); ranks and names; types and typification; author citation; valid publication; rejection of names; principle of priority and its limitations; names of hybrids; classification systems of Bentham and Hooker; Angiosperm Phylogeny Group (APG III) classification.

Unit 4: Numerical and molecular systematics

Characters; variations; Operational Taxonomic Units; character weighting and coding; phenograms; cladograms; DNA barcoding; phylogenetic tree (rooted,unrooted, ultrametric trees); clades: monophyly, paraphyly, polyphyly; homology and analogy; parallelism and convergence.

Unit 5: Introduction to Biogeography

Genes as unit of evolutionary change; mutation; genetic drift; gene flow; natural selection; geographic and ecological variation; biogeographical rules – Gloger's rule, Bergmann's rule, Allen's rule, Geist rule; biogeographical realms and their fauna; endemic, rare, exotic, and cosmopolitan species.

Unit 6: Speciation and extinction

Types and processes of speciation – allopatric, parapatric, sympatric; ecological diversification; adaptive radiation, convergent and parallel evolution; dispersal and immigration; means of dispersal and barriers to dispersal; extinction.

Unit 7: Historical Biogeography

Earth's history; paleo-records of diversity & diversification; continental drift & plate tectonics & their role in biogeographic patterns past & present; biogeographical dynamics of climate change,ice age.

Unit 8: Ecological Biogeography

Species' habitats; environment and niche concepts; biotic and abiotic determinants of communities; species-area relationships; concept of rarity & commonness; Island Biogeography theory; Equilibrium Theory of Insular Biogeography; geography of diversification and invasion; phylogeography.

Unit 9: Conservation Biogeography Biogeographical rules in design of protected area & biosphere reserves; use of remote sensing in conservational planning.

EVS - 402 URBAN ECOSYSTEMS

L	T	P
3	0	1

Unit 1: Introduction

Introduction to urbanization; urban sprawl and associated environmental issues.

Unit 2: Environment in an urban setting

Man as the driver of urban ecosystem; co modification of nature; metros, cities and towns as sources and sinks of resources; resource consumption and its social, cultural, economic and ecological perspectives; urban transformation; increasing challenges posed by modernity for the environment; urban pollution (air, water, soil).

Unit 3: Urban dwelling

Housing scenario across a range of large-medium-small cities; poverty and slums in an urban context; Town planning Acts and their environmental aspects; energy consumption and waste disposal as well as accumulation; environmental costs of urban infrastructure.

Unit 4: Urban interface with the environment

Management of urban environment; alternative resources; policy and management decisions; urban settings as loci of sustainability; challenges associated with sustainability and urban future.

Unit 5: Natural spaces in a city

Concept of 'controlled nature'; scope, importance and threats to nature in the city; organization and planning of green spaces such as parks, gardens and public spaces; concept of green belts; urban natural forest ecosystem as green lungs.

Unit 6: Planning and environmental management

Urban planning and its environmental aspects from historical and contemporary perspectives; benefits of environmental management; introduction to green buildings; urban governance; political complexity of applying ecological science to urban policy and planning, smart cities.

EVS - 403	ENVIRONMENTAL LEGISLATION & POLICY	L	T	P
		3	0	0

Unit 1: Introduction

Constitution of India; fundamental rights; fundamental duties; Union of India; union list, state list, concurrent list; legislature; state assemblies; judiciary; panchayats and municipal bodies; National Green Tribunal.

Unit 2: History of environmental legislation & policy

Ancient period: worship of water, air, trees; Mauryan period: Kautilya's Arthashastra, Yajnavalkyasmriti and Charaksamhita; Medieval period: forests as woodland and hunting resourcesduring Mughal reign; British India: Indian Penal Code 1860,Forest Act 1865, Fisheries Act 1897; Independent India: Van Mahotsava 1950, National Forest Policy 1952, Orissa River pollution and prevention Act 1953.

Unit 3: Environmental legislation

Legal definitions (environmental pollution, natural resource, biodiversity, forest, sustainable development); Article 48A (The protection and improvement of environment and safeguarding of forests and wildlife); Article 51 A (Fundamental duties).

Unit 4: Legislative Instruments

The Indian Forest Act 1927; The Wildlife (Protection) Act 1972; The Water (Prevention and Control of Pollution) Act 1974; The Forests (Conservation) Act 1980; The Air (Prevention and Control of Pollution) Act 1981; The Environment (Protection) Act 1986; Motor Vehicle Act 1988; The Public Liability Insurance Act 1991; Noise Pollution (Regulation and Control) Rules 2000; The Biological Diversity Act 2002; The Schedule Tribes and other Traditional Dwellers (Recognition of Forests Rights) Act 2006; The National Green Tribunal Act 2010; scheme and labeling of environment friendly products, Ecomarks.

Unit 5: Government institutions

Role of Ministry of Environment, Forests & Climate Changein environmental law and policy making; role of central and state pollution control boards in environmental law and policy making.

Unit 6: Case studies

National Green Tribunal: Aditya N Prasad vs. Union of India & Others; Ganga Tanneries Case: M.C. Mehta vs. Union of India 1988; environmental education case: M.C. Mehta vs. Union of India, WP 860/1991.

Unit 7: International laws and policy

Stockholm Conference 1972; United Nations Conference on Environment and Development 1992; Rio de Janeiro (Rio Declaration, Agenda 21); Montreal Protocol 1987; Kyoto Protocol 1997; Copenhagen and Paris summits; Ramsar convention.

EVS - 404	ENVIRONMENT IMPACT & RISK ASSESSMENT	L	T	P
		3	0	0

Unit 1: Environmental impact assessment (EIA): definitions, introduction and concepts; rationale and historical development of EIA; scope and methodologies of EIA; role of project proponents, project developers and consultants; Terms of Reference; impact identification and prediction; baseline data collection; Environmental Impact Statement (EIS), Environmental Management Plan (EMP)

Unit 2: Rapid EIA; Strategic Environmental Assessment; Social Impact Assessment; Cost-Benefit analysis; Life cycle assessment; environmental appraisal; environmental management - principles, problems and strategies; environmental planning; environmental audit; introduction to ISO and ISO 14000; sustainable development.

Unit 3: EIA regulations in India; status of EIA in India; current issues in EIA; case study of hydropower projects/ thermal projects.

Unit 4: Risk assessment: introduction and scope; project planning; exposure assessment; toxicity assessment; hazard identification and assessment; risk characterization; risk communication; environmental monitoring; community involvement; legal and regulatory framework; human and ecological risk assessment.

Suggested Readings

1. Barrow, C.J. 2000. *Social Impact Assessment: An Introduction.* Oxford University Press.
2. Glasson, J., Therivel, R., Chadwick, A. 1994. *Introduction to Environmental Impact Assessment*. London, Research Press, UK.
3. Judith, P. 1999. *Handbook of Environmental Impact Assessment*. Blackwell Science.
4. Marriott, B. 1997. *Environmental Impact Assessment: A Practical Guide*. McGraw-Hill, New York, USA.

EVS - 405 GREEN TECHNOLOGIES L T P
3 0 2

Unit 1: Introduction

Definition and concepts: green technology, green energy, green infrastructure, green economy, and, green chemistry; sustainable consumption of resources; individual and community level participation such as small-scale composting pits for biodegradable waste, energy conservation; encouraged use of public transport instead of private transport.

Unit 2: Green technologies

Green technologies in historical and contemporary perspectives; successful green technologies: wind turbines, solar panels; 3 R's of green technology: recycle, renew and reduce; paradigm shift from 'cradle to cradle' to 'cradle to grave'

Unit 3: Green infrastructure, planning and economy

Green buildings; history of green buildings, need and relevance of green buildings over conventional buildings, construction of green buildings; associated costs and benefits; outlined examples of green buildings; LEED certified building; Eco-mark certification, establishment of Eco-mark in India, its importance and implementation; Green planning: role of governmental bodies, land use planning, concept of green cities, waste reduction and recycling in cities, role of informal sector in waste management, public transportation for sustainable development, green belts. ; Introduction to UNEP's green economy initiative, inclusive economic growth of the society, REDD+ initiative, and cap and trade concept; green banking.

Unit 4: Applications of green technologies

Increase in energy efficiency: cogeneration, motor system optimization, oxy-fuel firing, isothermal melting process, energy efficient fume hoods, compact fluorescent lights, motion detection lighting, or programmable thermostats). Green House Gas emissions reduction: carbon capture and storage technologies, purchase and use of carbon offsets, promotion and/or subsidy of alternative forms of transportation for employees, such as carpools, fuel efficient vehicles, and mass transit, methane emissions reduction and/or reuse). Pollution reduction and removal Flue Gas Desulfurization methods, catalytic or thermal destruction of NOX, Fluidized Bed Combustion, Dioxins reduction and removal methods, Thermal Oxidizers or Wet Scrubbers to neutralize chemicals or heavy metals, solvent recovery systems, Low Volatile Organic Compound paints and sealers.

Unit 5: Green chemistry

Introduction to green chemistry; principles and recognition of green criteria in chemistry; bio- degradable and bio-accumulative products in environment; green nanotechnology; reagents, reactions and technologies that should be and realistically could be replaced by green alternatives; photodegradable plastic bags.

Unit 6: Green future

Agenda of green development; reduction of ecological footprint; role of green technologies towards a sustainable future; major challenges and their resolution for implementation of green technologies; green practices to conserve natural resources (organic agriculture, agroforestry, reducing paper usage and consumption, etc.); emphasis on waste reduction instead of recycling, emphasis on innovation for green future; role of advancement in science in developing environmental friendly

technologies.

EVS - 406 REMOTE SENSING, GEOGRAPHIC INFORMATION SYSTEM & MODELLING

L	T	P
3	0	2

Unit 1: Remote Sensing: definitions and principles; electromagnetic (EME) spectrum; interaction of EMR with Earth's surface; spectral signature; satellites and sensors; aerial photography and image interpretation.

Unit 2: Geographical Information Systems: definitions and components; spatial and non-spatial data; raster and vector data; database generation; database management system; land use/ land cover mapping; overview of GIS software packages; GPS survey, data import, processing, and mapping.

Unit 3: Applications and case studies of remote sensing and GIS in geosciences, water resource management, land use planning, forest resources, agriculture, marine and atmospheric studies.

Unit 4: Basic elements of statistical analyses: sampling; types of distribution – normal, binomial, poisson; measurements of central tendency and dispersion; skewness; kurtosis; hypothesis testing; parametric and non-parametric tests; correlation and regression; curve fitting; analysis of variance; ordination.

Suggested Readings

1. Zar, J.H. 2010. *Biostatistical Analysis* (5th edition). Prentice Hall Publications.
2. Edmondson, A. & Druce, D.1996.*Advanced Biology Statistics*. Oxford University Press.
3. Demers, M.N. 2005. *Fundamentals of Geographic Information System*. Wiley & Sons.
4. Richards, J. A. & Jia, X. 1999. *Remote Sensing and Digital Image Processing*. Springer.

Sabins, F. F. 1996. *Remote Sensing: Principles an Interpretation*. W. H. Freeman

B. Sc. (Hons.) Environmental Sciences
SEMESTER V

Sl. No.	Subect Code	Subject				Sessional Exam			External Exam	Subject Total	Credit Hours
			L	T	P	CA	TA	Total			
1	EVS-501	Earth & Earth Surface Process	4	0	0	20	20	40	60	100	4
2	EVS - 502	Organismal & Evolutionary Biology	4	0	0	20	20	40	60	100	4
3	EVS - 503	Energy & Environment	5	0	0	20	20	40	60	100	5
4	EVS - 504	Environmental Economics	5	0	0	20	20	40	60	100	5
Practical											
1	EVSP - 502	Organismal & Evolutionary Biology	0	0	2			25	25	50	2
2	EVSP - 503	Energy & Environment	0	0	2			25	25	50	2
3	EVSP - 504	Environmental Economics	0	0	1			25	25	50	1
Total										750	23

EVS - 501 EARTH & EARTH SURFACE PROCESS L T P
4 0 0

Unit 1: History of Earth

Solar system formation and planetary differentiation; formation of the Earth: formation and composition of core, mantle, crust, atmosphere and hydrosphere; chemical composition of Earth; geological time scale and major changes on the Earth's surface; Holocene and the emergence of humans, role of humans in shaping landscapes; development of cultural landscapes.

Unit 2: Earth system processes

Movement of lithosphere plates; mantle convection and plate tectonics, major plates and hot spots, plate boundaries; sea floor spread; earthquakes; volcanic activities; orogeny; isostasy; gravitational and magnetic fields of the earth; origin of the main geomagnetic field; continental drift, Pangaea and present-day continents, paleontological evidences of plate tectonics; continental collision and mountain formation with specific example of the Himalaya.

Unit 3: Minerals and rocks

Minerals and important rock forming minerals; rock cycle: lithification and metamorphism; Three rock laws; rock structure, igneous, sedimentary and metamorphic rocks; weathering: physical, biogeochemical processes; erosion: physical processes of erosion, factors affecting erosion; agents of erosion: rivers and streams, glacial and aeolian transportation and deposition of sediments by running water, wind and glaciers.

Unit 4: Earth surface processes

Atmosphere: evolution of earth's atmosphere, composition of atmosphere, physical and optical properties, circulation; interfaces: atmosphere–ocean interface, atmosphere–land interface, ocean–land interface; land surface processes: fluvial and glacial processes, rivers and geomorphology; types of glaciers, glacier dynamics, erosional and depositional processes and glaciated landscapes; coastal processes.

Unit 5: Importance of being a mountain

Formation of Peninsular Indian mountain systems - Western and Eastern Ghats, Vindhyas, Aravallis, etc. Formation of the Himalaya; development of glaciers, perennial river systems and evolution of monsoon in Indian subcontinent; formation of Indo-Gangetic Plains, arrival of humans; evolution of Indus Valley civilization; progression of agriculture in the Indian subcontinent in Holocene; withdrawing monsoon and lessons to draw.

EVS - 502 ORGANISMAL & EVOLUTIONARY BIOLOGY L T P
4 0 2

Unit 1: History of life on Earth

Paleontology and evolutionary History; evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origins of unicellular and multi cellular organisms; major groups of plants and animals; stages in primate evolution including Homo.

Unit 2: Introduction

Lamarck's concept of evolution; Darwin's Evolutionary Theory: variation, adaptation, struggle, fitness and natural selection; Mendelism; spontaneity of mutations; The Evolutionary Synthesis.

Unit 3: Evolution of unicellular life

Origin of cells and unicellular evolution and basic biological molecules; abiotic synthesis of organic monomers and polymers; Oparin-Haldane hypothesis; study of Miller; the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism.

Unit 4: Geography of evolution

Biogeographic evidence of evolution; patterns of distribution; historical factors affecting geographic distribution; evolution of geographic patterns of diversity.

Unit 5: Molecular evolution

Neutral evolution; molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence.

Unit 6: Fundamentals of population genetics

Concepts of populations, gene pool, gene frequency; concepts and rate of change in gene frequency through natural selection, migration and genetic drift; adaptive radiation; isolating mechanisms; speciation (allopatric, sympatric, peripatric and parapatric); convergent evolution; sexual selection; co- evolution; Hardy-Weinberg Law.

EVS - 503 ENERGY & ENVIRONMENT L T P
5 0 2

Unit 1: Introduction

Defining energy; forms and importance; energy use from a historical perspective: discovery of fire, discovery of locomotive engine and fossil fuels, electrification of cities, oil wars in the Middle East, advent of nuclear energy; sources and sinks of energy; energy over-consumption in urban setting

Unit 2: Energy resources

Global energy resources; renewable and non-renewable resources: distribution and availability; past, present, and future technologies for capturing and integrating these resources into our energy infrastructure; energy-use scenarios in rural and urban setups; energy conservation.

Unit 3: Energy demand

Global energy demand: historical and current perspective; energy demand and use in domestic, industrial, agriculture and transportation sector; generation and utilization in rural and urban environments; changes in demand in major world economies; energy subsidies and environmental costs.

Unit 4: Energy, environment and society

Nature, scope and analysis of local and global impacts of energy use on the environment; fossil fuel burning and related issues of air pollution, greenhouse effect, global warming and, urban heat island effect; nuclear energy and related issues such as radioactive waste, spent fuel; social inequalities related to energy production, distribution, and use.

Unit 5: Energy, ecology and the environment

Energy production as driver of environmental change; energy production, transformation and utilization associated environmental impacts (Chernobyl and Fukushima nuclear accidents, construction of dams, environmental pollution); energy over-consumption and its impact on the environment, economy, and global change.

Unit 7: Politics of energy policy

Political choices in energy policy globally and in the Indian context (historical and contemporary case studies); domestic and international energy policy; energy diplomacy and bilateral ties of India with her neighbors.

Unit 8: Our energy future

Current and future energy use patterns in the world and in India; evolution of energy use over time; alternative sources as green energy (biofuels, wind energy, solar energy, geothermal energy; ocean energy; nuclear energy); need for energy efficiency; energy conservation and sustainability; action strategies for sustainable energy mix and management from a future perspective.

EVS - 504 ENVIRONMENTAL ECONOMICS L T P
5 0 1

Unit 1: Introduction to microeconomics

Definition and scope of environmental economics; environmental economics versus traditional economics; brief introduction to major components of economy: consumer, firm and their interaction in the market, producer and consumer surplus, market failure, law of demand and supply, tangible and non tangible goods; utilitariasm; Pareto optimality; compensation principle.

Unit 2: Environmental economics

Main characteristics of environmental goods; marginal analysis; markets and market failure; social benefit, costs and welfare functions; meaning and types of environmental values; measures of economic values; tangible and intangible benefits; Pareto principle or criterion; Hardin's Thesis of 'The Tragedy of Commons'; prisoner's dilemma game; methods of abatement of externalities; social cost benefit analysis; cost-effectiveness analysis.

Unit 3: Economic solutions to environmental problems

Social costs and benefits of environmental programmes: marginal social benefit of abatement, marginal social cost of abatement; pollution control: policies for controlling air and water pollution, disposal of toxic and hazardous waste- standards vs. emissions charges, environmental subsidies, modelling and emission charges; polluter pay principles; pollution permit trading system.

Unit 4: Natural resource economics

Economics of non-renewable resources; economics of fuels and minerals; Hotelling's rule and extensions; taxation; economics of renewable resources; economics of water use, management of fisheries and forests; introduction to natural resource accounting.

Unit 5: Tools for environmental economic policy

Growth and environment; environmental audit and accounting, Kuznets curve, environmental risk analysis, assessing benefits and cost for environmental decision making; cost benefit analysis and valuation: discounting, principles of Cost-Benefit Analysis, estimation ofcosts and benefits, techniques of valuation, adjusting and comparing environmental benefits and costs.

B. Sc. (Hons.) Environmental Sciences
SEMESTER VI

Sl. No.	Subject Code	Subect				Sessional Exam			External Exam	Subject Total	Credit Hours
			L	T	P	CA	TA	Total			
1	EVS-601	Environmental Pollution and Human Health	4	0	0	20	20	40	60	100	4
2	EVS - 602	Natural Resources Management & Sustainability	4	0	0	20	20	40	60	100	4
3	EVS - 603	Natural Hazards & Disaster Management	5	0	0	20	20	40	60	100	5
4	EVS - 604	Solid Waste Management	5	0	0	20	20	40	60	100	5
Practical											
1	EVSP - 601	Environmental Pollution and Human Health	0	0	2			25	25	50	2
2	EVSP - 602	Natural Hazards & Disaster Management	0	0	2			25	25	50	2
3	EVSP - 604	Solid Waste Management	0	0	1			25	25	50	1
Total										650	23

EVS – 601 ENVIRONMENTAL POLLUTION & HUMAN HEALTH L T P
4 0 2

Unit 1: Introduction

Definition of pollution; pollutants; classification of pollutants.

Unit 2: Air pollution

Ambient air quality: monitoring and standards (National Ambient Air Quality Standards of India); air quality index; sources and types of pollutants (primary and secondary); smog (case study); effects of different pollutants on human health (NO_x, SO_x, PM, CO, CO_2, hydrocarbons and VOCs) and control measures; indoor air pollution: sources and effects on human health.

Unit 3: Water pollution

Sources of surface and ground water pollution; water quality parameters and standards; organic waste and water pollution; eutrophication; COD, BOD, DO; effect of water contaminants on human health (nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides); water borne diseases; concept and working of effluent treatment plants (ETPs).

Unit 4: Soil pollution

Causes of soil pollution and degradation; effect of soil pollution on environment, vegetation and other life forms; control strategies.

Unit 5: Noise pollution

Noise pollution – sources; frequency, intensity and permissible ambient noise levels; effect on communication, impacts on life forms and humans - working efficiency, physical and mental health; control measures.

Unit 6: Radioactive and thermal pollution

Radioactive material and sources of radioactive pollution; effect of radiation on human health (somatic and genetic effects); thermal pollution and its effects.

Unit 7: Marine pollution

Marine resources and their importance; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management; existing challenges and management techniques (planning, construction, environmental monitoring of coastal zones).

Unit 8: Chemistry of environmental pollutants

Solubility of pollutants (hydrophilic and lipophilic pollutants), transfer of pollutants within different mediums, role of chelating agents in transferring pollutants, concept of biotransformation and bioaccumulation, concept of radioactivity, radioactive decay and half-life of pollutants, organometallic compounds, acid mine drainage.

Unit 9: Pollution control

Activated Sludge Process (ASP) – Trickling Filters – oxidation ponds, fluidized bed reactors, membrane bioreactor neutralization, ETP sludge management; digesters, up flow anaerobic sludge blanket reactor, fixed film reactors, sequencing batch reactors,

hybrid reactors, bioscrubbers, biotrickling filters; regulatory framework for pollution monitoring and control; case study: Ganga Action Plan; Yamuna Action Plan; implementation of CNG in NCT of Delhi.

EVS - 602 NATURAL RESOURCE MANAGEMENT & SUSTAINABILITY

L	T	P
4	0	0

Unit 1: Introduction

Resource and reserves; classification of natural resources; renewable and non-renewable resources; resource degradation; resource conservation; resource availability and factors influencing its availability; land resources; water resources; fisheries and other marine resources; energy resources; mineral resources; human impact on natural resources; ecological, social and economic dimension of resource management.

Unit2: Natural resources and conservation

Forest resources: economic and ecological importance of forests, forest management strategies, sustainable forestry; water resources: supply, renewal, and use of water resources, freshwater shortages, strategies of water conservation; soil resources: importance of soil, soil conservation strategies; food resources: world food problem, techniques to increase world food production, green revolution.

Unit 3: Mineral resources

Mineral resources and the rock cycle; identified resources; undiscovered resources; reserves; types of mining: surface, subsurface, open-pit, dredging, strip; reserve-to-production ratio; global consumption patterns of mineral resources techniques to increase mineral resource supplies; ocean mining for mineral resources; environmental effects of extracting and using mineral resources.

Unit4: Non-renewable energy resources Oil: formation, exploration, extraction and processing, oil shale, tar sands; natural gas: exploration, liquefied petroleum gas, liquefied natural gas; coal: reserves, classification, formation, extraction, processing, coal gasification; environmental impacts of non renewable energy consumption; impact of energy consumption on global economy; application of green technology; future energy options and challenges

.

Unit 5: Renewable energy resources

Energy efficiency; life cycle cost; cogeneration; solar energy: technology, advantages, passive and active solar heating system, solar thermal systems, solar cells, JNN solar mission; hydropower: technology, potential, operational costs, benefits of hydropower development; nuclear power: nuclear fission, fusion, reactors, pros and cons of nuclear power, storage of radioactive waste, radioactive contamination; tidal energy; wave energy; ocean thermal energy conversion (OTEC); geothermal energy; energy from biomass; bio-diesel.

Unit 6: Resource management

Approaches in resource management: ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management

strategies; concept of sustainability science: different approach towards sustainable development and its different constituents; sustainability of society, resources and framework; sustainable energy strategy; principles of energy conservation; Indian renewable energy program.

EVS - 603 NATURAL HAZARDS & DISASTER MANAGEMENT L T P

5 0 2

Unit 1: Introduction

Definition of hazard; natural, technological, and context hazards; concept of risk and vulnerability; reasons of vulnerability - rapid population growth, urban expansion, environmental pollution, epidemics, industrial accidents, inadequate government policies.

Unit 2: Natural hazards

Natural hazards: hydrological, atmospheric & geological hazards; earthquake: seismic waves, epicenter; volcanoes: causes of volcanism, geographic distribution; floods: types and nature, frequency of flooding; landslides: causes and types of landslides, landslide analysis; drought: types of drought - meteorological, agricultural, hydrological, and famine; Glacial Lake Outburst Floods (GLOF); tornadoes, cyclone & hurricanes; tsunamis: causes and location of tsunamis; coastal erosion, sea level changes and its impact on coastal areas and coastal zone management.

Unit 3: Anthropogenic hazards

Impacts of anthropogenic activities such as rapid urbanization, injudicious ground water extraction, sand mining from river bank, deforestation, mangroves destruction; role of construction along river banks in elevating flood hazard; disturbing flood plains. deforestation and landslide hazards associated with it; large scale developmental projects, like dams and nuclear reactors in hazard prone zones; nature and impact of accidents, wildfires and biophysical hazards. Case studies of Bhopal, Minamata and Chernobyl disaster.

Unit 4: Risk and vulnerability assessment

Two components of risk: likelihood and consequences, qualitative likelihood measurement index; categories of consequences (direct losses, indirect losses, tangible losses, and intangible losses); application of geoinformatics in hazard, risk & vulnerability assessment.

Unit 5: Mitigation and preparedness

Concept of mitigation; types of mitigation: structural and non-structural mitigation, use of technologies in mitigations such as barrier, deflection and retention systems; concept of preparedness; importance of planning, exercise, and training in preparedness; role of public, education and media in hazard preparedness.

Unit 6: Disaster management in India

Lessons from the past considering the examples of Bhuj earthquake, tsunami disaster, and Bhopal tragedy; National Disaster Management Framework, national response mechanism, role of government bodies such as NDMC and IMD; role of armed forces and media in disaster management; role of space technology in disaster management; case study of efficient disaster management during cyclone '*Phailin*' in 2013.

EVS - 604 SOLID WASTE MANAGEMENT

L	T	P
5	0	1

Unit 1: Introduction

Sources and generation of solid waste, their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste.

Unit 2: Effect of solid waste disposal on environment

Impact of solid waste on environment, human and plant health; effect of solid waste and industrial effluent discharge on water quality and aquatic life; mining waste and land degradation; effect of land fill leachate on soil characteristics and ground water pollution.

Unit 3: Solid waste Management

Different techniques used in collection, storage, transportation and disposal of solid waste (municipal, hazardous and biomedical waste); landfill (traditional and sanitary landfill design); thermal treatment (pyrolysis and incineration) of waste material; drawbacks in waste management techniques.

Unit 4: Industrial waste management

Types of industrial waste: hazardous and non-hazardous; effect of industrial waste on air, water and soil; industrial waste management and its importance; stack emission control and emission monitoring; effluent treatment plant and sewage treatment plant.

Unit 5: Resource Recovery

4R- reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment.

Unit 6: Waste- to- energy

Concept of energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification.

Unit 7: Integrated waste management

Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management.

Unit 8: Life cycle assessment

Cradle to grave approach; lifecycle inventory of solid waste; role of LCA in waste management; advantage and limitation of LCA; case study on LCA of a product.

Unit 9: Policies for solid waste management

Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Eco friendly or green products.