ADAMAS UNIVERSITY

School of Basic and Applied Sciences

Department of Chemistry

B.Sc. (Honours) in Environmental Science

Course Structure

Academic Year: 2021-22

Course-wise distribution:

Summary of the Programme	
Course Credit	**Theory +Practical**
Core Course (CC)	
15 Theory Papers (4 credits each)	15×4=60
14 Practical Papers (2 credits each)	14×2=28
Discipline Specific Elective Course (DSE)	
4 Theory Papers (4 credits each)	4×4=16
4 Practical Papers (2 credits each)	4×2=08
Generic Elective (GE)	
4 Theory Papers (4 credits each)	4×4=16
4 Practical Papers (2 credits each)	4×2=08
Ability Enhancement Compulsory Course (AECC)	
2 AECC Paper (2 credits each)	2×2= 04
Skill Enhancement Elective Course (SEC)	
2 Theory Papers (2 credits each)	2×2=04
Value Added Courses	
5 Value Added Courses	10
Summer Internship/Environmental camp/Dissertation//Viva Voce	
Credits	6
Total credit	**160**

Course-wise distribution:

A. ENVIRONMENTAL SCIENCE (THEORY)

	Discipline/ Name (Theory)	Paper No	Total Credits	L-T-P
1.	Earth and Earth Surface Processes	1	4	4-0-0
2.	Physics and Chemistry of the Environment	1	4	4-0-0
3.	Energy and Environment	1	4	4-0-0
4.	Atmospheric science and Climate Change	1	4	4-0-0
5.	Water And Water Resources Management	1	4	4-0-0
6.	Land and Soil Conservation and Management	1	4	4-0-0
7.	Mathematics for Environmental Modelling	1	4	4-0-0
8.	Ecology and Ecosystems	1	4	4-0-0
9.	Evolutionary biology	1	4	4-0-0
10.	Environmental Biochemistry and Biotechnology	1	4	4-0-0
11.	Natural Resource Management and Sustainability	1	4	4-0-0
12.	Systematics and Biodiversity	1	4	4-0-0
13.	Environmental Pollution and Human health	1	4	4-0-0
14.	Analytical methods, instrumentation, and Measurement	1	4	4-0-0
15.	Environmental Legislation and Environmental Impact Assessment	1	4	4-0-0
	Total	**15**	**60**	

B. ENVIRONMENTAL SCIENCE (PRACTICAL)

	Discipline/ Name (Practical)	Paper No	Total Credits	L-T-P
1.	Earth and Earth Surface Processes	1	2	0-0-3
2.	Physics and Chemistry of the Environment	1	2	0-0-3
3.	Energy and Environment Lab	1	2	0-0-3
4.	Atmospheric science and Climate Change Lab	1	2	0-0-3
5.	Water And Water Resources Management Lab	1	2	0-0-3
6.	Land and Soil Conservation and Management Lab	1	2	0-0-3
7.	Ecology and Ecosystems	1	2	0-0-3
8.	Evolutionary Biology Lab			
9.	Environmental Biochemistry and Biotechnology Lab	1	2	0-0-3
10.	Natural Resource Management and Sustainability Lab	1	2	0-0-3
11.	Systematics and biodiversity Lab	1	2	0-0-3
12.	Environmental Pollution and Human health Lab			
13.	Analytical methods, instrumentation, and Measurement	1	2	0-0-3
14.	Waste Management Site Study	1	2	0-0-3
	Total	**8**	**16**	

Course-wise distribution:

C. GENERIC ELECTIVE Papers

Discipline/ Name	Paper No	Total Credits	L-T-P
1. GE Chemistry I	1	4	3-1-0
2. GE Chemistry I (Lab)	1	2	0-0-3
3. GE Chemistry II	1	4	3-1-0
4. GE Chemistry II (Lab)	1	2	0-0-3
5. GE Geography I	1	4	3-1-0
6. GE Geography I Lab	1	2	0-0-4
7. GE Geography II	1	4	3-1-0
8. GE Geography II Lab	1	2	0-0-4
Total	**8**	**24**	

D. SKILL ENHANCEMENT COURSES SUBJECTS

	Discipline/ Name	Paper No	Total Credits	L-T-P
1.	**SEC A1: Natural Hazards & Disaster Management** **Or** **SEC A2: Wildlife Management**	1	2	2-0-0
2.	**SEC B1: Gender and Environment** **Or** **SEC B2: Health, Safety and Environment**	1	2	2-0-0
	Total	**2**	**4**	

E. DISCIPLINE SPECIFIC ELECTIVE PAPERS

	Discipline/ Name	Paper No. Theory + Lab	Total Credits
1.	**Environmental Economics and Statistics** Or **Solid Waste Management**	1+1	4+2
2.	**Green Technologies** Or **Urban Ecosystem**	1+1	4+2
3.	**Wastewater Engineering** Or **Environmental Health and Toxicology**	1+1	4+2
4.	**Remote Sensing and Geographic Information System** Or **Environmental data analysis**	1+1	4+2
	Total	**8**	**24**

Course-wise distribution:

F. ABILITY ENHANCEMENT COMPULSORY COURSES:

	Discipline/ Name	Paper No	Total Credits	L-T-P
1	AECC-1 (English / Modern Indian Language)	1	2	2-0-0
2	AECC-2 (Environmental Science and Energy Resources)	1	2	2-0-0
	Total	**2**	**4**	

G. DISSERTATION/VIVAVOCE

	Discipline/ Name	Paper No	Total Credits
1.	Summer Internship/Environmental camp	1	2
2.	Dissertation/Project and Viva voce	1	4

H. VALUE ADDED COURSES

	Discipline/ Name	Paper No	Total Credits
1.	Design Thinking	1	2
2.	Inter Disciplinary Project	1	3
3.	Community Service	1	1
4.	Venture Ideation	1	2
5.	Human Values and Professional Ethics	1	2
	Total	**5**	**10**

1ST Year – SEMESTER I								
Sl. No.	**Type**	**Course Code**	**Title of the Course**	**Lecture**	**Tutorial**	**Practical**	**Credit**	**Contact Hours/ per week**
1.	Core Theory	**EVS11201**	**Earth and Earth Surface Processes**	4	0	0	4	4
2.	Core Theory	**EVS11202**	**Physics and Chemistry of the Environment**	4	0	0	4	4
3.	Core Theory	**EVS11203**	**Energy and Environment**	4	0	0	4	4
4.	GE Theory	**CHM11151**	**Generic Elective Chemistry I**	3	1	.0	4	4
5.	AECC Theory	**ENG11057**	**AECC-1: English Communication (Modern Indian Language)**	2	0	0	2	2
6.	Value Added Course Theory	**DGS11011**	**Design Thinking**	2	0	0	2	2
7.	Core Practical	**EVS12204**	**Earth and Earth Surface Processes Lab**	0	0	3	2	3
8.	Core Practical	**EVS12205**	**Physics and Chemistry of Environment Lab**	0	0	3	2	3
9.	Core Practical	**EVS12206**	**Energy and Environment Lab**	0	0	3	2	3
10.	GE Practical	**CHM12152**	**Generic Elective Chemistry-I Lab**	0	0	3	2	3
			Total	**19**	**1**	**12**	**28**	**32**

1ST Year – SEMESTER II								
Sl. No.	**Type**	**Course Code**	**Title of the Course**	**Lecture**	**Tutorial**	**Practical**	**Credit**	**Contact Hours per week**
1.	Core Theory	**EVS11207**	**Atmospheric Science and Climate Change**	4	0	0	4	4
2.	Core Theory	**EVS11208**	**Water And Water Resources Management**	4	0	0	4	4
3.	Core Theory	**EVS11209**	**Land and Soil Conservation and Management**	4	0	0	4	4
4.	Core Theory	**MTH11512**	**Mathematics for Environmental Modelling**	3	1	0	4	4
5.	GE Theory	**CHM11153**	**Generic Elective Chemistry II**	3	1	0	4	4
6.	AECC Theory	**EVS11105**	**AECC-2: Environmental Science and Energy Resources**	2	0	0	2	2
7.	Core Practical	**EVS12210**	**Atmospheric Science and Climate Change Lab**	0	0	3	2	3

8.	Core Practical	**EVS12211**	**Water and Water Resources Management Lab**	0	0	3	2	3
9.	Core Practical	**EVS12212**	**Land and Soil Conservation and Management Lab**	0	0	3	2	3
10.	GE Practical	**CHM12154**	**Generic Elective Chemistry II Lab**	0	0	3	2	3
			Total	**20**	**2**	**12**	**30**	**34**

2ND Year – SEMESTER III								
Sl. No.	**Type**	**Course Code**	**Title of the Course**	**Lecture**	**Tutorial**	**Practical**	**Credit**	**Contact Hours per week**
1.	Core Theory	**EVS11213**	**Ecology and Ecosystems**	4	0	0	4	4
2.	Core Theory	**EVS11214**	**Evolutionary Biology**	4	0	0	4	4
3.	GE Theory	**GEO11001**	**Generic Elective Geography-I**	4	0	0	4	4
4.	Core Practical	**EVS12215**	**Ecology and Ecosystems Lab**	0	0	3	2	3
5.	Core Practical	**EVS12216**	**Evolutionary Biology Lab**	0	0	3	2	3
6.	GE Practical	**GEO12002**	**Generic Elective Geography-I Lab**	0	0	4	2	4
7.	Value Added Course	**IDP14001**	**Inter Disciplinary Project**	-	3	-	3	3
8.	Value Added Course	**SOC14100**	**Community Service**	-	-	-	-	-
9.	Value Added Course	**EIC11001**	**Venture Ideation**	2	0	0	2	2
10.	SEC Theory	**EVS11217**	**SEC A1: Natural Hazards & Disaster Management**	2	0	0	2	2
		Or						
		EVS11218	**SEC A2: Wildlife Management**					
			Total	**20**	**2**	**13**	**29**	**32**

2ND Year – SEMESTER IV								
Sl. No.	**Type**	**Course Code**	**Title of the Course**	**Lecture**	**Tutorial**	**Practical**	**Credit**	**Contact Hours per week**
1.	Core Theory	**EVS11219**	**Environmental Biochemistry and Biotechnology**	4	0	0	4	4
2.	Core Theory	**EVS11220**	**Natural Resource Management and Sustainability**	4	0	0	4	4
3.	Core Theory	**EVS11221**	**Systematics and Biodiversity**	4	0	0	4	4
4.	GE Theory	**GEO11005**	**GE Geography II**	4	0	0	4	4
5.	Core Practical	**EVS12222**	**Environmental Biochemistry and Biotechnology Lab**	0	0	3	2	3
6.	Core Practical	**EVS12223**	**Natural Resource Management and Sustainability Lab**	0	0	3	2	3
7.	Core Practical	**EVS12224**	**Systematics and biodiversity Lab**	0	0	3	2	3
8.	GE Practical	**GEO12006**	**GE Geography II Lab**	0	0	4	2	4
9.	Value Added Course	**PSG11021**	**Human Values and Professional Ethics**	0	2	0	2	2
10.	SEC Theory	**EVS11225**	**SEC B1: Gender and Environment**	2	0	0	2	2
		Or						
		EVS11226	**SEC B2: Health, Safety and Environment**					
			Total	**18**	**2**	**13**	**28**	**33**

#Summer Internship / Environment Camp for 7-15 days will be taken at the end of 4th semester and will be evaluated in the 5th semester.

3RD Year – SEMESTER V								
Sl. No.	**Type**	**Course Code**	**Title of the Course**	**Lecture**	**Tutorial**	**Practical**	**Credit**	**Contact Hours per week**
1.	Core Theory	**EVS11227**	**Environmental Pollution and Human health**	**4**	**0**	**0**	**4**	**4**
2.	Core Theory	**EVS11228**	**Analytical methods, Instrumentation and Measurement**	**4**	**0**	**0**	**4**	**4**
3.	DSE I Theory	**EVS11229**	**Environmental Economics and Statistics**	**4**	**0**	**0**	**4**	**4**
		Or						
		EVS11230	**Solid Waste management**					
4.	DSE II Theory	**EVS11231**	**Green Technologies**	**4**	**0**	**0**	**4**	**4**
5.		**Or**						
6.		**EVS11232**	**Urban Ecosystem**					
7.	Core Practical	**EVS12233**	**Environmental Pollution and Human health Lab**	**0**	**0**	**3**	**2**	**3**
8.	Core Practical	**EVS12234**	**Analytical methods, instrumentation, and Measurement Lab**	**0**	**0**	**3**	**2**	**3**
9.	Core Practical	**EVS12235**	**Waste Management Site Visit**	**-**	**-**	**-**	**2**	**3**
10.	Core Practical	**EVS14236**	**Summer Internship / Environmental camp**	**-**	**-**	**-**	**2**	**3**
11.	DSE I Practical	**EVS12237**	**Environmental Economics and Statistics**	**0**	**0**	**3**	**2**	**3**
		Or						
		EVS12238	**Solid Waste Management**					
12.	DSE II Practical	**EVS12239**	**Green Technologies Lab**	**0**	**0**	**3**	**2**	**3**
		Or						
		EVS12240	**Urban Ecosystem**					
			Total	**16**	**0**	**12**	**28**	**28**

3RD Year – SEMESTER VI								
Sl. No.	**Type**	**Course Code**	**Title of the Course**	**Lecture**	**Tutorial**	**Practical**	**Credit**	**Contact Hours per week**
1.	Core Theory	**EVS11241**	**Environmental Legislation and Environmental Impact Assessment**	**4**	**0**	**0**	**4**	**4**
2.	DSE III Theory	**EVS11242**	**Wastewater Engineering**	**4**	**0**	**0**	**4**	**4**
		Or						
		EVS11243	**Environmental Health and Toxicology**					
3.	DSE IV Theory	**EVS11244**	**Remote Sensing and Geographic Information System**	**4**	**0**	**0**	**4**	**4**
		Or						
		EVS11245	**Environmental data analytics**					
4.	DSE III Practical	**EVS12246**	**Wastewater Engineering**	**0**	**0**	**3**	**2**	**3**
		Or						
		EVS12247	**Environmental Health and Toxicology**					
5.	DSE IV Practical	**EVS12248**	**Remote Sensing and Geographic Information System**	**0**	**0**	**3**	**2**	**3**
		Or						
		EVS12249	**Environmental Data Analytics lab**					
6.	Core Practical/ Dissertation Project	**EVS15250**	**Dissertation Project and Viva voce**	**0**	**0**	**0**	**4**	**0**
			Total	**12**	**0**	**6**	**20**	**18**

Semester I

EVS11201	Earth and Earth Surface Processes				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 4	T: 0	P : 0	C:4

Unit 1: History of Earth (10 lectures)
Introduction of Solar system, formation of the Earth: formation and composition of core, mantle, crust, lithosphere, atmosphere and hydrosphere; chemical composition of Earth; geological time scale and major changes on the Earth's surface.

Unit 2: Earth system processes (10 lectures)
Continental drift, Pangaea and present-day continents, evidences of continental drift; Ocean floor and sea floor spreading; Plate tectonics, major plates and hot spots, plate boundaries, mantle convection and movement of lithosphere plates; , ; earthquakes; volcanic activities; orogeny; isostasy; gravitational and magnetic fields of the earth; origin of the main geomagnetic field; continental collision and mountain formation with specific example of the Himalaya.

Unit 3: Minerals and rocks (15 lectures)
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 (15 lectures)
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 mountains in Environmental processes (10 lectures)
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, evolution of Indus Valley civilization; progression of agriculture in the Indian subcontinent; withdrawing monsoon and lessons to draw.

Suggested Readings:

1. Bridge, J., & Demicco, R. 2008. *Earth Surface Processes, Landforms and Sediment deposits*. Cambridge University Press.

2. Duff, P. M. D., & Duff, D. (Eds.). 1993. *Holmes' Principles of Physical Geology*. Taylor & Francis.

3. Gupta, A. K., Anderson, D. M., & Overpeck, J. T. 2003. Abrupt changes in the Asian southwest monsoon during the Holocene and their links to the North Atlantic Ocean. *Nature* 421: 354-357.

4. Gupta, A. K., Anderson, D. M., Pandey, D. N., & Singhvi, A. K. 2006. Adaptation and human migration, and evidence of agriculture coincident with changes in the Indian summer monsoon during the Holocene. *Current Science* 90: 1082-1090.

5. Keller, E.A. 2011. *Introduction to Environmental Geology* (5th edition). Pearson Prentice Hall.

6. Krishnan, M. S. 1982. *Geology of India and Burma*. CBS Publishers & Distributors.

7. Leeder, M., Arlucea, M.P. 2005. *Physical Processes in Earth and Environmental Sciences.* Blackwell Publishing.

8. Pelletier, J. D. 2008. *Quantitative Modeling of Earth Surface Processes* (Vol. 304). Cambridge: Cambridge University Press. Chicago.

EVS11202	**Physics and Chemistry of Environment**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 4**	**T: 0**	**P : 0**	**C:4**

Unit 1: Fundamentals of Environmental Physics (15 lectures)

Basic concepts of pressure, force, work and energy; types of forces and their relation (pressure gradient, viscous, Coriolis, gravitational, centripetal, and centrifugal force); concept of heat transfer, conduction, convection; concept of temperature, lapse rate (dry and moist adiabatic); laws of thermodynamics; concept of heat and work, Carnot engine, transmission of electrical power, efficiency of turbines, wind-mills and hydroelectric power plants.

Basic concepts of light and matter; spectroscopic concepts: Introduction to the concept of absorption and transmission of light, Beer–Lambert law, photovoltaic and solar cells; scattering of light, Rayleigh and Mie's scattering.

Unit 2: Fundamentals of environmental chemistry (15 lectures)

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.

Thermodynamics and chemical equilibrium; 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, basic concepts of organic synthesis.

Unit 3: Atmospheric chemistry (8 lectures)

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 4: Water chemistry (8 lectures)

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 and metalloids in water.

Unit 5: Soil chemistry (8 lectures)
Soil composition; relation between organic carbon and organic matter, inorganic and organic components in soil; soil humus; cation and anion exchange reactions in soil; nitrogen, phosphorus and potassium in soil; phenolic compounds in soil.

Unit 6: Movement of pollutants in environment (6 lectures)
Diffusion and dispersion, point, line and area source pollutants, pollutant dispersal; Gaussian plume model, Inversion and mixing heights, hydraulic potential, Darcy's equation, types of flow, laminar and turbulence, super-critical, critical and sub-critical.

Suggested Readings:

1. Beard, J.M. 2013. *Environmental Chemistry in Society* (2nd edition). CRC Press.

2. Boeker, E. & Grondelle, R. 2011. *Environmental Physics: Sustainable Energy and Climate Change*. Wiley.

3. Connell, D.W. 2005. *Basic Concepts of Environmental Chemistry* (2nd edition). CRC Press.

4. Forinash, K. 2010. *Foundation of Environmental Physics*. Island Press.

5. Girard, J. 2013. *Principles of Environmental Chemistry* (3rd edition). Jones & Bartlett.

6. Harnung, S.E. & Johnson, M.S. 2012. *Chemistry and the Environment*. Cambridge University Press.

7. Hites, R.A. 2012. *Elements of Environmental Chemistry* (2nd edition). Wiley & Sons.

8. Manahan, S. E. 2000. *Fundamentals of Environmental Chemistry*. CRC Press.

9. Pani, B. 2007. *Textbook of Environmental Chemistry*. IK international Publishing House.

EVS11203	**Energy and Environment**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 4**	**T: 0**	**P : 0**	**C: 4**

Unit 1: Introduction (8 lectures)
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 (8 lectures)
Global energy resources; renewable and non-renewable resources, specific examples: 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 (10 lectures)
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 (10 lectures)
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 and the environment (6 lectures)
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 (8 lectures)
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 (10 lectures)
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.

Suggested Readings

1. McKibben, B. 2012. *Global Warming's Terrifying New Math*, Rolling Stone Magazine.

2. Craig. J.R., Vaughan, D.J., Skinner. B.J. 1996. *Resources of the Earth: Origin, use, and environmental impact* (2nd edition). Prentice Hall, New Jersey.

3. Elliott, D. 1997. *Sustainable Technology. Energy, Society and Environment* (Chapter 3). New York, Routledge Press.

4. Rowlands, I.H. 2009. *Renewable Electricity: The Prospects for Innovation and Integration in Provincial Policies* in Debora L. Van Nijnatten and Robert Boardman (eds), Canadian Environmental Policy and Politics: Prospects for Leadership and Innovation, Third Edition. Oxford University Press, pp. 167-82.

5. Oliver, J. 2013. Dispelling the Myths about Canada's Energy Future, Policy: Canadian Politics and Public Policy, June-July.

6. Mallon, K. 2006. *Myths, Pitfalls and Oversights, Renewable Energy Policy and Politics: A Handbook for Decision-Making*. EarthScan.

EVS12204	Earth and Earth Surface Processes				FM: 100
Academic year: 2021-22	Contact Hours – 45	L: 0	T: 0	P : 3	C:2

l. Identification of rocks & minerals (Hand Specimen)
a) Rocks- Granite, Basalt, Dolerite, Shale, Sandstone, Limestone, Slate, Marble, Quartzite, Schist, Gneiss. (15 lectures)
b) Minerals- Talc, Bauxite, Mica, Quartz, Hematite, Galena. (10 lectures)

2. a. Toposheet interpretation.
b. Use of GPS (15 lectures)

3. Viva Voce

EVS12205	Physics and Chemistry of Environment				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 0	T: 0	P : 3	C:2

1. Acidity, Alkalinity (PA & TA),
2. Total Hardness of water, Calcium Hardness of Water
3. DO, BOD, COD
4. Water holding capacity
5. TOC
6. Soil moisture, Soil pH, Soil electrical conductivity. (30 lectures)
7. Viva Voce & Laboratory notebook.

EVS12206	Energy and Environment Lab				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 0	T: 0	P : 3	C: 2

1. Calculation of energy efficiency from given data. EVS12206

2. Preparation of energy audit of a domestic unit and report submission.

3. Checklist for energy saving measures.

4. Viva-voce & Laboratory Notebooks.

Suggested Readings:

1. McKibben, B. 2012. *Global Warming's Terrifying New Math*, Rolling Stone Magazine.

2. Craig. J. R., Vaughan, D. J., Skinner. B. J. 1996. *Resources of the Earth: Origin, use, and environmental impact* (2ndedition). Prentice Hall, New Jersey.

3. Elliott, D. 1997. *Sustainable Technology. Energy, Society and Environment* (Chapter 3). New York, Routledge Press.

4. Rowlands, I. H. 2009. *Renewable Electricity: The Prospects for Innovation and Integration in Provincial Policies* in Debora L. Van Nijnatten and Robert Boardman (eds), Canadian Environmental Policy and Politics: Prospects for Leadership and Innovation, Third Edition. Oxford University Press, pp. 167-82.

5. Oliver, J. 2013. Dispelling the Myths about Canada's Energy Future, Policy: Canadian Politics and Public Policy, June-July.

6. Mallon, K. 2006. *Myths, Pitfalls and Oversights, Renewable Energy Policy and Politics: A Handbook for Decision-Making*. Earth Scan.

ENG11057	**AECC-1: English Language and Literature**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 30**	**L: 2**	**T: 0**	**P : 0**	**C:2**

* N.B.: The examination and evaluation will be conducted by subject experts.

Unit 1: Communication

a) Theory and Types of Communication

b) Verbal and Non-verbal Communication

c) Barriers and Strategies of Communication

d) Workplace and Telephone Communication

Unit 2: Grammar and Syntax:

a) Tense

b) Parts of Speech

c) Articles

d) Prepositions

e) Sentence-Making

f) Voice change

g) Synonyms and antonyms

h) One- Word Substitutions

Unit 3: Literature: Reading and Textual analysis

a) Close Reading: Short Story: "The Gift of the Magi": by O' Henry

b) Paraphrasing: Poem: "Stopping by Woods on a Snowy Evening": Robert Frost

c) Summary: Non-fiction: Extracts from The Great Derangement: Climate Change and The Unthinkable by Amitav Ghosh

d) Reading Comprehension

e) Interpreting Graphs and Charts

Unit 4: Speaking skills

a) Introduction

b) Interpersonal Communication

c) Group Discussion

d) Interview

Unit 5: Writing Skills

a) Composition

b) Letter writing- CV and application letter

c) Report Writing

d) Memo-Writing

e) Note-making

f) Business Communication

Unit 6: Listening skills

a) Active Listening

b) Types of Listening

c) Listening Exercises

d) Reading Exercises: Comprehension

Reference Books:

1. Kaul Asha. Effective Business Communication. PHI Learning Pvt Ltd. 2014.

2. Wren and Martin. High School Grammar And Composition. S. Chand, 1995.

3. Lewis, Norman. Word Power Made Easy. Anchor: 2014.

4. Riordan, Daniel G & Pauley Steven A. : Technical Report Writing Today. 2004.

5. Hamp-Lyons and Heasely, B . Study Writing; A Course in Written English. For Academic and Professional Purposes, Cambridge Univ. Press, 2006.

6. Quirk R., Greenbaum S., Leech G., and Svartik, J. A Comprehensive Grammar of the English language, Longman:London, 1985.

7. Gupta, A. English Reading Comprehension. Ramesh Publishing House, 2009.

8. Balasubramaniam, T. A Textbook of English Phonetics for Indian Students. Macmillan: 2012.

Semester II

EVS11207	Atmospheric Science and Climate Change				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 4	T: 0	P : 0	C:4

Unit 1: Introduction (4 lectures)

Concepts of weather and climate; Evolution and development of Earth's atmosphere; atmospheric structure and composition; significance of atmosphere in making the Earth, the only biosphere; Milankovitch cycles, greenhouse effect and its effect on environment.

Unit 2: Global energy balance (4 lectures)

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

Unit 3: Atmospheric circulation (10 lectures)

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 microclimate; Asian brown clouds.

Unit 4: Meteorology and atmospheric stability (12 lectures)

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

Unit 5: Global warming and climate change (15 lectures)

Earth's climate through ages; trends of global warming and climate change; drivers of global warming and the potential of different greenhouse 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, CO2 fertilization and agriculture; impact on economy and spread of human diseases.

Unit 7: Ozone layer depletion (15 lectures)

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

Suggested Readings:

1. Barry, R. G. 2003. *Atmosphere, Weather and Climate*. Routledge Press, UK.

2. Gillespie, A. 2006. *Climate Change, Ozone Depletion and Air Pollution: Legal Commentaries with Policy and Science Considerations*. Martinus Nijhoff Publishers.

3. Hardy, J.T. 2003. *Climate Change: Causes, Effects and Solutions*. John Wiley & Sons.

4. Harvey, D. 2000. *Climate and Global Climate Change*. Prentice Hall.

5. Manahan, S.E. 2010. *Environmental Chemistry*. CRC Press, Taylor and Francis Group.

6. Maslin, M. 2014. *Climate Change: A Very Short Introduction*. Oxford Publications.

7. Mathez, E.A. 2009. *Climate Change: The Science of Global Warming and our Energy Future*. Columbia University Press.

8. Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. & Sen, K. 2004. *Climate Change and India*. Universities Press, India.

9. Philander, S.G. 2012. *Encyclopedia of Global Warming and Climate Cha*nge (2nd edition). Sage Publications.

EVS11208	**Water And Water Resources Management**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 4**	**T: 0**	**P : 0**	**C:4**

Unit 1: Introduction (4 lectures)
Sources and types of water; hydrological cycle; precipitation, runoff, infiltration, evaporation, evapotranspiration; classification of water resources (oceans, rivers, lakes and wetlands).' Global water crisis.

Unit 6: Water resource in India (8 lectures)
Water resources of India, Demand for water (agriculture, industrial, domestic); water crisis; 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 2: Properties of water (8 lectures)
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

Unit 3: Surface and subsurface water (12 lectures)
Introduction to surface and ground water; surface and ground water pollution; water table and piezometric surface; vertical distribution of water; classification of sub-surface lithology and types of aquifers; river structure and patterns; rainwater harvesting and artificial recharge.watershed management; classification of watershed; importance of watershed

Unit 4: Wetlands and their management (8 lectures)
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 (6 lectures)
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); Saline water intrusion and its management

Unit 7: Water resources conflicts (8 lectures)

Water resources and sharing problems, case studies on Kaveri and Krishna river water disputes; Multipurpose 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 (6 lectures)
National water policy; The Easement Act, 1882, Water pollution (control and prevention) Act 1974; Indus water treaty; West Bengal Ground Water Resources (Management, Control and Regulation) Act, 2005, Ganges water treaty; Teesta water treaty; Indian River linking project: ecological and economic impacts.

Suggested Readings:

1. Bansil, P.C. 2004. *Water Management in India*. Concept Publishing Company, India.

2. Brebbia, C.A. 2013. *Water Resources Management VII*. WIT Press.

3. CEA. 2011. *Water Resources and Power Maps of India*. Central Board of Irrigation & Power.

4. Grumbine, R.E. & Pandit, M.K. 2013. Threats from India's Himalaya dams. *Science* 339: 36-37.

5. Loucks, D.P., Stedinger, J.R. & Haith, D. A. 1981. *Water Resource Systems Planning and Analysis*. Englewood Cliffs, NJ, Prentice Hall.

6. Mays, L.W. 2006. *Water Resources Sustainability*. The McGraw-Hill Publications.

7. Schward& Zhang, 2003. *Fundamentals of Groundwater*. John Willey and Sons.

8. Souvorov, A.V. 1999. *Marine Ecologonomics: The Ecology and Economics of Marine Natural Resource Management*. Elsevier Publications.

9. Vickers, A. 2001. *Handbook of Water Use and Conservation*. Water Plow Press.

EVS11209	**Land and Soil Conservation and Management**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 4**	**T: 0**	**P : 0**	**C:4**

Unit 1: Introduction (5 lectures)
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 (10 lectures)
Soil formation; soil components; classification of soil; soil architecture; physical properties of soil; soil texture; soil water holding capacity; soil forming factors, soil development; 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 (10 lectures)
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: Landuse/Land cover changes and land degradation (15 lectures)
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 (15 lectures)
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: Soil conservation and Management of land degradation (5 lectures)
Soil conservation; 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, land reclamation.

Suggested Readings:

1. Brady, N.C. & Well, R.R. 2007.*The Nature and Properties of Soils* (13th edition), Pearson Education Inc.

2. Gadgil, M. 1993. Biodiversity and India's degraded lands. *Ambio* 22: 167-172.

3. Johnson, D.L. 2006. *Land Degradation* (2nd edition). Rowman& Littlefield Publishers.

4. Marsh, W. M. & Dozier,J. 1983. *Landscape Planning: Environmental Applications*. John Wiley and Sons.

5. Oldeman, L. R. 1994. The global extent of soil degradation. *Soil resilience and sustainable land use*, 9. (http://library.wur.nl/isric/fulltext/isricu_i26803_001.pdf).

6. Pandit, M.K. et. al. 2007. Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya. *Biodiversity Conservation* 16: 153-163.

7. Pandit, M.K. &Kumar, V. 2013. Land use and conservation challenges in Himalaya: Past, present and future. In: Sodhi, N.S., Gibson, L. & Raven, P.H. *Conservation Biology: Voices from the Tropics.* pp. 123-133. Wiley-Blackwell, Oxford, UK .

8. Peterson, G. D., Cumming, G. S. & Carpenter, S. R. 2003. Scenario planning: a tool for conservation in an uncertain world. *Conservation Biology* 17: 358-366.

9. Scherr, S. J. 1999. *Soil degradation: A threat to developing-country food security by 2020?* (Vol. 27). International Food Policy Research Institute.

MTH11512	Mathematics for Environmental Modelling				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 3	T: 1	P : 0	C:4

Unit I **(12 Lectures)**

Basic Algebra: Real valued functions, classification and graphs of real valued functions, surd, indices, exponentials and logarithms, quadratic equations, system of linear equations with two variables, partial fractions

Unit II **(15 Lectures)**

Matrix Algebra: Introduction to matrices and determinant, types of matrices, matrix operations, transpose, addition, subtraction, matrix multiplication, determinants, singular and non-singular matrices, minors, cofactors, adjoint, inverse, solution of system of linear equations using matrix inversion method and Cramer's Rule

Unit III **(12 Lectures)**

Differentiation: Definition of derivative, rules of differentiation (without Proof), derivatives of algebraic, trigonometric, exponential and logarithmic functions, Chain rule, second order derivative with examples, maxima/minima of functions, and its applications.

Integration*:* Definition of integration, standard formulas, method of substitution, integration by parts, definite integrals

Unit IV **(15 Lectures)**

Differential Equations: Some basic definitions, formation of differential equations, order and degree, equations in separable form, homogeneous equations, exact equations, linear differential equations, application of first order differential equations, concept of higher order differential equations

Unit V **(6 Lectures)**

Applications of basic statistics in Environmental Science

References:

1. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers

2. P. K. Sharma, Remedial Mathematics, Nirali Prakaschan

3. N. Piskunov, Differential and Integral Calculus, Vol II, CBS Publishers and Distributors

EVS11105	AECC2: Environmental Science and Energy Resources				FM: 100
Academic year: 2021-22	Contact Hours – 30	L: 2	T: 0	P : 0	C: 2

Unit I: Enery and Natural Resources (10 Lectures)

Multidisciplinary nature of environmental sciences; scope and importance; need for public awareness; concept of sustainability and sustainable development

Forest resources: Function of forests, cause and effects of deforestation, case studies.

Water resources: distribution of water, hydrological cycle, use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems

Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies

Food Resources: World food problems and environmental concern, Food security, case studies

Energy resources: Concept of energy, SI Units of Work, Heat and Power, World energy use, Energy consumption pattern in India and U.S., Environmental aspects of energy utilization Renewable and non-renewable sources; Fossil fuel: types, use and environmental impacts, Solar energy: Solar Radiation – Passive and active solar systems – Flat Plate and Concentrating Collectors – Solar direct Thermal Application– Fundamentals of Solar Photo Voltaic Conversion- advantages and disadvantages of Solar Power generation, Solar energy status in India; Wind Energy: site selection, Wind turbine: basic working principle and types, Wind energy status in India, advantages and disadvantages of Wind Power generation; Hydroelectric power : How is it generated, advantages and disadvantages; Biomass energy: various types, generations of biofuel, Biogas plants, Bio diesel; Geothermal Energy: source, advantages and disadvantages, Nuclear Power: nuclear fission, moderation of reaction, nuclear reactor: pressurized water reactor, advantages and disadvantages

Unit II: Ecosystems (5 Lectures)

Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Food chains, food webs and ecological pyramids, energy flow, ecological succession

Unit III: Biodiversity and its conservation (5 Lectures)

Levels of Biodiversity: genetic, species and ecosystem diversity. Biogeographical classification of India, Values of biodiversity, Biodiversity at global, National and local levels, India as a mega-diversity nation, Biodiversity hotspots, Threats to Biodiversity, In-situ and Ex-situ conservation of Biodiversity

Unit – IV: Environmental Pollution and Waste Management (5 Lectures)

Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution, marine pollution; case studies. Nuclear hazards and human health risks.

Sources and generation of solid wastes, their characterization, chemical composition and classification. Different methods of disposal and management of solid wastes (Hospital Wastes and Hazardous Wastes) Recycling of waste material. Waste minimization technologies. Hazardous Wastes Management and Handling Rules, 1989

Unit – V: Global Issues and Environmental Acts (5 Lectures)

Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents.

Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act. International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD).

Text Books:

1. Principles of Environmental Science, 4th edition by Cunningham, W.P. and Cunningham, M.A. (2002), Tata McGraw-Hill Publishing Company, New Delhi

2. Basic Environmental Engineering & Elementary Biology by Monidranath Patra and Rahul Kumar Singha, Aryan Publishing house

3. Introduction to Environmental Engineering and Science, by Masters, G.M., Prentice Hall of India, Second Indian Reprint.

Reference Books:

1 Wastewater Engineering: Treatment and Reuse, 4th Edition, Metcalf and Eddy, Inc. McGraw-Hill, Inc., New York, 2002

2 Environmental Engineering", Howard S. Peavy, Donald R. Rowe and George Tchobanoglous, McGraw-Hill Education (India) Private Limited, New Delhi

3 Introduction to Environmental Engineering, 2nd Ed. by Davis, M. L. and Cornwell D. A. McGraw Hill, Singapore.

4 Environmental Sciences: The Environment and Human Impact by Jackson, A.R.W. and Jackson, J.M., , Longman Publishers

EVS12210	**Atmospheric Science and Climate Change Lab**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 0**	**T: 0**	**P: 3**	**C:2**

1. Estimation of atmospheric pressure, relative humidity, rainfall, insolation, wind speed, light intensity (Lux meter).

2. Viva-voce & Laboratory notebook.

EVS12211	**Water and Water Resources Management**	**FM: 100**

Academic year: 2021-22	**Contact Hours – 60**	**L: 0**	**T: 0**	**P : 3**	**C:2**

1. Chemical characteristics of water:
    Turbidity
    pH,
    Electrical conductivity
    Salinity (through Chloride Estimation),
    Dissolved oxygen, BOD, COD
    Total Suspended Solids (TSS),
    Total Dissolved Solids (TDS),
    Iron.

2. Viva Voce & Laboratory Notebook.

EVS12212	**Land Management and Soil Conservation**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 0**	**T: 0**	**P : 3**	**C:2**

1. Chemical characteristics of Soil:
    Soil Organic Carbon,
    Water Holding Capacity,
    Determination of Soil carbonate and Bicarbonate,
    Available NPK of Soil (Demonstration only).

    Viva voce & Laboratory Notebook.

Semester III

EVS11213	Ecology and Ecosystems				FM:
Academic year: 2021-22	Contact Hours – 60	L: 4	T: 0	P : 0	C:4

Unit 1: Ecosystem Ecology (15 lectures)

Basic concepts and definitions: biosphere, ecology, landscape, ecosystems, ecosystem stability, resistance and resilience; concepts of autecology and synecology; Biogeographic zones in India and concepts of Protected Area Network; Types of ecosystem: forest, grassland, lentic, lotic, estuarine, marine, desert, wetlands; Aquatic ecology Biological: phytoplankton, phytobenthos, zooplankton, macro-invertebrates and microbes; 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; 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 2: Ecology of individuals (10 lectures)

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 populations (10 lectures)

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

Unit : Community Ecology and Ecological succession (10 lectures)

Discrete versus continuum community view; community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; Concepts of species diversity; Concepts of stability and diversity in ecosystem; ecological succession: primary and secondary successions, concepts of allogenic and autogenic succession, models and types of successions, Facilitation, Tolerance and Inhibition; Concept of sere, climax community concepts, examples of succession (aquatic and terrestrial)

Unit 5: Behavioral Ecology (8 lectures)
Learning and Imptinting, types of examples; Sexual Selection, Red Queen Hypothesis, Handicap Principle; Basic concepts of sociobiology; Basis of kin and group selection; Reciprocal Altruism

Suggested Readings:

1. Groom. B. & Jenkins. M. 2000.*Global Biodiversity: Earth's Living Resources in the 21st Century.* World Conservation Press, Cambridge, UK.

2. Gurevitch, J., Scheiner, S. M., & Fox, G. A. 2002. *The Ecology of Plants*. Sinauer associates incorporated.

3. Loreau, M. & Inchausti, P. 2002. *Biodiversity and Ecosystem functioning: Synthesis and Perspectives.* Oxford University Press, Oxford, UK.

4. Odum, E.P. 1971. *Fundamentals of Ecology*. W.B. Sounders.

5. Pandit, M.K., White, S.M.& Pocock, M.J.O. 2014. The contrasting effects of genome size, chromosome number and ploidy level on plant invasiveness: a global analysis. *New Phytologist*. 203: 697-703.

6. Pimentel, D. (Ed.). 2011. *Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species*. CRC Press.

7. Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. *Ecology, Environment and Resource Conservation.* Anamaya Publications.

8. Wilson, E. O. 1985. The Biological Diversity Crisis. *BioScience* 35: 700-706.

EVS11214	**Evolutionary biology**				**FM:100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 4**	**T: 0**	**P : 0**	**C:4**

Unit 1: Emergence of life and the evolutionary path:
Paleo-records of diversity and diversification; Paleontology and evolutionary History; Geological time scale; major events in the evolutionary time scale; Origin of life: abiotic synthesis of basic biological molecules, micelles, monomers and polymers; Oparin-Haldane hypothesis; study of Urey and Miller's experiment of early life on earth; the first cell and unicellular evolution,

Unit 2: Basics of cellular organization and metabolism:
A. Prokaryotes cell and life processes; Cellular organization and functions, outer membrane of Gram-negative bacteria and its relevance in pathogenicity, anaerobic metabolism and electron transport, motility and quorum sensing,

B. Evolution of eukaryotic metabolism; Origins of multicellular organisms. Eukaryotic cell organization, Membrane structure & transport; Anabolic and catabolic processes: photosynthesis and

aerobic metabolism. Role of Mitochondria in eukaryotic metabolism energetic, Cell cycle - An overview of cell cycle and Programmed cell death (Apoptosis);

Unit 3: Molecular evolution:
Neutral evolution; molecular divergence and molecular clocks; classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence. Concepts of populations, gene pool, gene frequency; concepts and rate of change in gene frequency through natural selection, Mendelism; spontaneity of mutations; migration and genetic drift; Concept of Kettlewall; Hardy-Weinberg Law; adaptive radiation; isolating mechanisms; speciation (allopatric, sympatric, peripatric and parapatric); convergent and divergent evolution; Concept of selection, Directional, Stabilising and Disruptive; sexual selection; coevolution.

Unit 4: Biogeography of Species evolution:
Species' habitats; environment and niche concepts; biotic and abiotic determinants of communities; species-area relationships; concept of rarity and commonness; Island Biogeography theory; geography of diversification and invasion; biogeographical rules – Gloger's rule, Bergmann's rule, Allen's rule, Geist rule; biogeographical realms and their fauna; endemic, rare, exotic, and cosmopolitan species. De Vries' mutation theory, Synthetic theory of evolution; Concept of stasis; Punctuated Equilibrium Theory; Lamarck's concept of evolution; Darwin's Evolutionary Theory: variation, adaptation, struggle, fitness and natural selection;

Suggested Readings:

1. Lodish, H.F., Baltimore, D., Berk, A. Zipursky, S.L. Matsudiara, P. & Darnell, J. 1995. *Molecular Cell Biology*. W.H. Freeman.
2. Thorne, J. L., Kishino, H., & Painter, I. S. 1998. Estimating the rate of evolution of the rate of molecular evolution. *Molecular Biology and Evolution* **15**: 1647-1657.
3. Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton, 2008. Prescott, Harley, and Klein's microbiology. 7th ed. McGraw-Hill.
4. Futuyma, D.J. 2009. *Evolution* (2nd edition). Sinauer Associates.
5. Gillespie, J. H. 1991. *The Causes of Molecular Evolution*. Oxford University Press.
6. Graur, D. & Li, W.H. 1999. *Fundamentals of Molecular Evolution* (2nd edition). Sinauer Associates.
7. Kimura, M. 1984. *The Neutral Theory of Molecular Evolution*. Cambridge University Press.
8. Nei, M. & Kumar, S. 2000. *Molecular Evolution and Phylogenetics*. Oxford University Press.
9. Thorne, J. L., Kishino, H., & Painter, I. S. 1998. Estimating the rate of evolution of the rate of molecular evolution. *Molecular Biology and Evolution* **15**: 1647-1657.

EVS12215	**Ecology and Ecosystems**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 0**	**T: 0**	**P : 3**	**C:2**

1. Field study in ecology using both qualitative and quantitative studies (Checklist/ Quadrate/ Transect) from any one of the following bio-geographical area (coastal/ forest/ Hills) with report submission.
2. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.

3. Biological parameters of water: Identification of Plankton, Neuston, Nekton, Periphyton, Benthos.
4. Study and verification of Hardy-Weinberg Law by chi square analysis.
5. Viva-voce.

EVS12216	Evolutionary biology				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 0	T: 0	P : 3	C: 2

1. Numerical problems on pedigree and population genetics.
2. Visit to the museum.
3. Hardy-Weinberg Law and its applications.
4. Determination of change in allelic frequency due to natural selection, mutation and genetic drift
5. based on data provided from suggested readings (Sl. 5 & 6).
6. Laboratory Notebook and Viva Voce.

Suggested Readings:

1. Graur, D. & Li, W. H. 1999. *Fundamentals of Molecular Evolution* (2nd edition). Sinauer Associates.

2. Brian Hall, Monroe W. Strickberger and Benedikt Hallgrimsson. *Strickberger's Evolution*. Jones & Bartlett Learning, 2008.

3. Nei, M. & Kumar, S. 2000. *Molecular Evolution and Phylogenetics*. Oxford University Press.

4. Nei, M. 1987. *Molecular Evolutionary Genetics*. Columbia university press.

5. Stansfield W. D. Schaums Outline of Theory and Problems of Genetics. McGraw-Hill Book Company; New York.

6. Banerjee, P. K. Problems on Genetics, Molecular Genetics and Evolutionary Genetics. New Central Book Agency, Kolkata.

EVS11217	Natural Hazards and Disaster Management				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 2	T: 0	P : 0	C: 2

Unit 1: Introduction (5 lectures)
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 (15 lectures)
Natural hazards: hydrological, atmospheric & geological hazards; earthquake: seismic waves, epicenter; volcanoes: causes of volcanism, geographic distribution; landslides: causes and types of landslides, landslide analysis; cyclones; lighting; hailstorms; floods: types and nature, frequency of flooding;;

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 (15 lectures)
Impacts of anthropogenic activities such as rapid urbanization, injudicious ground water extraction, sand mining from riverbank, 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 (5 lectures)
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 (10 lectures)
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 (10 lectures)
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 studies of efficient disaster management protocols undertaken during tropical cyclones in India.

Suggested Readings:

1. Coppola D. P. 2007. *Introduction to International Disaster Management*. Butterworth Heinemann.

2. Cutter, S.L. 2012. *Hazards Vulnerability and Environmental Justice*. EarthScan, Routledge Press.

3. Keller, E. A. 1996. *Introduction to Environmental Geology*. Prentice Hall, Upper Saddle River, New Jersey.

4. Pine, J.C. 2009. *Natural Hazards Analysis: Reducing the Impact of Disasters*. CRC Press, Taylor and Francis Group.

5. Schneid, T.D. & Collins, L. 2001. *Disaster Management and Preparedness*. Lewis Publishers, New York, NY.

6. Smith, K. 2001. *Environmental Hazards: Assessing Risk and Reducing Disaster*. Routledge Press.

7. Wallace, J.M. & Hobbs, P.V. 1977. *Atmospheric Science: An Introductory Survey*. Academic Press, New York.

8. Wasson, R.J., Sundriyal, Y.P., Chaudhary, S., Jaiswal, M.K., Morthekai, P., Sati, S.P.&Juyal, N. 2013. A 1000-year history of large floods in the upper Ganga catchment, central Himalaya, India. *Quaternary Science Reviews* 77: 156–166.

EVS11218	Human-Wildlife Conflict and Management				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 2	T: 0	P : 0	C:2

Unit 1: Introduction to wildlife management (10 lectures)
Need of environmental management; wildlife conservation: moral obligation? philosophy of wildlife management; why is it necessary to worry about human wildlife conflicts? What is the role of government, wildlife biologists and social scientists, concept of deep and shallow ecology.

Unit 2: Evolution of the concept of wildlife management (10 lectures)
Journey of mankind from predator to conservator; prehistoric association between wildlife and humans: records from Bhimbetka wall paintings; conservation of wildlife in the reign of king Ashoka: excerpts from rock edicts; Bishnoi community; understanding wildlife management, conservation and policies regarding protected areas in 21st century; positive values provided by wildlife conservation (monetary, recreational, scientific and ecological benefits).

Unit 3: Wildlife conservation laws in India (10 lectures)
Types of protected areas (Wildlife Sanctuaries, National Parks, Biosphere Reserves); IUCN categories of protected areas, Natural World Heritage sites; concept of core and buffer area in a protected range, brief introduction to Wildlife Protection Act of 1972, Forest act 1927, Environmental Protection Act 1986, and Forest conservation Act 1920; introduction of Tiger task force, Status of current protected areas in India.

Unit 4: Socio-economic and legal basis of conflicts (10 lectures)
Concepts of development and encroachment, who is the intruders: human or animal? Impact of conflict on humans and wildlife, impact of habitat fragmentation, social inequality in terms of forest conservation: luxury hotels within protected areas vs. displacement of native tribes, forest produce as a need vs. forest exploitation, introduction to tribal rights in India, demographic profile of tribes in India, importance of forest produce to tribal populations, Scheduled tribes and other traditional Forest dwellers (Recognition of forest right) Act, 2006.

Unit 5: Wildlife conflicts (6 lectures)
Insight into the important conflicts: Keoladeo National park conflict of Bharatpur, Human and elephant conflicts of Kerala, Fisherman and tiger conflict of Sundarbans forest, shifting cultivation in North east India.

Unit 6: Human wildlife coexistence (14 lectures)
Symbiotic relationship between tribals and forest, forest and development, focus on the inclusive growth of tribes: community participation in forest management, case study of Chipko movement, sacred groves forests, India's Bishnoi community and their conservation practices; ecological economic welfare and development: conservation of indigenous culture and traditions, role of international organizations: Man and biosphere programmes; concept of conservation reserves and community reserves, importance of wildlife corridors in minimizing the conflicts and conservation.

Suggested Readings:

1. Conover, M. 2001. *Resolving Human Wildlife Conflicts*, CRC Press.

2. Dickman, A. J. 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Animal Conservation* 13: 458-466.

3. Messmer, T. A. 2000. The emergence of human–wildlife conflict management: Turning challenges into opportunities. *International Biodeterioration & Biodegradation* 45: 97-102.

4. Paty, C. 2007. *Forest Government and Tribe*. Concept Publishing Company.

5. Treves, A. & Karanth, K. U. 2003. Human---carnivore conflict and perspectives on carnivore management worldwide. *Conservation Biology* 17: 1491-1499.

6. Woodroffe, R. 2005. *People and Wildlife: Conflict and Coexistence*. Cambridge.

7. Woodroffe, R., Thirgood, S., & Rabinowitz, A. 2005. *People and Wildlife, Conflict or Coexistence?* (No. 9). Cambridge University Press.

Semester IV

EVS11219	Environmental Biochemistry and Biotechnology				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 4	T: 0	P: 0	C:4

Unit 1 – Biomolecules: (15L)

Monosaccharides: Aldoses and ketoses, structure of D- glucose & D-fructose (configuration & conformation), anomeric effect, mutarotation. nature of glycosidic linkages; structure and systematic names of sucrose, lactose, maltose, Amino acids: Synthesis: (Strecker, Gabriel, acetamidomalonic ester, azlactone); isoelectric point, ninhydrin reaction. Peptides: peptide linkage, synthesis of peptides using N-protection & C-protection, solid phase synthesis; peptide sequence: C-terminal and N-terminal amino acid determination (Edman, Sanger & dansyl chloride). Primary, secondary, tertiary and quaternary structure of proteins and protein folding. Nucleic acids: pyrimidine & purine bases (only structure & nomenclature), nucleosides and nucleotides, DNA: Watson-Crick model, 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.; .Fatty acids- properties of saturated and unsaturated fatty acids. Esters of fatty acids-formation and hydrolysis; Essential fatty acids. Triacylglycerols. Reactions and characterization of fats Biological significance of fats. Cofactors – Definition, examples of a) metal ions b) coenzymes c) prosthetic group; Definition, examples of holoenzymes, Apoenzyme. Classification of enzymes, IUPAC system, Name & examples of each class Mechanism of enzyme activity Concept of Central Dogma

Unit 2 –Few important biochemical pathways and cycles: (15 lectures)

Bioenergetics and Metabolism: Principles of Bioenergetics: Bioenergetics and Thermodynamics, Phosphoryl group transfers and ATP generation, Biological Oxidation and Reduction reaction. Intracellular metabolism of glucose - glycolysis, reaction and energetic of TCA cycle, (gluconeogenesis, glycogenesis, glycogenolysis, reactions and physiological significance of pentose phosphate pathway, regulation of glycolysis, TCA cycle, and glycogen metabolism).

Unit 3: Ecological restoration and bioremediation (20 lectures)

Wastewater treatment: anaerobic, aerobic process, methanogenesis, bioreactors, cell and protein (enzyme) immobilization techniques; treatment schemes for wastewater: 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 (10 lectures)

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. Basic concept of bio-patenting.

Suggested Readings:

1. Evans, G.G. & Furlong, J. 2010. *Environmental Biotechnology: Theory and Application* (2nd edition). Wiley Blackwell Publications.
1. 2. Jordening, H.J. & Winter J. 2005. *Environmental Biotechnology: Concepts and Applications*. John Wiley & Sons.
2. 3. Lodish, H.F., Baltimore, D., Berk, A. Zipursky, S.L. Matsudiara, P. & Darnell, J. 1995. *Molecular Cell Biology*. W.H. Freeman.
3. 4. Nelson, D.L. & Cox, M.M. 2013. *Lehninger's Principles of Biochemistry*. W.H. Freeman.
4. 5. Rittman, B.E. & McCarty, P.L. 2001. *Environmental Biotechnology. Principles and Applications.* McGraw-Hill, New York.
5. 6. Scagg, A.H. 2005. *Environmental Biotechnology*. Oxford University Press.
6. 7. Snustad, D.P. & Simmons, M.J. 2011. *Principles of Genetics* (6th edition). John Wiley & Sons.
7. 8. Wainwright, M. 1999. *An Introduction to Environmental Biotechnology*. Springer.

EVS11220	**Natural Resource Management and Sustainability**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 4**	**T: 0**	**P : 0**	**C: 4**

Unit 1: Introduction (10 lectures)
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.

Unit 2: Natural resources and conservation (10 lectures)
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 (10 lectures)
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.

Unit 4: Energy resources (20 lectures)
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.
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 5: Resource management (10 lectures)
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 programme.

Suggested Readings:

1. Craig, J.R., Vaughan. D.J. & Skinner. B.J. 1996. *Resources of the Earth: Origin, Use, and Environmental Impacts* (2nd edition). Prentice Hall, New Jersey.

2. Freeman, A.M. 2001. *Measures of value and Resources: Resources for the Future*. Washington DC.

3. Freeman, A.M. 2003. *Millennium Ecosystem Assessment: Conceptual Framework*. Island Press.

4. Ginley, D.S. & Cahen, D. 2011. *Fundamentals of Materials for Energy and Environmental Sustainability*. Cambridge University Press.

5. Klee, G.A. 1991. *Conservation of Natural Resources*. Prentice Hall Publication.

6. Miller, T.G. 2012. *Environmental Science*. Wadsworth Publishing Co.

7. Owen, O.S, Chiras, D.D, & Reganold, J.P. 1998. *Natural Resource Conservation – Management for Sustainable Future* (7th edition). Prentice Hall.

8. Ramade, F. 1984. *Ecology of Natural Resources*. John Wiley & Sons Ltd.

9. Tiwari, G.N. & Ghosal. M. K. 2005. *Renewable Energy Resources: Basic Principles and Application*. Narosa Publishing House.

EVS11221	Systematics and Biodiversity				FM:100
Academic year: 2021-22	Contact Hours – 60	L: 4	T: 0	P : 0	C:4

Unit 1: Concept of Taxonomic hierarchy and Nomenclature (15 lectures)
Definition of systematics; taxonomic identification; keys; taxonomic literature; nomenclature; Concept of taxa (species, genus, family, order, class, phylum, kingdom); concept of species (taxonomic, typological, biological, evolutionary, phylogenetic); taxonomic hierarchy, taxonomy databases, International Code of Botanical and Zoological Nomenclature; ranks and names; types and typification; principle classification schemes of Bentham and Hooker; Characters; variations; phenograms; cladograms; DNA barcoding; phylogenetic tree (rooted,unrooted, ultrametric trees); clades: monophyly, paraphyly, polyphyly; homology and analogy; parallelism and convergence.

Unit 2: From genes to ecosystems: (15 lectures)
Tree of life; history of character transformation; organic evolution through geographic time scale; species concept – what's in a name?; how many species are there on earth?; concept and types of speciation. Spatial patterns: latitudinal and elevational trends in biodiversity; temporal patterns: seasonal fluctuations in biodiversity patterns; importance of biodiversity patterns in conservation. Sampling strategies and surveys: floristic, faunal, and aquatic; qualitative and quantitative methods: scoring, habitat assessment, richness, density, frequency, abundance, evenness, diversity, biomass estimation; community diversity estimation: alpha, beta and gamma diversity; molecular techniques: RAPD, RFLP, AFLP; NCBI database, BLAST analyses.

Unit 3: Importance of biodiversity: (10 lectures)
Economic values – medicinal plants, drugs, fisheries and livelihoods; ecological services – primary productivity, role in hydrological cycle, biogeochemical cycling; ecosystem services – purification of water and air, nutrient cycling, climate control, pest control, pollination, and formation and protection of soil; social, aesthetic, consumptive, and ethical values of biodiversity.

Unit 4: Conservation Biogeography: (10 lectures)
Natural and anthropogenic disturbances; habitat loss, habitat degradation, and habitat fragmentation; climate change; pollution; hunting; over-exploitation; land use changes; overgrazing; invasive species; man-wildlife conflicts; consequences of biodiversity loss. In-situ and Ex-situ conservation, role of local communities and traditional knowledge in conservation; biodiversity hotspots; IUCN Red List categorization – guidelines, practice and application; Red Data book; ecological restoration: social forestry; agro forestry; joint forest management; role of remote sensing in management of natural resources. Application of biogeographical rules in design of protected area and biosphere reserves; use of remote sensing in conservational planning. India as a mega-diversity nation; phytogeographic and zoogeographic zones of the country, National Biodiversity Action Plan.

Unit 5: Biological invasions (10 lectures)
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 invasions.

Suggested Readings:

1. Lomolino, M.V., Riddle, B.R., Whittaker, R.J. & Brown, J.H. 2010. *Biogeography* (4th edition). Sinauer Associates, Sunderland.

2. Mani, M.S. 1974. *Ecology and Biogeography in India*. Dr. W Junk Publishers., The Hague.

3. Singh, G. 2012. *Plant Systematics: Theory and Practice* (3rd edition). Oxford & IBH Pvt. Ltd., New Delhi.

5. Williams, D. M. & Ebach, M.C. 2008. *Foundations of Systematics and Biogeography*. Springer.

6. Wilkins, J. S. 2009. *Species: A History of the Idea* (Vol. 1). University of California Press.

7. Gaston, K J. & Spicer, J.I. 1998. *Biodiversity: An Introduction.* Blackwell Science, London, UK.

8. Krishnamurthy, K.V. 2004. *An Advanced Text Book of Biodiversity - Principles and Practices*. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.

9. Primack, R.B. 2002. *Essentials of Conservation Biology* (3rd edition). Sinauer Associates, Sunderland, USA.

10. Singh, J. S. & Singh, S. P. 1987. Forest vegetation of the Himalaya. *The Botanical Review* **53**: 80-192.

11. Singh, J. S., Singh, S.P. & Gupta, S. 2006. *Ecology, Environment and Resource Conservation.* Anamaya Publications, New Delhi.

12. Sodhi, N.S. & Ehrlich, P.R. (Eds). 2010. *Conservation Biology for All*. Oxford University Press.

EVS12222	**Environmental Biochemistry and Biotechnology Lab**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 45**	**L: 0**	**T: 0**	**P: 3**	**C:2**

1. Isolation and characterisation of soil bacteria.
2. Gram staining of bacterial sample.
3. Enumeration of heterotrophic bacteria from water and soil samples (Spread plate/pore plate technique).
4. Determination of chlorophylls, enzymes (catalase, peroxidase and ascorbic acid of plant samples).
5. Bioassay of toxic compounds by enzyme assay or seed germination test.
6. Estimation of carbohydrate, protein and DNA.
7. Study of mitotic and meotic stages (A. cepa and grasshopper testis or pollen).
8. Gram Staining, Total coliform count (MPN), ABO Blood grouping.
9. Qualitative tests for carbohydrates, proteins and lipids
10. Qualitative estimation of Urea & Uric acid
11. Paper chromatography of amino acids.
12. Quantitative estimation of water soluble proteins following Lowry Method
13. Gram Staining
14. Total coliform count (MPN)
15. Packing and sterilization of glass and plastic wares for cell culture.
16. Preparation of culture media.
17. Preparation of genomic DNA from E. coli/animals/ human.

18. Plasmid DNA isolation (pUC 18/19) and DNA quantitation using agarose gel electrophoresis (by using lambda DNA as standard).

EVS12223	Natural Resource Management and Sustainability Lab				FM: 100
Academic year: 2021-22	Contact Hours – 45	L: 0	T: 0	P : 3	C:2

Practical:

1. Forest area mapping techniques.
2. Water bodies mapping techniques.
3. Water audit of college/ industry.
4. Energy audit of college/ industry.
5. Environmental audit of college.
6. Visit to mine area, forest area and aquaculture farm.

EVS12224	Systematics and Biodiversity Lab				FM: 100
Academic year: 2021-22	Contact Hours – 45	L: 0	T: 0	P : 3	C: 2

1. Identification of suitable flora and fauna (Definite list of specimens of ecological and economic significance). (20)

Specimens for Identification	**Specimens for Identification**
Agaricus sp.	*Hirudinea* sp.
Crustose Lichen	*Physalia* sp.
Azolla sp.	*Taenia solium*
Pteris sp.	*Ascaris lumbricoides*
Ceratophyllum sp.	*Entamoeba histolytica*
Andrographis paniculata	*Coccinella septempunctata*
Eichhornia crassipes	*Tryporyza incertulas*
Lemna minor	Spider
Parthenium hysterophorus	*Lamellidens marginalis*
Lantana camara	*Octopus* sp.
Jatropha sp.	*Pila* sp.
Rauvolfia serpentina/canescens	*Asterias* sp.
Acanthus ilicifolius	*Carcharodon carcharias*
Pisum sativum	*Tilapia* sp.
Opuntia dillenii	*Exocetus* sp.
Solanum lycopersicum	*Rhacophorus* sp.
Ficus benghalensis	*Naja* sp.
Datura metel	*Chamaeleo* sp.
Vanda roxburghii	*Columba livia*
Aloe vera	*Culex* sp.

Anopheles sp.

Aedes sp.

2. Identification Key Preparation.

3. Assessments of Biodiversity (Frequency, density, abundance, relative density)

4. Biodiversity indices (Shannon wiener diversity index, Simpson's index, Simpson's index of diversity, evenness index)

5. Laboratory Note book and Viva Voce.

Suggested Readings:

1. Krishnamurthy, K. V. 2004. *An Advanced Text Book of Biodiversity - Principles and Practices*. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.

2. Jeffries, M. J. 2006. Biodiversity and Conservation. Routledge.

3. Singh, J. S., Singh, S. P. & Gupta, S. 2006. *Ecology, Environment and Resource Conservation.* Anamaya Publications, New Delhi.

4. Sodhi, N. S., Gibson, L. & Raven, P. H. 2013. *Conservation Biology: Voices from the Tropics.* Wiley Blackwell, Oxford, UK.

5. Maity, P. K. and Maity, P. 2011. Biodiversity –Perception, Peril & Preservation. PHI.

EVS11225	**Gender and Environment**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 30**	**L: 2**	**T: 0**	**P : 0**	**C: 2**

Unit 1: Introduction (2 lectures)
The socially constructed 'gender' concept.

Unit 2: Gender and society (5 lectures)
Gender existence in society; gender: matriarchy and patriarchy as means of social exclusion (case studies in an Indian context); gender equity issues in rural and urban settings.

Unit 3: Gender and the environment (7 lectures)
Relevance of the concept in an environmental context; evolution of gender hierarchies in historical and contemporary perspective; gendered division of roles in cultural, social and economic perspective; gender inequalities.

Unit 4: Gender, resources and the environment (5 lectures)
Knowledge about the environment among men and women; differential dependencies on environmental resources; implications of gendered responses to environmental degradation.

Unit 5: Gender and environmental management (10 lectures)
Women's participation in environmental movements and conservation; historical and contemporary case studies; role of women in environmental education, awareness and sustainable development.

Unit 6: Strategies for change (7 lectures)
Need for gender equity; Instruments for change: education, media, action groups, policy and management; equity in resource availability and consumption for a sustainable future.

Suggested Readings:

1. Agarwal, B. 1992. *The Gender and Environment Debate: Lessons from India*. Feminist Studies (Minnesota).

2. Agarwal, B. 1997. Gender, Environment and Poverty Interlinks: Regional Variations and Temporal Shifts in Rural India: 1971-1991. *World Development* 25: 1-42.

3. Agarwal, B. 2001. Participatory exclusions, community forestry, and gender: An analysis for South Asia and a conceptual framework. *World Development* 29: 1623-1648.

4. Jackson, C. 1993. Doing what comes naturally? Women and environment in development *World Development* 21: 1947-63.

5. Krishna, S. 2004. *Livelihood and Gender*. New Delhi, Sage.

6. Leach, M. 2007. Earth Mother myths and other ecofeminist fables: How a strategic notion rose and fell. *Development and Change* 38: 67-85.

7. Miller, B. 1993. *Sex and Gender Hierarchies*. Cambridge University Press

8. Stein, R. (ed.). 2004. *New Perspectives on Environmental Justice: Gender, Sexuality, and Activism*. Rutgers University Press.

9. Steingraber, S. 1998. *Living Downstream: A Scientist's Personal Investigation of Cancer and the Environment.* New York: Vintage Books.

10. Zwarteveen, M.Z. 1995. *Linking women to the main canal: Gender and irrigation management*. Gatekeeper Series 54, IIED.

EVS11226	**Health, Safety and Environment**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 30**	**L: 2**	**T: 0**	**P : 0**	**C:2**

Unit 1: Physical and Chemical Hazards (5 Lectures)
Recognition, Evaluation and Control of Physical Hazards.
Noise and Vibration: Effects and Control Measures, Thermal Stress, Parameter Control.
Radiation: Types, Source: Effect and Control Illumination & Lighting. Recognition, Evaluation and Control of Chemical Hazards- Types - Dust-Fumes -Mist -Vapor-Fog etc., Air Contaminants-Evaluation - Types of Sampling-Air Sampling System-Method Analysis-Control Measures.

Unit 2: Occupational Health (10 lectures)
Evaluation of injuries: Medical services in industrial establishment, its function, action programs for work related diseases at the national level.

Personal Protective Equipment: Introduction, requirements and assessment of PPE, types of PPE. Non-respiratory personal protective devices; head, ear, face and eye protection, feet and body protection, supply, use, care and maintenance of PPE, requirements under factory Acts and Rules.
Respiratory PPE: Types of respiratory PPE, supply, use, care and maintenance of breathing apparatus, training for the use of breathing apparatus. Concept and Spectrum of Health-Functional Units and Activities of Occupational Health Services Occupational and Work-Related Disease-Levels of Prevention of Diseases - Notifiable Occupational Diseases such as Silicosis- Asbestosis- Pneumoconiosis-- Aluminosis and Anthrax. Lead-Nickel, Chromium and Manganese Toxicity-Gas Poisoning (such as CO, Ammonia, Coal Dust etc.,) their effects and Prevention- Cardiopulmonary Resuscitation- Audiology-Hearing Conservation Programme-Effects of Ultraviolet Radiation and Infrared Radiation on Human Systems Industrial Toxicology-Local and Systemic and Chronic Effects Temporary and Cumulative Effects Carcinogens Entry into Human System Ergonomics, Personnel Protective Equipment, Personnel Monitoring

Unit 3: Personal Hygiene and First Aid (5 Lectures)
Hygiene Concepts: Correct and Clean Dresses, Clean Body, Washing, Good Habits, Oral and Stomach Hygiene: Cleaning, Compressed Air and Degreasing Agents, Long Hair and Nails and Torn and loosely Hanging Clothes, Smoking, Lavatories Maintenance, Living in Unhygienic Areas.
First aid concept: First Aid Boxes, Legal Requirements, Industrial Hygiene, Medical Surveillance, Medical Surveillance Program Development, Recommended Medical Programme, Emergency Treatment, Non-Emergency Treatment, Exposures to Hazardous Materials.

Unit 4: Protection from radiation (5 Lectures)
Radiation Control: Radiation Shielding, Radiation Dose, Dose Measurements, Units of Exposure, Exposure Limits, Barriers for Control of Radioactivity Release, Control of Radiation Exposure to Plant Personnel, Health Physics Surveillance - Waste Management and Disposal Practices – Environmental, Releases.

Unit 5: Safety audit (5 Lectures)
Definition of accidents: injury, types of accidents, causes and remedial measures, injury records, prevention, modes of prevention, physiological factors, Environmental Safety: Safety awareness, annual toll of industrial accidents in India, need for safety, legal, humanitarian factors impending safety, safety audit and steps to an effective safety audit.

Semester V

EVS11227	Environmental Pollution and Human health				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 4	T: 0	P: 0	C:2

Unit 1: Introduction (2 lectures)
Definition of pollution; pollutants; classification of pollutants.

Unit 2: Air pollution (8 lectures)
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); indoor air pollution: sources and effects on human health.

Unit 3: Water pollution (15 lectures)
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 (5 lectures)
Causes of soil pollution and degradation; effect of soil pollution on environment, vegetation and other life forms; control strategies, Effects of pesticides on human health.

Unit 5: Noise pollution (5 lectures)
Noise pollution – sources; frequency, intensity; sound pressure level; sound intensity level 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 (5 lectures)
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 (5 lectures)
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 (10 lectures)
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 (10 lectures)

Waterwater treatment- 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.

Methods for treatment of drinking water - aeration, flocculation, sedimentation, filtration, and disinfection

Air pollution control measures for PM (gravitational settling chambers, centrifugal collector, wet scrubber, bag house filter and ESP); for gaseous pollutant (absorption, adsorption, condensation and combustion);

EVS11228	**Analytical methods, Instrumentation and Measurement**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 4**	**T: 0**	**P : 0**	**C:2**

Unit 1: Qualitative and quantitative aspects of analysis (5 Lectures)

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

Unit 2: Titrimetric and Optical methods of analysis (20 Lectures)

Sampling, preservation, storage techniques; Principles and applications of titrimetry (Acidimetry, Alkalimetry, Complexometry, Argentometry, Iodometry) gravimetry, potentiometry, conductimetry.

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy andselection rules, validity of Beer-Lambert's law.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

Unit 3: Thermal and electroanalytical methods (15 Lectures)

Theory of thermogravimetry (TG), basic principle of instrumentation techniques for quantitative estimation of Ca and Mg from their mixture.

Electroanalytical methods:

Classification of electroanalytical methods, basic principle of pH metric, potentiometric andconductometric titrations. Techniques used for the determination of equivalence points.Techniques used for the determination of pKa values.

Unit 4: Separation techniques: (20 Lectures)

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC,TLC and HPLC.

Reference Books:

• Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H.Jeffery and others) 5th Ed. The English Language Book Society of Longman .

• Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. WardsworthPublishing Company, Belmont, California, USA, 1988.

• Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York,2004.

• Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.

• Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.

• Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis,Thomson Asia Pvt. Ltd

EVS11229	Environmental Economics and Statistics				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 4	T: 0	P : 0	C: 4

Unit 1: Environmental economics (10 lectures)

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; Contingent Valuation; Hedonic Pricing; Concept of travel Cost method.

Unit 2: Natural resource economics (5 lectures)

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 3: Economic solutions to environmental problems (15 lectures)

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: Tools for environmental economic policy (10 lectures)

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 of costs and benefits, techniques of valuation, adjusting and comparing environmental benefits and costs.

Unit 5: Statistical techniques applied to Environmental systems (20 lectures)
Variables, population and Sampling, sampling methods, sampling error, frequency distribution, bar diagram, pie diagram, arithmetic and geometric mean, mode, median, measures of deviation, null and alternative hypothesis, probability distribution, t-test, $\chi 2$ Test, f-test, correlation and regression.

Suggested Readings

1. Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C.S., Jansson, B.O., Levin, S., Maler, K.G., Perrings, C., Pimentel, D. 1995. Economic growth, carrying capacity, and the environment. *Ecological Economics* 15: 91-95.

2. Hanley, N., Shogren, J. F., & White, B. 2007. *Environmental Economics: In Theory and Practice*. Palgrave Macmillan.

3. Kolstad, C.D. 2010. *Environmental Economic*s. Oxford University Press.

4. Perman, R. 2003. *Natural Resource and Environmental Economics*. Pearson Education.

5. Singh, K. & Shishodia, A. 2007. *Environmental Economics: Theory and Applications*. Sage Publications.

6. Thomas, J.M. & Callan, S.J. 2007.*Environmental Economics*. Thomson Learning Inc.

7. Tietenberg, T. 2004. *Environmental and Natural Resource Economics* (6th Edition). Pearson Education Pvt. Ltd.

8. Tietenberg, T. H. & Lewis, L. 2010. *Environmental Economics and Policy*. Addison-Wesley.

EVS11230	**Solid Waste Management**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 4**	**T: 0**	**P : 0**	**C: 4**

Unit 1: Introduction (3 lectures)
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 (5 lectures)
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 (12 lectures)
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 (6 lectures)

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 (6 lectures)
4R's - 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 (WTE) (4 lectures)
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 (4 lectures)
Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management.

Unit 8: Policies for solid waste management (10 lectures)
Municipal Solid Wastes (Management and Handling) Rules 2016; Hazardous and other Wastes (Management and Transboundary Movement) 2016; Bio-Medical Waste Management Rules 2016; Plastic Waste Management Rules, 2016 and Plastic Waste Management (Amendment) Rules, 2018; E-Waste (Management) Rules, 2016 and E- Waste (Management) Amendment Rules, 2018.

Suggested Readings:

1. Asnani, P. U. 2006. Solid waste management. *India Infrastructure Report 570*.

2. Bagchi, A. 2004. *Design of Landfills and Integrated Solid Waste Management*. John Wiley & Sons.

3. Blackman, W.C. 2001. *Basic Hazardous Waste Management*. CRC Press.

4. McDougall, F. R., White, P. R., Franke, M., & Hindle, P. 2008. *Integrated Solid Waste Management: A Life Cycle Inventory*. John Wiley & Sons.

5. US EPA. 1999. *Guide for Industrial Waste Management*. Washington D.C.

6. White, P.R., Franke, M. &Hindle P. 1995. *Integrated Solid waste Management: A Lifecycle Inventory*. Blackie Academic & Professionals.

7. Zhu, D., Asnani, P.U., Zurbrugg, C., Anapolsky, S. & Mani, S. 2008. *Improving Municipal Solid waste Management in India.* The World Bank, Washington D.C.

EVS11231	**Green Technologies**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 4**	**T: 0**	**P : 0**	**C:4**

Unit 1: Introduction (5 lectures)
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 (5 lectures)

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 grave' to 'cradle to cradle'

Unit 3: Green infrastructure, planning and economy (15 lectures)

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 (15 lectures)

Increase in energy efficiency: cogeneration, motor system optimization, oxy-fuel firing, isothermal melting process, energy efficient fume hoods, compact fluorescent lights (CFLs), motion detection lighting, or programmable thermostats). Green House Gas (GHG) emissions reduction: carbon capture and storage (CCS) 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 (FGD) 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 (VOC) paints and sealers).

Unit 5: Green chemistry (10 lectures)

Introduction to green chemistry; principles and recognition of green criteria in chemistry; biodegradable 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 (10 lectures)

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.

Suggested Readings

1. Anastas, P.T. & Warner, J.C. 1998. *Green Chemistry: Theory & Practice*. Oxford University Press.

2. Arceivala, S.L. 2014. *Green Technologies: For a Better Future*. Mc-Graw Hill Publications.

3. Baker, S. 2006. *Sustainable Development*. Routledge Press.

4. Hrubovcak, J., Vasavada, U. & Aldy, J. E. 1999. *Green technologies for a more sustainable agriculture* (No. 33721). United States Department of Agriculture, Economic Research Service.

5. Thangavel, P. & Sridevi, G. 2015. *Environmental Sustainability: Role of Green Technologies*. Springer Publications.

6. Woolley, T. & Kimmins, S. 2002. *Green Building Handbook* (Volume 1 and 2). Spon Press.

EVS11232	Urban Ecosystems				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 4	T: 0	P : 0	C: 4

Unit 1: Introduction (4 lectures)
Introduction to urbanization; urban sprawl and associated environmental issues.

Unit 2: Environment in an urban setting (10 lectures)
Man as the driver of urban ecosystem; commodification 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 (12 lectures)
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 (12 lectures)
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 (10 lectures)
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 (12 lectures)
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.

Suggested Readings

1. D'Monte, Darryl. 1985. *Industry versus Environment Temples or Tombs*. Three Controversies,Delhi, CSE.

2. Ernstson, H. 2011. *Re-translating nature in post-apartheid Cape Town: The material semiotics ofpeople and plants at Bottom Road*. In: Heeks, R., (Ed.) Conference on "UnderstandingDevelopment through Actor-Network Theory", London School of Economics, 30 June, London.

3. Gaston, K.J. 2010. *Urban Ecology*. Cambridge University Press, New York.

4. Grimm, N. B., Faeth, S. H., et al. 2008. Global Change and the Ecology of Cities. *Science* **319**:756-760.

5. Hinchliffe, S. & Whatmore, S. 2006. Living cities: Towards a politics of conviviality. *Science asCulture* **15**: 123–138.

6. McIntyre, N.E. 2000. Urban ecology as an interdisciplinary field: differences in the use of 'urban'between the social and natural sciences. *Urban Ecosystems* **4**: 5-24.

7. Montgomery, M.R. 2009. Urban Transformation of the developing world. *Science* **319:** 761-764.

8. Richter, M. & Weiland, U. (ed.). 2012. *Applied Urban Ecology*. Wiley-Blackwell, UK

EVS12233	**Environmental Pollution and Human health Lab**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 0**	**T: 0**	**P : 3**	**C: 2**

1. Estimation of Ground & surface water quality parameters (COD, BOD, DO, nitrate, fluoride,
2. arsenic, chlorine, cadmium, mercury, pesticides).
3. Estimation of air quality parameters (NOx, SOx, SPM).
4. Field visit to effluent treatment plants (ETP)/ sewage treatment plants (STP)
5. Total coliform load of water sample.
6. Noise monitoring (Leq).

Suggested Readings

1. Gurjar, B. R., Molina, L. T. & Ojha C. S. P. 2010. Air Pollution: Health and Environmental Impacts. CRC Press, Taylor & Francis.
2. Hester, R. E. & Harrison, R. M. 1998. Air Pollution and Health. The Royal Society of Chemistry, UK.
3. Park, K. 2015. Park's Textbook of Preventive and Social Medicine (23rd edition). Banarsidas Bhanot Publishers.
4. Pepper, I. L., Gerba, C.P. & Brusseau, M. L. 2006. Environmental and Pollution Science. Elsevier Academic Press.
5. Purohit, S. S. & Ranjan, R. 2007. Ecology, Environment & Pollution. Agrobios Publications.
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6. Vesilind, P. J., Peirce, J. J., & Weiner R. F. 1990. Environmental Pollution and Control. Butterworth-Heinemann, USA

EVS12234	**Analytical methods, instrumentation, and Measurement Lab**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 0**	**T: 0**	**P : 3**	**C: 2**

1. Gravimetric estimation of TSS, TDS in water.
2. Gravimetric estimation of oil and grease present in water.
3. Gravimetric estimation of chloride in water.
4. Determination of pKa values of indicator using spectrophotometry.
5. Colourimetric estimation of iron in water.
6. Spectrophotometric analysis of $SO_4^{2-}$and PO_4^{3-} in water.
7. Spectrophotometric analysis of NO_3^{2-} in water.
8. Sampling of air using High Volume Sampler/Respirable Dust Sampler

9. Analysis of SOx and NOx in air.
10. Analysis of Pb in water and soil using atomic absorption spectrophotometer.

EVS12237	Environmental Economics and Statistics Lab				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 0	T: 0	P :3	C: 2

1. Numerical problems on biostatistics:

   Chi-Square test (Goodness of fit, Contingency),
   Student's t test (Paired and Unpaired).
   Analysis of Variance (ANOVA)

2. Valuation of a forest/wetland- model exercise based on field study.

3. Viva-voce & Laboratory Notebooks.

Suggested Readings:

1. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.

2. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.

3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.

4. Kolstad, C.D. 2010. *Environmental Economic*s. Oxford University Press.

5. Perman, R. 2003. *Natural Resource and Environmental Economics*. Pearson Education.

EVS12238	Solid Waste Management Lab				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 0	T: 0	P : 3	C: 2

1. Sample Preparation and Sampling Techniques
2. Coning and Quartering Method
3. Profile sampling of municipal solid waste
4. Analysis of solid waste/ sludge for moisture content
5. Analysis of solid waste/ sludge for particle size
6. Analysis of solid waste/ sludge for calorific value
7. Visit to a Solid Waste Management site and Report submission.
8. Viva-voce.

Suggested Readings:

1. Asnani, P. U. 2006. Solid waste management. *India Infrastructure Report 570*.

2. Bagchi, A. 2004. *Design of Landfills and Integrated Solid Waste Management*. John Wiley & Sons.

3. Blackman, W. C. 2001. *Basic Hazardous Waste Management*. CRC Press.

4. McDougall, F. R., White, P. R., Franke, M., & Hindle, P. 2008. *Integrated Solid Waste Management: A Life Cycle Inventory*. John Wiley & Sons.

5. US EPA. 1999. *Guide for Industrial Waste Management*. Washington D.C.

6. White, P. R., Franke, M. & Hindle P. 1995. *Integrated Solid waste Management: A Life cycle Inventory*. Blackie Academic & Professionals.

7. Zhu, D., Asnani, P. U., Zurbrugg, C., Anapolsky, S. & Mani, S. 2008. *Improving Municipal Solid waste Management in India.* The World Bank, Washington D.C.

EVS12239	**Green Technologies Lab**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 0**	**T: 0**	**P : 3**	**C: 2**

1. Worksheet preparation of schemes of different green processes and practices based on industry visit
2. Photocatalytic treatment of wastewater.
3. Designing a green building.
4. Study of degradability of plastics.
5. Preparation of biodiesel from vegetable oil.
6. Planning a rainwater harvesting protocol
7. Visit to biofertilizer, vermicomposting units, organic agriculture farms and report preparation.

Suggested Readings

1. Anastas, P. T. & Warner, J. C. 1998. *Green Chemistry: Theory & Practice*. Oxford University Press.

2. Arceivala, S. L. 2014. *Green Technologies: For a Better Future*. Mc-Graw Hill Publications.

3. Baker, S. 2006. *Sustainable Development*. Routledge Press.

4. Hrubovcak, J., Vasavada, U. & Aldy, J. E. 1999. *Green technologies for a more sustainable agriculture* (No. 33721). United States Department of Agriculture, Economic Research Service.

5. Thangavel, P. & Sridevi, G. 2015. *Environmental Sustainability: Role of Green Technologies*. Springer Publications.

6. Woolley, T. & Kimmins, S. 2002. *Green Building Handbook* (Volume 1 and 2). Spon Press.

EVS12240	**Urban Ecosystems Lab**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 0**	**T: 0**	**P : 3**	**C: 2**

Field survey based analysis, exercise and interpretation
Exercises: Students will carry out a group work in which the development of the infrastructure of the city of the future is explored and presented. The assignment concentrates on the development of one infrastructure (clean water, wastewater or energy) in two possible surroundings (newly built city or transition from present to future situation).

Tutorial focusing on introducing the state-of-the-art technologies for drinking water supply, wastewater treatment, energy supply and material/nutrient recycling and recovery.
Individual assignment the student will perform a technological assessment for the solution of a specific urban environmental problem performing basic calculations on urban flows and their transformations and considering the sustainability outcome.

Field visits to experience various environmental technologies working in practice.

Suggested Readings:

1. Niemelä, J., Breuste, J. H., Guntenspergen, G., McIntyre, N. E., Elmqvist, T., James, P. (eds) (2011) Urban Ecology. Patterns, Processes, and Applications. Oxford University Press: UK.

2. Van Bueren, E. M, van Bohemen, H., Itard, L., Visscher, H. (Eds). (2011) Sustainable Urban environment. An ecosystem approach. Springer.

3. D'Monte, Darryl. 1985. *Industry versus Environment Temples or Tombs*. Three Controversies, Delhi, CE.

4. Gaston, K. J. 2010. *Urban Ecology*. Cambridge University Press, New York.

5. Montgomery, M. R. 2009. Urban Transformation of the developing world. *Science* 319: 761-764.

6. Richter, M & Weiland, U. (ed.) 2012. *Applied Urban Ecology*. Wiley-Blackwell, UK.

Semester VI

EVS11241	Environmental Legislation and Policy				FM: 100
Academic year: 2021-22	Contact Hours – 60	L: 4	T: 0	P : 0	C:4

Unit 1: History of environmental legislation and policy (10 lectures)
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 2: Environmental legislation (15 Lectures)
Constitution of India; fundamental rights; fundamental duties; Role of Ministry of Environment, Forests & Climate Change in environmental law and policy making; role of central and state pollution control boards and panchayats and municipal bodies in environmental law and policy making.
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). 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, Concept of Ecomark and Ecolabelling.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. Waste Management Rules 2016.

Unit 3: International laws and policy (10 Lectures)
Stockholm Conference 1972; United Nations Conference on Environment and Development 1992; Rio de Janeiro (Rio Declaration, Agenda 21); Montreal Protocol 1987; Kyoto Protocol 1997; Outcomes of recent United Nations Climate Change Conferences (COPs); Ramsar convention. Basel Convention; 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.

Unit 4: Environmental impact assessment (EIA) (15 Lectures)
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). EIA regulations in India-EIA Notification 2006, Status of EIA in India; Current issues in EIA regulation.
Case study of hydropower projects/ thermal projects. 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 ISO14000; sustainable development.

Unit 5: Risk assessment (10 Lectures)
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. Concept of Ecomark and Ecolabelling

Suggested Readings:

1. Abraham, C.M. 1999. *Environmental Jurisprudence in India*. Kluwer Law International.

2. Agarwal, V.K. 2005. Environmental Laws in India: Challenges for Enforcement. *Bulletin of the National Institute of Ecology* 15: 227-238.

3. Divan, S. & Rosencranz, A. 2001. *Environmental Law and Policy in India*. Oxford University Press.

4. Divan, S. & Rosencranz, A. 2002. *Environmental Law and Policy in India: Cases, Materials and Statues* (2nd edition). Oxford University Press.

5. Gupta, K.R. 2006. *Environmental Legislation in India*. Atlantic Publishers and Distributors.

6. Leelakrishnan, P. 2008. *Environmental Law in India* (3rd edition). Lexis Nexis India.

7. Naseem, M. 2011. *Environmental Law in India Mohammad*. Kluwer Law International.

8. Venkat, A. 2011. *Environmental Law and Policy*. PHI Learning Private Ltd.

9. Barrow, C.J. 2000. *Social Impact Assessment: An Introduction.* Oxford University Press.

10. Glasson, J., Therivel, R., Chadwick, A. 1994. *Introduction to Environmental Impact Assessment*. London, Research Press, UK.

11. Judith, P. 1999. *Handbook of Environmental Impact Assessment*. Blackwell Science.

12. Marriott, B. 1997. *Environmental Impact Assessment: A Practical Guide*. McGraw-Hill, New York, USA.

EVS11242	**Wastewater Engineering**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 4**	**T: 0**	**P : 0**	**C: 4**

Unit 1: Basics of wastewater treatment (12 Lectures)
Physical, chemical and biological characteristics of wastewater.

Unit 2: Preliminary and primary treatment (12 Lectures)
Analysis and selection of wastewater flow rates and constituent loadings for process design. Physical unit operations: Screening, grit chamber, sedimentation and air flotation. Chemical unit operations: coagulation, precipitation, chemical oxidation and scale control.

Unit 3: Secondary Treatment (12 Lectures)
Biological treatment introduction, biomass growth kinetics. Advanced wastewater treatment: nutrient removal – Nitrogen and phosphorus removal, activated sludge processes and attached growth processes.

Unit 4: Advanced Secondary Treatment (12 Lectures)

Anaerobic treatment processes, sludge treatment and disposal: sources, characteristics and quantities of sludge. Treatment processes, gravity and flotation thickening, sludge digestion, vacuum and pressure filtration. Ultimate sludge disposal.

Unit 5: Tertiary Treatment (12 Lectures)

Advanced treatment through membrane technology, MBR, MBBR technologies.

Text Books:

1 Metcalf and Eddy, "Wastewater Engineering", 4th edition, McGraw-Hill, 2003.

2 Viessman and Hammer, "Water Pollution and Control", 7th edition, Pearson Prentice Hall, 2004.

3 Hammer M.J. (2000): Water and wastewater technology. Prentice Hall of India Pvt. Ltd., New Delhi.

Reference Books:

1 Henze Harremoes La Cour Jansen, Arvin (1998): Wastewater treatment. Prentice Hall of India, USA.

2 Bristle, L.R. (1997): Theory and principles of water and wastewater treatment. John Willey and Sons, New Delhi.

3 Woodard, F. (2001): Industrial Waste Treatment Handbook. Butterworth Heinemonn, New Delhi.

EVS11243	**Environmental Health And Toxicology**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 4**	**T: 0**	**P : 0**	**C: 4**

Unit 1: Epidemiology and Health (6 lectures)

Concept of Health and Disease, principles of epidemiology and epidemiological methods, aims of epidemiology, measurement of mortality, measurement of morbidity.

Unit 2: Concept of Disease (10 lectures)

Concept of screening the diseases, some communicable diseases like smallpox, cholera, acute diarrheal disease, viral hepatitis, water borne pathogens, vector borne diseases, diseases caused by contaminated food and water, soil borne infections, insect borne diseases,

Unit 3: Concept of Immunology (12 lectures)

Elementary idea about antigens and antibody, hypersensitivity, allergic reactions, pollens and their allergens. Immunological techniques.

Unit 4: Community and Health (2 lectures)

Communication for health education, health care of the country.

Unit 5: Basic Concept of Toxicology (20 lectures)

Different types of toxicants, toxicity test, toxicity by different factors, exposure effect relationship, effects of heavy metals and metalloids on health, different route of exposure, synergistic and

antagonistic effect, Biotransformation, bioaccumulation and Biomagnification. Detoxification, toxicodynamics; Basic concepts of toxicological assays (Eg. Comet Assay)

Suggested Readings:

1. Klassen, C. 2017. Cassarett & Doull's Toxicology: The Basic Science of Poisons. McGraw-Hill.

2. Newman, M. C. and W. H. Clements, 2008: Ecotoxicology- A comprehensive treatment, CRC press.

3. Wright, D. A. and P. Welbourn, 2002. Environmental toxicology, Cambridge University press.

4. Willium P. L. and J. L. Burson, 1985. Industrial toxicology, safety and health applications in the workplace, Van Nostard Reinhold, New York.

5. Girard, J. E. 2015. Principles of Environmental chemistry. 3rd Ed. Jones & Barllett learning, New Delhi.

6. Walker, C. 2014. Ecotoxicology. CRC Press.

7. Jorgensen, SE. 2016. Ecotoxicology and Chemistry Applications in Environmental Management. CRC Press.

8. Lu F.C. & S Kacew 2002. Lu's Basic Toxicology. CRC Press.

9. Santra S. C. Environmental Science. New Central Book Agency.

EVS11244	**Remote Sensing and Geographic Information System**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 4**	**T: 0**	**P : 0**	**C:4**

Unit 1: Introduction to remote sensing (12 Lectures)
Principles of Remote Sensing – History, Development of RS in India, Concept & Principles, Electromagnetic Radiation (EMR) and Its characteristics, Interaction of EMR with Atmosphere and Earth's Surface, Spectral Response and Spectral Signature, Spectral, Spatial, Temporal and Radiometric resolutions. Satellites and their Characteristics: Geo Synchronous and Sun Synchronous, Remote sensing systems, Platforms and their characteristics, Sensor classification: Active, Passive.

Unit 2: Geographical Information Systems (12 Lectures)
Introduction to GIS: Definition, Philosophy & Historical evolution of GIS, Basic concepts about spatial information, Spatial vs. non-spatial data, Spatial data models – Raster and Vector, Components of GIS, Hardware/software requirements for GIS, GIS Vs Cartography, Basics of Cartography: Map Scale, Categories of Maps, Grids and Graticules.

Unit 3: Data Structure (12 Lectures)
GIS Data structure and format : Raster Data & its Representation: Data Structure, Data Compression, Raster file formats, Vector data representation: Data Structure, Comparison between Raster & Vector Data. Data Acquisition through Scanners and Digitizers, Methods of Digitization (Manual vs. Automated), Geometric Transformations of Raster and Vector Data, RMS Error, Sources of Errors in

spatial data and, Spatial Data Quality: Accuracy, Precision, Error and Uncertainty. Data reception and data products: Data Formats, Ground segment organization, Pre-processing, Referencing Scheme, Data product generation, Data product output medium, Open Data Sources

Unit 4: Applications and case studies (12 Lectures)
Applications and case studies of remote sensing and GIS in geosciences, water resource management, land use planning, forest resources, agriculture, marine and atmospheric studies.

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

EVS11245	**Environmental Data Analysis**				**FM: 100**
Academic year: 2021-22	**Contact Hours – 60**	**L: 4**	**T: 0**	**P : 0**	**C:4**

Unit 1: Introduction (5 Lectures)
Data visualization, and distributions, Objectives, overview and organization, Visualizing distributions, Descriptive statistics, robust measures.

Unit 2: Introduction to R (15 Lectures)
What is R, Installation of R, A Few Important Syntax Conventions in R, Variables and Types, Data Structures, R Operators, Creating Subsets of a Matrix or Data Frame, Row or Column Operations on a Matrix or Data Frame Functions in R, Getting Data Into and Out of R, Plotting in R, Getting Help in R, Libraries and Packages, Tutorials for Learning R

Unit 3: Data screening and adjustments (15 Lectures)
Summary statistics (e.g., means, standard deviations, quantiles), Missing data (e.g., single variable and multi-variable imputation), Frequency of occurrence and abundance plots, Dropping variables, Single variable distributions, Relationships between pairs of variables, Outliers, Data transformations, Data standardizations, Dissimilarity matrices

Unit 4: Analysis of Environmental Data (15 Lectures)
Deterministic functions, What is a deterministic (mathematical) function, Linear function – Example of local faunal species, Logistic function – Example of local faunal species, Ricker function , Bestiary of deterministic functions

Unit 5: Probability distributions (5 Lectures)

What is a probability distribution, Plotting distributions, Bestiary of probability distributions, Classical tests:, Single sample, Two samples

Unit 6: Resampling procedures and stochastic simulations (5 Lectures)

Bootstrap, Randomization tests, Stochastic simulations, Simulating static ecological processes, Simulating dynamic processes – population matrix mode

EVS12246	Wastewater Engineering Lab				FM: 100
Academic year: 2021-22	Contact Hours – 45	L: 0	T: 0	P : 3	C: 2

Sampling and analysis of Industrial wastewater.
Sampling and analysis of surface water.
Designing a wastewater treatment plant
Determination of iron
Determination of sodium content
Determination of potassium content
Determination of nitrates
Determination of optimum dosage of coagulant
Determination of quantity of residual chlorine

EVS12247	Environmental Health and Toxicology Lab				FM: 100
Academic year: 2021-22	Contact Hours – 45	L: 0	T: 0	P : 3	C: 2

1. Dose- Response Relationship; Whole Effluent Toxicity (WET) test; Bioassay - types, methodologies and application.
2. Methods on Basic analytical toxicology.

EVS12248	Remote Sensing and Geographic Information System Lab				FM: 100
Academic year: 2021-22	Contact Hours – 45	L: 0	T: 0	P : 3	C: 2

Unit 1:

Familiarization with the various remote sensing software, downloading satellite data from various sources in the world wide web, displaying satellite image in different colour composites, Field Spectra Collection: vegetation, bare soil, and concrete using Spectro Radiometer and analyse it with satellite data, Extraction of Water bodies and Agricultural land use from a given satellite image, Discriminate Land surface features using spectral, thermal and microwave satellite images.

Unit 2:

Familiarization with the GIS software, Georeferencing of spatial data in GIS software, Geodatabase creation and Digitization of point line and polygon features, Creation of Spatial data from Non-spatial data, Topology creation of spatial data, Removing topological error, Attribute data Integration with spatial data, Map Designing (layout creation), Thematic Map creation, Performing vector analysis; Attribute query, buffering, overlay.

EVS12249	Environmental Data Analysis Lab				FM: 100
Academic year: 2021-22	Contact Hours – 45	L: 0	T: 0	P : 3	C: 2

1. Major pollutants in the Ganga River

- major ions in local precipitation and surface waters
- how does an ion chromatograph work?
- standards and error bars
- calibration curves
- how to write a lab report

2. Particulate matter in Kolkata

- atmospheric chemistry of ozone
- basics in Excel, data entry
- atmospheric transport in NYC area, average, standard deviation, median
- evaluation of ozone data of a particular day for everybody
- basic statistics (histogram, mean, SD), lab report format
- evaluation of extended ozone data set
- how to conduct an experiment
- particulate matter in air
- evaluation of particulate matter experiment
- advanced statistics: normal distributions, significance tests (t-tests)
- statistical analysis of data, determination of fluxes, discussion of p.m. sources

3. Bathymetry and sediment distribution in the Ganga River off Kolkata

- Overview of GIS systems and applications
- Coordinate systems and projections
- Spatial data formats and editing spatial data
- Working with attribute tables in a GIS
- Basic spatial analysis
- Making maps with ArcGIS
- Using GIS to analyze the Bathymetry and sediment distribution in the Hudson River
- GIS on the Internet