UNIVERSITY OF KALYANI

CURRICULUM AND CREDIT FRAMEWORK FOR FOUR-YEAR UNDERGRADUATE PROGRAMME (FYUP) in ENVIRONMENTAL SCIENCE (Under NEP 2020)

With Effect from Academic Session 2023 – 2024

Undergraduate Board of Studies in Environmental Science

UNIVERSITY OF KALYANI

COURSE STRUCTURE FOR FOUR-YEAR UNDERGRADUATE PROGRAMME (FYUP) IN ENVIRONMENTAL SCIENCE (NEP-2020)

Semester – I

Course Code	Course Title	Nature of Course	Credits of Course	Class hour /week	Evaluation		Total
					Internal	Semester End	
ENVS-M-1 ENVS-M-1-L ENVS-M-1-P	**FUNDAMENTALS OF ENVIRONMENT AND ECOLOGY**	Major Course	4(L)+2(P)	4(L)+4(P)	10+5	40+20	75
ENVS-MI – Course 1	**ENVIRONMENTAL POLLUTION** (*To be **OPTED** by the students from **OTHER** departments*)	Minor Course	3(L) + 1(P)	3(L) + 2(P)	10	40	50
ENVS-MDC	**NATURAL RESOURCE MANAGEMENT** (*To be **OPTED** by the students from **OTHER** departments*)	Multidisciplinary Course	3	3	10	35	45
ENVS-SEC-1	**WATER AND AIR QUALITY ANALYSIS**	Skill Enhancement Course	3(P)	6(P)	10	35	45
ENVS-VA	**ENVIRONMENTAL EDUCATION**	Value Added Course	4 (L)	4	10	40	50
Total Credits/ Courses= 20/5			**20**	**26**			**265**

Semester – II

Course Code	Course Title	Nature of Course	Credits of Course	Class hour/week	Evaluation		Total
					Internal	Semester End	
ENVS-M-2 ENVS-M-2-L ENVS-M-2-P	**ENVIRONMENTAL POLLUTION AND MITIGATION**	Major Course	4(L) + 2(P)	4(L)+4(P)	10+5	40+20	75
ENVS-MI – Course 1	**ENVIRONMENTAL POLLUTION** (*To be **OPTED** by the students from **OTHER** departments*)	Minor Course	3(L) + 1(P)	3(L) + 2(P)	10	40	50
ENVS-MDC	**NATURAL RESOURCE MANAGEMENT** (*To be **OPTED** by the students from **OTHER** departments*)	Multidisciplinary Course	3	3	10	35	45
AECC-I	**COMMUNICATIVE ENGLISH**	Ability Enhancement Course	4 (L)	4	10	40	50
ENVS-SEC-2	**SOIL QUALITY ANALYSIS AND NOISE MONITORING**	Skill Enhancement Course	3(P)	6(P)	10	35	45
ENVS-SI-1	**SUMMER INTERNSHIP** (Additional for Certificate/Diploma Course)	Summer Internship	-	-			
Total Credits/ Courses= 20/5			**20**	**26**			**265**

COURSE STRUCTURE FOUR-YEAR UNDERGRADUATE PROGRAMME (FYUP) IN ENVIRONMENTAL SCIENCE (NEP-2020)

Semester – III

Course Code	Course Title	Nature of Course	Credit of Course	Class hour/week	Evaluation		Total
					Internal	Semester End	
ENVS-M-3 ENVS-M-3-L ENVS-M-3-P	**LAND AND WATER RESOURCE MANAGEMENT**	Major Course	4(L) + 2(P)	4(L) + 4(P)	10+5	40+20	75
ENVS-MI – Course 2	**BASICS OF BIODIVERSITY** (*To be **OPTED** by the students from **OTHER** departments*)	Minor Course	3(L) + 1(P)	3(L) + 2(P)	10	40	50
ENVS-MDC	**NATURAL RESOURCE MANAGEMENT** (*To be **OPTED** by the students from **OTHER** departments*)	Multidisciplinary Course	3	3	10	35	45
ENVS-SEC-3	**ANALYTICAL TECHNIQUES IN ENVIRONMENTAL MONITORING**	Skill Enhancement Course	3(P)	6(P)	10	35	45
VA	To be selected from the pool	Value Added Course	4 (L)	4	10	40	50
Total Credits/ Courses= 20/5			**20**	**26**			**265**

Semester – IV

Course Code	Course Title	Nature of Course	Credit of Course	Class hour/week	Evaluation		Total
					Internal	Semester End	
ENVS-M-4 ENVS-M-4-L ENVS-M-4-P	**ENVIRONMENTAL CHEMISTRY AND ENVIRONMENTAL PHYSICS**	Major Course	4(L) + 2(P)	4(L) + 4(P)	10+5	40+20	75
ENVS-M-5 ENVS-M-5-L ENVS-M-5-P	**ENVIRONMENTAL TOXICOLOGY AND HEALTH**	Major Course	4(L) + 2(P)	4(L) + 4(P)	10+5	40+20	75
ENVS-MI – Course 2	**BASICS OF BIODIVERSITY** (*To be **OPTED** by the students from **OTHER** departments*)	Minor Course	3(L) + 1(P)	3(L) + 2(P)	10	40	50
AECC-II	**MIL**	Ability enhancement course	4(L)	4	10	40	50
ENVS-SI-2	**SUMMER INTERNSHIP** (Additional for Certificate/Diploma Course)	Summer internship	-	-			
Total Credits/ Courses= 20/4			**20**	**25**			**250**

Semester – V

Course Code	Course Title	Nature of Course	Credit of Course	Class hour/week	Evaluation		Total
					Internal	Semester End	
ENVS-M-6 ENVS-M-6-L ENVS-M-6-P	**ENVIRONMENTAL GEOSCIENCE**	Major Course	4(L) + 2(P)	4(L) + 4(P)	10+5	40+20	75
ENVS-M-7 ENVS-M-7-L ENVS-M-7-P	**BIODIVERSITY MANAGEMENT**	Major Course	4(L) + 2(P)	4(L) + 4(P)	10+5	40+20	75
ENVS-MI – Course 3	**OCCUPATIONAL HEALTH AND SAFETY** (*To be **OPTED** by the students from **OTHER** departments*)	Minor Course	3(L) + 1(P)	3(L) + 2(P)	10	40	50
ENVS-MI Course 4	To be selected from the pool	Minor Course	-	-	-	-	-
Total Credits/ Courses= 20/4			**16**	**21**			**200**

Semester – VI

Course Code	Course Title	Nature of Course	Credit of Course	Class hour/week	Evaluation		Total
					Internal	Semester End	
ENVS-M-8 ENVS-M-8-L ENVS-M-8-P	**ENERGY AND ENVIRONMENT**	Major Course	4(L) + 2(P)	4(L) + 4(P)	10+5	40+20	75
ENVS-M-9 ENVS-M-9-L ENVS-M-9-P	**ENVIRONMENTAL STATISTICS AND MODELLING**	Major Course	4(L) + 2(P)	4(L) + 4(P)	10+5	40+20	75
ENVS-M-10 ENVS-M-10-L ENVS-M-10-P	**ENVIRONMENTAL LEGISLATION AND POLICY**	Major Course	4(L) + 2(P)	4(L) + 4(P)	10+5	40+20	75
ENVS-SI-3	**OUTREACH/ INTERNSHIP**	Outreach/Internship	2	-	-	-	-
Total Credits/ Courses+ Internship= 20/3			**20**	**24**			**225**

Semester – VII

Course Code	Course Title	Nature of Course	Credit of Course	Class hour/week	Evaluation		Total
					Internal	Semester End	
ENVS-M-11 ENVS-M-11-L ENVS-M-11-P	**ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY**	Major Course	4(L) + 2(P)	4(L) + 4(P)	10+5	40+20	75
ENVS-M-12 ENVS-M-12-L ENVS-M-12-P	**GREEN CHEMISTRY AND GREEN TECHNOLOGY**	Major Course	4(L) + 2(P)	4(L) + 4(P)	10+5	40+20	75
ENVS-M-13 ENVS-M-13-L ENVS-M-13-P	**ENVIRONMENTAL IMPACT AND RISK ASSESSMENT**	Major Course	4(L) + 2(P)	4(L) + 4(P)	10+5	40+20	75
ENVS-MI – Course 5	**DISASTER MANAGEMENT** (*To be **OPTED** by the students from **OTHER** departments*)	Minor Course	3(L) + 1(P)	3(L) + 2(P)	10	40	50
ENVS-MI – Course 6	To be selected from the pool	Minor Course					
Total Credits/ Courses= 26/5			**22**	**29**			**275**

Semester – VIII

Course Code	Course Title	Nature of Course	Credit of Course	Class hour/week	Evaluation		Total
					Internal	Semester End	
ENVS-M-14	**WASTE MANAGEMENT**	Major Course	3(L) + 1(P)	3(L) + 2(P)	10	40	50
ENVS-M-15	**REMOTE SENSING, GEOGRAPHIC INFORMATION SYSTEM (GIS) AND APPLICATIONS**	Major Course	3(L) + 1(P)	3(L) + 2(P)	10	40	50
ENVS-M-16	**NATURAL HAZARDS AND DISASTER MANAGEMENT**	Major Course	3(L) + 1(P)	3(L) + 2(P)	10	40	50
UG Honours without Research: Two Additional Major Courses							
ENVS-M-17 ENVS-M-17-L ENVS-M-17-P	**FOREST AND WILDLIFE MANAGEMENT**	Major Course	4(L) + 2(P)	4(L) + 4(P)	10+5	40+20	75
ENVS-M-18 ENVS-M-18-L ENVS-M-18-P	**SUSTAINABLE DEVELOPMENT**	Major Course	4(L) + 2(P)	4(L) + 4(P)	10+5	40+20	75
Total Credits/ Courses= 24/5			**24**	**31**			**300**
UG Honours with Research: One Summer Internship							
ENVS-SI-4	Research Project/ Dissertation		12	-			
Total = 03+Research Project			**24**	**-**			

Summary of Courses
(Semester I- Semester VIII)

Semester	Major Course	Minor Course	Multi-disciplinary Course	Skill Enhancement Course	Value Added Course	AECC
Semester – I	**M-1:** Fundamentals of Environment and Ecology	**MI-Course 1:** Environmental Pollution	**MDC:** Natural Resource Management	**SEC-1:** Water and Air Quality Analysis	**ENVS-VA:** Environmental Education	-
Semester – II	**M-2:** Environmental Pollution and Mitigation	**MI-Course 1:** Environmental Pollution	**MDC:** Natural Resource Management	**SEC-2:** Soil Quality Analysis and Noise Monitoring	-	Communicative English
Semester – III	**M-3:** Land and Water Resource Management	**MI-Course 2:** Basics of Biodiversity	**MDC:** Natural Resource Management	**SEC-3:** Analytical Techniques in Environmental Monitoring	To be selected from the pool	-
Semester – IV	**M-4:** Environmental Chemistry and Environmental Physics **M-5:** Environmental Toxicology and Health	**MI-Course 2:** Basics of Biodiversity	-	-	-	Modern Indian Language (MIL)
Semester – V	**M-6:** Environmental Geoscience **M-7:** Biodiversity Management	**MI-Course 3:** Occupational Health and Safety **MI-Course 4:** To be Selected from the Pool	-	-	-	-
Semester – VI	**M-8:** Energy and Management **M-9:** Environmental Statistics and Modelling **M-10:** Environmental Legislation and Policy	-	-	-	-	-
Semester – VII	**M-11:** Environmental Microbiology and Biotechnology **M-12:** Green Chemistry and GreenTechnology **M-13:** Environmental Impact and Risk Assessment	**MI-Course 5:** Disaster Management **MI-Course 6:** To be Selected from the Pool	-	-	-	-
Semester – VIII	**M-14:** Waste Management **M-15:** Remote Sensing, Geographic Information System (GIS) and Applications **M-16:** Natural Hazards and Disaster Management **M-17:** Forest and Wildlife Management **M-18:** Sustainable Development	-	-	-	-	-

Semester - I

Major Course:

Course Code: ENVS-M-1
Course Title: Fundamentals of Environment and Ecology
Full marks: 75 Credits: 4(L) +2(P) = 06 No. of Lectures: 75

Preamble: This paper will introduce to the students the basic understanding of environment and ecology. It will explore the interconnectedness among all the biotic and abiotic components of environment and the dynamic nature of the ecological processes in maintaining equilibrium in nature.

ENVS-M-1-L Credits: 4 Full Marks: 40+10(Internal Assessment)

Unit 1: Life and Environment: Origin of Earth, its environment and life (with special reference to Big Bang, chemical and biochemical evolution); Gaia hypothesis and life-environment interactions.

Unit 2: Environmental Systems and Subsystems: Basic concepts of atmosphere; hydrosphere; lithosphere; biosphere; anthro(po)sphere; circulation systems; catchment basin system; weathering system; slope system; fluvial system; glacial system; aeolian system; coastal system; ecosystem; landscape; biome.

Unit 3: Ecology of Individuals: Ecological amplitude; Limiting factors; Liebig's law of the minimum; Shelford's law of tolerance; phenotypic plasticity; ecotypes; ecoclines; 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 4: Population Ecology: Concept of population and meta-population; r-and K-selection; characteristics of population (density, dispersion, natality, mortality, life tables, survivorship curves, age structure); population growth: geometric, exponential, logistic, density-dependent; limits of population growth; deterministic and stochastic models of population dynamics; ruderal, competitive and stress-tolerance strategies.

Unit 5: Community Ecology: Discrete versus continuum community view; community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; interspecies interactions (symbiosis, mutualism, commensalism, amensalism, proto-cooperation, predation, competition, parasitism, mimicry, herbivory); ecological succession: types, processes and models.

Unit 6: Ecosystem Ecology: Ecosystem structure and functions; abiotic and biotic components of ecosystem; ecosystem metabolism; primary production; secondary production and trophic efficiency; ecosystem connections: food chain, food web; models of energy flow; ecological efficiencies; ecological pyramids; ecosystem homeostasis (resistance and resilience stability); ecosystem services; Some model ecosystems: forest, grassland, estuarine, marine, desert, wetland.

Unit 7: Biogeochemical cycles and nutrient cycling: Concepts of pools, flux, turnover time; types of biogeochemical cycles; carbon cycle; nitrogen cycle; phosphorus cycle; sulphur cycle; hydrological cycle; impact of anthropogenic activities on the nutrient cycles; nutrient conservation strategies.

ENVS-M-1-P **Credits: 2** **Full Marks: 20+5 (Internal Assessment)**

Unit 8: Practical

- Determination of dissolved oxygen, free carbon dioxide, and primary productivity of water samples collected from aquatic ecosystems.
- Qualitative and quantitative analysis of planktons of aquatic systems.
- Determination of species, dominance and frequency using quadrate/ plot method.
- Ecological field visit: pond/forest/river/wetland or other ecosystem.

Suggested Readings:

1. Odum, E. P. & Barrett, G. W. 2006. Fundamentals of Ecology (Cengage).
2. Molles, M. C. Ecology. 2009, McGraw Hill.
3. Beeby, A. Applied Ecology. Chapman and Hall.
4. Begon, M. Harper, J. L & Townsend, C. R. 2006. Ecology (Blackwell).
5. Smith, R. L & Smith, T. M. Ecology and Field Biology. Benjamin Cummings/Addition Wesley.
6. Loreau, M. & Inchausti, P. 2002. Biodiversity and Ecosystem functioning: Synthesis and Perspectives. Oxford University Press, Oxford, UK.
7. Dash, M. C. & S. P. Dash, Fundamental of Ecology. Tata McGraw Hill Publication.
8. Singh, J. S., Singh, S. P. & Gupta, S. R. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications.
9. Santra, S. C. 2010. Fundamentals of Ecology and Environmental Biology, New Central Book Agency.

Minor Course:

Course Code: ENVS-MI-Course 1
Course Title: Environmental Pollution
Full marks: 40+10 (Internal Assessment) **Credits: 3(L) +1(P) = 04** **No. of Lectures: 50**

Preamble: To impart students the different types of pollution, causes and mitigation strategies. The students will be aware of the types of pollutants, sources, impacts and mitigation practices.

Unit 1: Air pollution: Natural and anthropogenic sources of air pollution; Primary and secondary air pollutants; Air quality standards; control of air pollution; Effects of air pollutants (SO_x, NO_x, CO, SPM) on humans, plants, animals; Automobile pollution; Acid Rain; Photochemical smog; Global Warming; Ozone layer depletion.

Unit 2: Water pollution: Sources of pollutants; causes and consequences of water pollution; water quality parameters and water quality standards; sewage and wastewater treatment; surface and ground water pollution; control strategies; thermal pollution; marine pollution: causes and consequences.

Unit 3: Soil pollution: Sources, causes and consequences of soil pollution; control strategies; concept of soil quality.

Unit 4: Solid and hazardous waste: Sources and generation of solid waste; different methods of disposal and management of solid wastes (plastic, biomedical, electrical and electronic and other hazardous wastes); waste management hierarchy; minimization technologies: recycling and recovery of resources from wastes.

Unit 5: Noise and Radioactive pollution: Sources of noise pollution; measurement of noise and noise indices; noise exposure levels and standards; noise pollution control strategies; impact of noise on human health; Ionizing and non-ionizing radiation and their effects; radioactive waste and its management.

Unit 6: Practical
Analysis of Water quality parameters: pH, Conductivity, Alkalinity, Hardness, Dissolved oxygen; Chloride; Noise level, SPM, RSPM (Demonstration).

Suggested Readings:

1. Rieuwerts, J. 2015, The Elements of Environmental Pollution, Routledge Taylor & Francis Group, UK.
2. Hill, M. K. 2010 Understanding Environmental Pollution, Cambridge University Press, UK.
3. Vesilind, P. A., Peirce J. J., & Weiner R. F. 1990, Environmental Pollution and Control, 3rd Edition, Elsevier Publication.
4. Rana, S. V. S. 2011. Environmental Pollution: Health and Toxicology. Alpha Science International Ltd.
5. Brusseau, M., Pepper, I., & Gerba, C. 2019, Environmental and Pollution Science, 3rd Edition, Elsevier Publication.

Multidisciplinary Course:

Course Code: ENVS-MDC
Course Title: Natural Resource Management
Full marks: 35+10 (Internal Assessment) Credits: 03 No. of Lectures: 45

Preamble: This paper aims to provide an idea of the nature Earth's resources, their generation, extraction, degradation and a critical insight of the major sustainability issues. The students are expected to understand effective natural resource management strategies from this course.

ENVS-MDC-L Credits: 3(L) Full Marks: 35+10 (Internal Assessment)

Unit 1: Introduction to natural resource: Concept and significance; types of natural resources; renewable and non-renewable resources; resource degradation; resource conservation.

Unit 2: Water resources management: Concept**,** world water balance; lakes, dams and reservoirs, coastal and marine water resources; conservation of water resources; integrated water resource management; rainwater harvesting; watershed management, wetland conservation and management.

Unit 3: Soil and land resources management: Concept, soil types, soil degradation and soil erosion; integrated strategies for soil conservation and regeneration; land resources: land use pattern and planning.

Unit 4: Mineral resources: Concept and types; environmental effects of extracting and using mineral resources.

Unit 5: Bioresource Management: Concept and categories, management of human and animal resources; biodiversity and its conservation; forest management; wildlife conservation and management.

Unit 6: Forest resources: Concept and types; use and over-exploitation, deforestation; impact of mining, dams on forest, mitigation strategies and tribal people.

Unit 7: Energy resources: Concept, types, conventional and non-conventional, non-renewable and renewable, fossil fuel, nuclear, geothermal, solar, wind, hydro-energy, bioenergy, energy conservation and management.

Unit 8: Practical
Field survey based analysis, exercise, report preparation and interpretation:

- Water audit of college / industry / domestic area.
- Energy audit of college / industry / domestic area.

Suggested Readings:

1. Ginley, D. S. & Cahen, D. 2011. Fundamentals of Materials for Energy and Environmental Sustainability. Cambridge University Press.
2. Klee, G. A. 1991. Conservation of Natural Resources. Prentice Hall Publication.
3. Miller, T. G. 2012. Environmental Science. Wadsworth Publishing Co.
4. Owen, O. S, Chiras, D. D, & Reganold, J. P. 1998. Natural Resource Conservation –Management for Sustainable Future (7th edition). Prentice Hall.
5. Ramade, F. 1984. Ecology of Natural Resources. John Wiley & Sons Ltd.

Skill Enhancement Course:

Course Code: ENVS-SEC-1-P
Course Title: Water and Air Quality Analysis
Full marks: 35+10(Internal Assessment) Credits: 3(P) No. of Lectures: 45

Preamble: This paper aims to provide knowledge about different types of sampling techniques, instruments handling, calibration methods, water and air quality analysis in order to develop skills among students.

Unit 1: Water and Air sampling techniques: Collection, processing and storage; Sample preparation methods; Standard curve preparation; Calibration of instruments - Method validation, Accuracy, Precision, Error analysis.

Unit 2: Estimation of physicochemical and biological properties of water: Temperature, pH, Eh, Conductivity, Turbidity, Total Solids, Total Suspended Solids and Total Dissolved Solids, Alkalinity, Hardness, Chloride, Dissolved oxygen, Qualitative and quantitative analysis of planktons.

Unit 3: Estimation of cations/anions by flame photometry (Sodium, Potassium) / spectrophotometry (Iron, Nitrate, Phosphate, etc.).

Unit 4: Air quality parameters, air quality standard (NAAQS), monitoring techniques using high volume sampler, estimation of Suspended Particulate matter, SO_x, NO_x, etc.

Unit 5: Estimation of relative humidity using dry and wet bulb thermometer; Preparation of wind rose plots.

Unit 6: Field visit.

Suggested Readings:

1. Trivedy, R. K. & Goel, P. K. (1986) Chemical and Biological method for water pollution studies. Environmental publication (Karad, India).
2. Nandini, N. (2009). Handbook on water quality monitoring and Assessment, Sapna Book House, Bengaluru.
3. Sawyer, C. N., & Mc Carty, P. L. (1978). Chemistry for Environmental Engineering. Mc Graw – Hill International.
4. Saxena, M. M. (1990). Environmental Analysis: Water, Soil and Air. Edition 2. Publisher, Agro Botanical Pub.
5. Standard Methods for Examination of Water and Wastewater. (2017). APHA – WEF.
6. Zhang, C. (2007). Fundamentals of environmental sampling and analysis. John Wiley & Sons.
7. Metcalf, L., Eddy, H. P. & Tchobanoglous, G. (1991). Wastewater engineering: treatment, disposal, and reuse (Vol. 4). New York: McGraw-Hill.

Value Added Course:

Course Code: ENVS-VA
Course Title: Environmental Education
Full marks: 40+10(Internal Assessment) **Credits: 4 (L) = 04** **No. of Lectures: 50**

Preamble: The course examines the relationship between the environment and society enabling the students to understand and appreciate the role played by environment, society, and, their interface in shaping environmental decisions. The students will be enabled to think critically on environmental issues.

Unit 1: Humans and the Environment: The man-environment interaction; impact of anthropogenic activities on the environment; Population growth and natural resource exploitation; Environmental world views: eco-centric, bio-centric and anthropocentric perspectives.

Unit 2: Natural Resources: Definition of resource; Classification of natural resources, renewable and non-renewable; Water resources; Soil/Land and mineral resources; Energy resources; Bioresources; Waste as resource and waste management; Issues and challenges related to resource management.

Unit 3: Ecosystems and Biodiversity:
Ecosystem: Definition; major types of ecosystem in India and their basic characteristics- forests, wetlands, grasslands, agriculture, coastal and marine; Ecosystem services.
Biodiversity: Definition, levels and types of biodiversity, biodiversity hotspots, importance of biodiversity: threats to biodiversity, Biodiversity loss; Conservation approaches, role of traditional knowledge, People's Biodiversity Register (PBR).

Unit 4: Environmental Pollution and Degradation: Definition of pollution; point and non-point sources of pollution; sources, causes, health effects and control strategies of air pollution, water pollution, soil pollution, noise pollution and radioactive pollution, fire cracker pollution; land degradation, deforestation, desertification, urbanization.

Unit 5: Climate Change: Weather *vs* climate, greenhouse gases, greenhouse effect and global warming; Natural *vs* anthropogenic radiative forcing; concepts of mitigation, adaptation, vulnerability and resilience (with reference to climate change); Impacts of climate change on: ocean and land systems, Sea level rise, marine and coastal ecosystems, forests and natural ecosystems, animal species, agriculture, health, urban infrastructure. Adaptation and mitigation measures; National and international policy instruments for mitigation; Climate justice; National Action Plan on Climate Change (NAPCC).

Unit 6: Environmental Treaties and Legislation: An overview of instruments of international cooperation; bilateral and multilateral agreements; conventions and protocols; Major International Environmental Agreements: Convention on Biological Diversity (CBD); Ramsar Convention on Wetlands of International Importance; Montreal Protocol; Basel Convention; United Nations Framework Convention on Climate Change (UNFCCC); Kyoto Protocol; Paris Agreement;Major Indian Environmental Legislations: The Wild Life (Protection) Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; The Forest (Conservation) Act, 1980; The Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986; The Biological Diversity Act, 2002; Noise Pollution (Regulation and Control) Rules,

2000; The Plastic Waste Management Rules, 2016; The Bio-Medical Waste Management Rules, 2016; The Solid Waste Management Rules, 2016; The e-waste (Management) Rules, 2016; Major International organisations and initiatives for environmental protection: United Nations Environment Programme (UNEP), International Union for Conservation of Nature (IUCN).

Unit 7: Environmental Ethics and Sustainable Development: Environmental ethics, Role of various religions and cultural practices in environmental conservation.
Environmental communication and public awareness: (Swachh Bharat Abhiyan, National Environment Awareness Campaign (NEAC); Sustainable development: Concept; overview of the United Nations Sustainable Development Goals (SDGs); sustainability ethics and sustainable lifestyle.

Suggested Readings:

1. Fisher, Michael H. (2018) An Environmental History of India- From Earliest Times to the Twenty-First Century, Cambridge University Press.
2. Headrick, Daniel R. (2020) Humans versus Nature- A Global Environmental History, Oxford University Press.
3. Perman, R., Ma, Y., McGilvray, J., & Common, M. (2003) Natural Resource and Environmental Economics. Pearson Education.
4. Chiras, D. D., & Reganold, J. P. (2010) Natural Resource Conservation: Management for a Sustainable Future.10th edition, Upper Saddle River, N. J. Benjamin/Cummins/Pearson.
5. John, W. Twidell & Anthony, D. (2015) Renewable Energy Sources, 3rd Edition, Weir Publisher.
6. Cunningham, W., & Cunningham, M. (2015) Environmental Science: A Global Concern, Publisher (Mc-Graw Hill, USA).
7. Masters, G. M., & Ela, W. P. (2008) An Introduction to Environmental Engineering and Science, Ela Publisher (Pearson).
8. Singh, J. S., Singh, S. P. & Gupta, S. R. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications https://sdgs.un.org/goals.
9. Harper, C. L. (2017) Environment and Society, Human Perspectives on Environmental Issues 6th Edition. Routledge.
10. Manahan, S. E. (2022) Environmental Chemistry (11th ed.). CRC Press.
11. Rajagopalan, R. (2011) Environmental Studies: From Crisis to Cure. India: Oxford University Press.
12. Bhagwat, S. (2018) Conservation and Development in India: Reimagining Wilderness, Earthscan Conservation and Development, Routledge.
13. Krishnamurthy, K.V. (2003) Textbook of Biodiversity, Science Publishers, Plymouth, UK.
14. Jackson, A. R., & Jackson, J. M. (2000) Environmental Science: The Natural Environment and Human Impact. Pearson Education.
15. Ahluwalia, V. K. (2015) Environmental Pollution, and Health. The Energy and Resources Institute.
16. Theodore, M. K. and Theodore, L. (2021) Introduction to Environmental Management, 2nd Edition. CRC Press.
17. Kanchi, K., & Menon, M. (2021) Development of Environment Laws in India, Cambridge University Press.

Semester - II

Major Course:

Course Code: ENVS-M-2
Course Title: Environmental Pollution and Mitigation
Full marks: 75 **Credits: 4(L) +2(P) = 06** **No. of Lectures: 75**

Preamble: This paper deals with different aspects of environmental contamination, which have adverse effects on human health. It will lay emphasis on understanding mechanisms of pollutants impacting human health by developing an understanding of different types of pollutants, their sources and mitigation measures. The students will also be introduced to the concept of permissible limits.

ENVS-M-2-L **Credits: 4** **Full Marks: 40+10 (Internal Assessment)**

Unit 1: Introduction: Definition of pollution; pollutants; classification of pollutants.
Unit 2: Air pollution: Ambient air quality: sources and types of air pollutants (primary and secondary); monitoring and standards (National Ambient Air Quality Standards of India); National air quality index; smog (case study); effects of different pollutants on human health (NO_x, SO_x, PM, CO, CO_2, hydrocarbons and VOCs) and control measures; indoor air pollution: sources, effects on human health and remedial strategies. Acid Rain, Ozone layer depletion, Vehicular pollution and control strategies.
Unit 3: Climate change and global environmental issues: Trends of global warming and climate change; drivers of global warming and the potential of different greenhouse gases (GHGs); radiative forcing and feedbacks (natural climate forcing, greenhouse gas forcing, atmospheric aerosol forcing, land-use change forcing) impact of climate change on atmosphere, weather patterns, sea level rise, water resources, biological responses, agriculture, and human health; Climate Change Mitigation and Adaptation; Carbon capture and storage (CCS); Carbon sequestration. International agreements; Montreal Protocol (1987); Kyoto Protocol (1997); Convention on Climate Change; carbon credit and carbon trading; clean development mechanism (CDM); National Action Plan for Climate Change (NAPCC).
Unit 4: Water pollution: Sources of surface and ground water pollution; emerging pollutants: microplastics, bisphenol-A, antibiotics; water quality parameters and standards; organic waste and water pollution; eutrophication; DO, BOD and COD; effect of water contaminants on human health (nitrate, fluoride, heavy metals, arsenic, pesticides); water borne diseases; concept and working of effluent treatment plants (ETPs); thermal pollution and its effects.
Unit 5: Soil pollution: Causes of soil pollution and degradation; effect of soil pollution on plants, animals and human health; control strategies.
Unit 6: Noise pollution: sources; frequency, intensity and permissible ambient noise levels; effect on communication, impacts on life forms and humans - working efficiency, physical and mental health; control measures.
Unit 7: Radioactive: Radioactive material and sources of radioactive pollution; effect of radiation on human health (somatic and genetic effects).
Unit 8: Marine pollution: Marine resources and their importance; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management; existing challenges and management techniques (planning, construction, environmental monitoring of coastal zones), London convention on the prevention of marine pollution.

Unit 9: Pollution control: Activated Sludge Process (ASP), Trickling Filters, oxidation ponds, fluidized bed reactors, membrane bioreactor neutralization; ETP sludge management; digesters, up flow anaerobic sludge blanket reactor, fixed film reactors, sequencing batch reactors, hybrid reactors, bioscrubbers, biotrickling filters; regulatory framework for pollution monitoring and control; case study: Ganga Action Plan; Application of clean technologies for pollution control.

Unit 10: Environmental Disasters: Minamata Disaster, Love Canal Disaster, Bhopal Gas Disaster (1984), Chernobyl Disaster (1986), Fukusima Daiichi nuclear disaster (2011).

ENVS-M-2-P **Credits: 2** **Full Marks: 20+5 (Internal Assessment)**

Unit 10: Practical

- Estimation of water quality parameters (dissolved oxygen, nitrate, sulphate, phosphate, chloride, arsenic etc.).
- Wastewater characterization: Biochemical Oxygen Demand, Chemical Oxygen Demand, Analysis of anions: (Sulphate, Phosphate, Nitrate, Chloride etc.), oil, grease and phenolics, MLSS, MLVSS, SVI, SDI and coliform load.
- Physicochemical characterization of sludge.
- Estimation of air quality parameters (NO_x, SO_x, SPM).
- Total coliform load of water sample.
- Noise monitoring (Leq).
- Visit to effluent treatment plants (ETP)/ sewage treatment plants (STP).

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.
6. Vesilind, P. J., Peirce, J. J., & Weiner R. F. (1990) Environmental Pollution and Control. Butterworth-Heinemann, USA.
7. Trivedy, R. K., & Goel, P. K. (1986) Chemical and Biological method for water pollution studies. Environmental publication (Karad, India).
8. Nandini, N. (2009) Handbook on water quality monitoring and Assessment, Sapna Book House, Bengaluru.
9. Sawyer, C. N., & Mc Carty, P. L. (1978) Chemistry for Environmental Engineering. Mc Graw – Hill International.
10. Saxena, M. M. (1990) Environmental Analysis: Water, Soil and Air. Edition 2, Publisher, Agro Botanical Pub.
11. Standard Methods for Examination of Water and Wastewater. (2017) APHA – WEF.
12. Zhang, C. (2007) Fundamentals of environmental sampling and analysis. John Wiley & Sons.
13. Metcalf, L., Eddy, H. P., & Tchobanoglous, G. (1991). Wastewater engineering: treatment, disposal, and reuse (Vol. 4). New York: McGraw-Hill.

Minor Course:

Course Code: ENVS-MI-Course 1
Course Title: Environmental Pollution
Full marks: 40+10 (Internal Assessment) Credits: 3(L) +1(P) = 04 No. of Lectures: 50

Preamble: To impart knowledge to students about different types of pollution, causes and mitigation strategies. The students will be aware of the types of pollutants, sources, impacts and mitigation practices.

Unit 1: Air pollution: Natural and anthropogenic sources of air pollution; Primary and secondary air pollutants; Air quality standards; control of air pollution; Effects of air pollutants (SOx, NOx, CO, SPM) on humans, plants, animals; Automobile pollution; Acid Rain; Photochemical smog; Global Warming; Ozone layer depletion.

Unit 2: Water pollution: Sources of pollutants; causes and consequences of water pollution; water quality parameters and water quality standards; sewage and wastewater treatment; surface and ground water pollution; control strategies; thermal pollution; marine pollution: causes and consequences.

Unit 3: Soil pollution: Sources, causes and consequences of soil pollution; control strategies; concept of soil quality.

Unit 4: Solid and hazardous waste: Sources and generation of solid waste; different methods of disposal and management of solid wastes (plastic, biomedical, electrical and electronic and other hazardous wastes); waste management hierarchy; minimization technologies: recycling and recovery of resources from wastes.

Unit 5: Noise and Radioactive pollution: Sources of noise pollution; measurement of noise and noise indices; noise exposure levels and standards; noise pollution control strategies; impact of noise on human health; Ionizing and non-ionizing radiation and their effects; radioactive waste and its management.

Unit 6: Practical
Analysis of Water quality parameters: pH, Conductivity, Alkalinity, Hardness, Dissolved oxygen; Chloride; Noise level, SPM, RSPM (Demonstration).

Suggested Readings:

1. Rieuwerts, J. (2015) The Elements of Environmental Pollution, Routledge Taylor & Francis Group, UK.
2. Hill, M. K. (2010) Understanding Environmental Pollution, Cambridge University Press, UK.
3. Vesilind, P. J., Peirce, J. J., & Weiner R. F. (1990) Environmental Pollution and Control, 3rd Edition, Elsevier Publication.
4. Rana, S. V. S. (2011) Environmental Pollution: Health and Toxicology. Alpha Science International Ltd.
5. Brusseau, M., Pepper, I., & Gerba, C. (2019) Environmental and Pollution Science, 3rd Edition, Elsevier Publication.

Multidisciplinary Course:

Course Code: ENVS-MDC

Course Title: Natural Resource Management

Full marks: 35+10 (Internal Assessment) **Credits: 03** **No. of Lectures: 45**

Preamble: This paper aims to provide an idea of the nature of Earth's resources, their generation, extraction, degradation and a critical insight of the major sustainability issues. The students are expected to understand effective natural resource management strategies from this course.

ENVS-MDC-L **Credits: 3(L)** **Full Marks: 35+10 (Internal Assessment)**

Unit 1: Introduction to natural resource: Concept and significance; types of natural resources; renewable and non-renewable resources; resource degradation; resource conservation.

Unit 2: Water resources management: Concept**,** world water balance; lakes, dams and reservoirs, coastal and marine water resources; conservation of water resources; integrated water resource management; rainwater harvesting; watershed management, wetland conservation and management.

Unit 3: Soil and land resources management: Concept, soil types, soil degradation and soil erosion; integrated strategies for soil conservation and regeneration; land resources: land use pattern and planning.

Unit 4: Mineral resources: Concept and types; environmental effects of extracting and using mineral resources.

Unit 5: Bioresource Management: Concept and categories, management of human and animal resources; biodiversity and its conservation; forest management; wildlife conservation and management.

Unit 6: Forest resources: Concept and types; use and over-exploitation, deforestation; impact of mining, dams on forest, mitigation strategies and tribal people.

Unit 7: Energy resources: Concept, types, conventional and non-conventional, non-renewable and renewable, fossil fuel, nuclear, geothermal, solar, wind, hydro-energy, bioenergy, energy conservation and management.

Unit 8: Practical

Field survey based analysis, exercise, report preparation and interpretation:

- Water audit of college / industry / domestic area.
- Energy audit of college / industry / domestic area.

Suggested Readings:

1. Ginley, D. S., & Cahen, D. (2011) Fundamentals of Materials for Energy and Environmental
2. Sustainability. Cambridge University Press.
3. Klee, G. A. (1991) Conservation of Natural Resources. Prentice Hall Publication.
4. Miller, T. G. (2012) Environmental Science. Wadsworth Publishing Co.
5. Owen, O. S., Chiras, D. D., & Reganold, J. P. (1998) Natural Resource Conservation –Management for Sustainable Future (7^{th} edition). Prentice Hall.
6. Ramade, F. (1984) Ecology of Natural Resources. John Wiley & Sons Ltd.

Skill Enhancement Course:

Course Code: ENVS-SEC-2-P

Course Title: Soil Quality Analysis and Noise Monitoring

Full marks: 35+10 (Internal Assessment) **Credits: 3(P)** **No. of Lectures: 45**

Preamble: This paper aims to provide knowledge about soil sampling techniques, analysis of soil and sediment, understanding of sound quality and noise level monitoring practices for skill development among students.

Unit 1: Soil sampling techniques: collection, processing, and storage; Sample preparation and analysis techniques.

Unit 2: Physicochemical analysis of soil and sediment: pH, Conductivity, Texture, Porosity and Bulk density, Water holding capacity, Moisture content, Hardness, Organic carbon, Nitrate, phosphate, cation exchange capacity, NPK etc.

Unit 3: Measurement of sound quality and noise level, $L_{eq.}$

Unit 4: Field visit.

Suggested Readings:

1. Trivedy, R. K., & Goel, P. K. (1986) Chemical and Biological method for water pollution studies. Environmental publication (Karad, India).
2. Saxena, M. M. (1990) Environmental Analysis: Water, Soil and Air. Edition 2. Publisher, Agro Botanical Pub.
3. Sawyer, C. N. & Mc Carty, P. L. (1978) Chemistry for Environmental Engineering. Mc Graw – Hill International.
4. Hesse, P. R. (2002) A text book of soil chemical analysis – CBS.
5. Jackson, M. L. (2012) Soil chemical analysis - Scientific Publishers.
6. Brandt, A. (2011) Noise and vibration analysis- Wiley.

Semester - III

Major Course:

Course Code: ENVS-M-3
Course Title: Land and Water Resource Management
Full marks: 75 **Credits: 4(L) +2(P) = 06** **No. of Lectures: 75**

Preamble: This paper introduces students to the fundamentals of land and soil degradation, emphasizing the impact of human activities. It explores issues related to water and wastewater management. The course also deals with relevant governmental policies for sustainable management and mitigation.

ENVS-M-3-L **Credits: 4(L)** **Full Marks: 40+10 (Internal Assessment)**

Unit 1: Introduction to Land and Water resource: concepts of- resource values, soil and water health, degradation, conservation and restoration.

Unit 2: Fundamentals of Soil Science: Formation; classification; soil profile; Soil texture; physico-chemical and biological properties; water holding capacity; soil acidity and alkalinity; soil salinity and sodicity; soil organic matter; macro- and micronutrients; Soil resistance and resilience.

Unit 3: Land and Soil Degradation and Management: Nature and Types; causes (landuse changes, deforestation, desertification; habitat loss, biodiversity loss; salinization; erosion; soil moisture loss; nutrient depletion; misuse and overuse of agrochemicals, pollution, mining and mineral extraction, industrial and urban development etc.); biological and physical phenomena in land degradation; indicators; costs of land degradation land use and land cover (LULC) change in major geographic zones and biodiverse regions with particular reference to the Himalaya and the Western Ghats; Strategies for controlling land degradation and soil conservation; Sustainable land use planning and management.

Unit 4: Introduction of Water resource: Sources and types of water and water resources (oceans, rivers, lakes and wetlands and ground water); hydrological cycle; formation and properties of aquifers; water table; physical (temperature, colour, odour, total dissolved solids & total suspended solids), chemical (major inorganic and organic constituents, dissolved gases, DO, COD, BOD, acidity and alkalinity, electrical conductivity, etc), and biological (phytoplankton, phytobenthos, zooplankton, macro-invertebrates and microbes) properties of water.

Unit 5 : Water Resource Issues and Management: Surface and ground water pollution; and depletion – causes and consequences; threats to wetlands and marine ecosystems; strategies for management of water resources; ground water recharge; watershed management; rain water harvesting in urban settings; marine ecosystem and resource management; integrated coastal zone management (ICZM); wetland conservation and management; Ramsar Convention

Unit 6: Wastewater Management: Sources and generation of wastewater; physicochemical and biological properties; treatment (primary, secondary and tertiary). Standards for wastewater discharge; reuse and recycling.

ENVS-M-3-P **Credits: 2(P)** **Full Marks: 20+5 (Internal Assessment)**

Unit 7: Practical

1. Determination of soil organic matter, nutrients (N, P, K), Soil water holding capacity, Soil texture analysis.
2. Wastewater analysis (TSS, TDS, BOD and COD).
3. Field study related to rainwater harvesting / groundwater wells and document preparation.
4. Field visit to wetland and document preparation.
5. Water demand in domestic/ agricultural fields/ industrial areas through preparation of survey sheets followed by documentation.

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, U*K.* *(file:///Users/mkpandit/Do*wnloads/Raven%20et%20al.%202013.%20CB%20Voices%20from%20Tropics%20(2).pdf).
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.
10. Bansil, P. C. (2004) *Water Management in India*. Concept Publishing Company, India.
11. Brebbia, C. A. (2013) *Water Resources Management VII*. WIT Press.
12. CEA. (2011) *Water Resources and Power Maps of India*. Central Board of Irrigation & Power.
13. Grumbine, R. E., & Pandit, M. K. (2013) Threats from India's Himalaya dams. *Science* 339: 36-37.
14. Loucks, D. P., Stedinger, J. R. & Haith, D. A. (1981) *Water Resource Systems Planning and Analysis*. Englewood Cliffs, NJ, Prentice Hall.
15. Mays, L.W. (2006) *Water Resources Sustainability*. The McGraw-Hill Publications.

16. Schward, F. W., & Zhang, H. (2003) *Fundamentals of Groundwater*. John Willey and Sons.

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

18. Vickers, A. (2001) *Handbook of Water Use and Conservation*. Water Plow Press.

Minor Course:

Course Code: ENVS-MI- Course 2
Course Title: Basics of Biodiversity
Full marks: 40+10 (Internal Assessment) **Credits: 3(L) +1(P)=04** **No. of Lectures: 50**

Preamble: This course is aimed at helping students to understand and appreciate various concepts and issues concerning biodiversity and conservation at local, regional and global levels. The course will attempt at encouraging students to appreciate the paradigm "think globally, act locally" for a sustainable common future of humankind.

Unit 1: Levels of organization in living world: Biological hierarchy: from genes to ecosystems; tree of life; organic evolution through geographic time scale; species concept and speciation.

Unit 2: Introduction to Biodiversity: Biodiversity: Concept, Definition, Levels, types (alpha, beta and gamma diversity), patterns; Concept of species richness, frequency, abundance, evenness, diversity; biodiversity hotspots and mega biodiversity countries; India as a mega diversity nation; Importance of biodiversity.

Unit 3: Threats to Biodiversity: Natural and anthropogenic threats to biodiversity; man-wildlife conflicts; consequences of biodiversity loss; IUCN Red List categorization and Red Data book.

Unit 4: Biodiversity Conservation: Concept of conservation and preservation; *In situ* and *Ex situ* conservation strategies; Biodiversity management measures: People Biodiversity Register (PBR); role of local communities and traditional knowledge in conservation. Biodiversity conservation scenario in India; National Biodiversity Action Plan. Biological diversity Act & Rule (2002/ 2004).

Unit 5 Practical:

Biodiversity measurement; Biodiversity richness and diversity indices; IUCN Red List categorization.

Suggested Readings:

1. Gaston, K. J., & Spicer, J. I. (1998) *Biodiversity: An Introduction.* Blackwell Science, London, UK.
2. Krishnamurthy, K. V. (2004) *An Advanced Text Book of Biodiversity - Principles and Practices*. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
3. Jeffries, M. J. (2006) Biodiversity and Conservation. Routledge.
4. Singh, J. S. & Singh, S. P. (1987) Forest vegetation of the Himalaya. *The Botanical Review* 53: 80-192.
5. Singh, J. S., Singh, S. P. & Gupta, S. (2006) *Ecology, Environment and Resource Conservation.* Anamaya Publications, New Delhi.
6. Sodhi, N. S. & Ehrlich, P. R. (Eds). (2010) *Conservation Biology for All*. Oxford University Press.
7. Sodhi, N. S., Gibson, L. & Raven, P. H. (2013) *Conservation Biology: Voices from the Tropics.* Wiley-Blackwell, Oxford, UK.
8. Maity, P. K., & Maity, P. (2011) Biodiversity –Perception, Peril & Preservation. PHI.

Multidisciplinary Course:

Course Code: ENVS-MDC
Course Title: Natural Resource Management
Full marks: 35+10(Internal Assessment) **Credits: 03** **No. of Lectures: 45**

Preamble: This paper aims to provide an idea of the nature of Earth's resources, their generation, extraction, degradation and a critical insight of the major sustainability issues. The students are expected to understand effective natural resource management strategies from this course.

ENVS-MDC-L **Credits: 3(L)** **Full Marks: 35+10(Internal Assessment)**

Unit 1: Introduction to natural resource: Concept and significance; types of natural resources; renewable and non-renewable resources; resource degradation; resource conservation.

Unit 2: Water resources management: Concept**,** world water balance; lakes, dams and reservoirs, coastal and marine water resources; conservation of water resources; integrated water resource management; rainwater harvesting; watershed management, wetland conservation and management.

Unit 3: Soil and land resources management: Concept**,** soil types, soil degradation and soil erosion; integrated strategies for soil conservation and regeneration; land resources: land use pattern and planning.

Unit 4: Mineral resources: Concept and types; environmental effects of extracting and using mineral resources.

Unit 5: Bioresource Management: Concept and categories, management of human and animal resources; biodiversity and its conservation; forest management; wildlife conservation and management.

Unit 6: Forest resources: Concept and types; use and over-exploitation, deforestation; impact of mining, dams on forest, mitigation strategies and tribal people.

Unit 7: Energy resources: Concept, types, conventional and non-conventional, non-renewable and renewable, fossil fuel, nuclear, geothermal, solar, wind, hydro-energy, bioenergy, energy conservation and management.

Unit 8: Practical
Field survey based analysis, exercise, report preparation and interpretation:

- Water audit of college/ industry/ domestic area.
- Energy audit of college/ industry / domestic area.

Suggested Readings:

1. Ginley, D. S. & Cahen, D. (2011) *Fundamentals of Materials for Energy and Environmental Sustainability. Cambridge University Press.*
2. Klee, G. A. (1991) *Conservation of Natural Resources. Prentice Hall Publication.*
3. Miller, T. G. (*2012*) *Environmental Science. Wadsworth Publishing Co.*
4. Owen, O. S., Chiras, D. D., & Reganold, J. P. (*1998*) *Natural Resource Conservation –Management for Sustainable Future (7th edition). Prentice Hall.*
5. Ramade, F. (1984) *Ecology of Natural Resources. John Wiley & Sons Ltd.*

Skill Enhancement Course:

Course Code: ENVS-SEC-3

Course Title: Analytical Techniques in Environmental Monitoring

Full marks: 35+10 (Internal Assessment) **Credits: 3(P)** **No. of Lectures: 45**

Preamble: This paper introduces the students to various instrumental techniques for environmental analysis along with their principle and applications. An attempt will be made to have a compressive idea about various sampling techniques along with sample preparation. The students will also be introduced to the concept of radioactivity detection techniques and their applications.

Unit 1: Introduction: Instrumental methods for environmental analysis.

Unit 2: Principle and Application: Titrimetry, gravimetry, potentiometry, nephelometry, turbidimetry, FTIR, spectrophotometry, spectro-fluorimetry, flame photometry, atomic absorption spectrometry (AAS), inductively coupled plasma mass spectrometry (ICPMS), chromatography, HPLC, gel electrophoresis, gas chromatography (GC). Microscopy, Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), X-ray fluorescence (XRF), X-ray diffraction (XRD).

Unit 3: Environmental Sampling: Sampling methods, sample preservation, storage and processing of air, water and soil samples; Techniques for measurement of noise level; Techniques for detecting radioactivity.

Unit 4: Field survey-based analysis, exercise and interpretation and document preparation.

Suggested Readings:

1. Instrumental methods of chemical analysis - Chatwal G. R. & S. K. Anand, 2005, Himalayan Pub. House, Mumbai.
2. Standard Methods for the Examination of water & Waste Water – 21st Edition 2005, APHA.

Semester - IV

Major Course:

Course Code: ENVS-M-4

Course Title: Environmental Chemistry and Environmental Physics

Full marks: 75 Credits: 4(L) +2(P) = 06 No. of Lectures: 75

Preamble: This paper aims to build conceptual understanding of students by exposing them to the basic principles behind various environmental processes. The paper has been divided into two sections, with the view to introduce students to the concepts of chemistry and physics associated with particle movement, chemical processes and pollutant chemistry.

ENVS-M-4-L Credits: 4(L) Full Marks: 40+10 (Internal Assessment)

Unit 1: Fundamentals of Environmental Chemistry: Atomic structure, electronic configuration, periodic properties of elements (ionization potential, electron affinity and electronegativity), types of chemical bonds (ionic, covalent, coordinate and hydrogen bonds), concepts of mole, molarity and normality; quantitative volumetric analysis.

Thermodynamic system; types of chemical & reactions products; solutes and solvents; redox reactions, concepts of pH equation, electrochemical cells.

Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, organic functional groups, polarity of the functional groups, xenobiotic compounds (e.g. pesticides and dyes), synthetic polymers.

Unit 2: Chemistry of Environmental Pollutants**:** Solubility of pollutants (hydrophilic and lipophilic pollutants), transfer of pollutants within different mediums, role of chelating agents in transferring pollutants, concept of biotransformation and bioaccumulation, organometallic compounds, acid mine drainage.

Unit 3: Atmospheric Chemistry: Composition of atmosphere; photochemical reactions in atmosphere; smog formation, types of smog (sulphur smog and photochemical smog), aerosols; chemistry of acid rain, case studies; reactions of NO_2 and SO_2; free radicals and ozone layer depletion, role of CFCs in ozone depletion.

Unit 4: Water Chemistry: Properties of water: Physical, chemical and biological; chemicals in water (elemental, ionic and compound forms), concept of water quality & water quality monitoring.

Unit 5: Soil Chemistry: Properties of soil; Soil composition; soil quality; 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; soil quality monitoring.

Unit 6: Fundamentals of Environmental Physics: Basic concepts of light and matter; quantum mechanics (relation between energy, wavelength and frequency), black body radiation, Kirchhoff's law, Boltzmann equation, 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 scattering. Concepts of radioactivity, radioactive decay and half-life of pollutants.

Basic concepts of pressure, force, work and energy; types of forces and their relation (pressure gradient, viscous, Cariolis, 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.

Unit 7: Movement of Pollutants in Environment: Diffusion and dispersion, point and area source pollutants, pollutant dispersal; Gaussian plume model, mixing heights, hydraulic potential, Darcy's equation, types of flow, turbulence.

ENVS-M-4-P **Credits: 2(P)** **Full Marks: 20+5 (Internal Assessment)**

Unit 8: Practical

- Stock solution and standard curve preparations (Nitrate, phosphate, iron, etc.).
- Measurement of physicochemical parameters of soil and water samples (pH, conductivity, hardness, alkalinity, etc.), soil organic matter.
- Field visit to renewable / non-renewable energy units.

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.

Major Course:

Course Code: ENVS-M-5

Course Title: Environmental Toxicology and Health

Full marks: 75 **Credits: 4(L) +2(P) = 06** **No. of Lectures: 75**

Preamble: This paper deals with basic concepts of toxicology, categories of toxicants, their sources, action and effects. It will also consider the preventive and curative measures to reverse toxic impact and maintenance of environmental health.

ENVS-M-5-L **Credits: 4(L)** **Full Marks: 40+10 (Internal Assessment)**

Unit 1: Introduction to Environmental Toxicology: Concepts of toxicants and xenobiotics: dose response relationship; EC_{50}, LC_{50}, LD_{50} and TD_{50}; bioavailability, bioaccumulation and biomagnifications; types of toxicants and their effects in living systems; biomonitoring of chemical and biological factors influencing toxicity.

Unit 2: Toxicity of Heavy Metals and Metalloids: Sources, distribution; toxic effects of heavy metals (lead, cadmium, chromium, mercury, etc.) and metalloids (arsenic and selenium); antidotal measures, case studies.

Unit 3: Pesticide Toxicity: Pesticide classification, nature, exposure routes, modes of action, biological health effect; concept of pesticide resistance.

Unit 4: Emerging Contaminants: Concept, types and modes of action, environmental threats and health hazards, micropastics, nanoparticles, endocrine disrupting substances, environmental carcinogens.

Unit 5: Environmental Epidemiology: Sources and impact on human life, present pollution and impact status in West Bengal; remedial measures; epidemiological studies with respect to arsenicosis, fluorosis and vector borne diseases.

Unit 6: Environmental Health: Basic concepts, physiological responses of human to relevant stress; industrial toxicology and occupational health hazards and toxic manifestations.

Unit 7: 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.

Unit 8: Environmental Safety: Safety awareness, annual toll of industrial accidents in India, need for safety, legal, humanitarian factors impending safety, safety audit.

Health concern for workers of textile, dye, bidi making and brick kiln factory/industry.

Unit 9: Definition of accidents: injury, types of accidents, causes and remedial measures, injury records, prevention, modes of prevention, physiological factors.

Unit 10: Assessment of training needs, design and developments of training program.

ENVS-M-4-P **Credits: 2(P)** **Full Marks: 20+5(Internal Assessment)**

Unit 11: Practical

- Toxicity bioassay through germination (LD_{50}).
- Toxicity bioassay through microbial test.
- Epidemiological study.

Unit 12: Demonstrative Exercise

1. Industry/ factory visit to assess the safety measures adopted for the workers in textile, dye, bidi making and brick kiln factory/ industry and fire.
2. Occupational health study of small scale industry workers through survey and documentation.

Suggested Readings:

1. Klassen, C. (2017) Cassarett & Doull's Toxicology: The Basic Science of Poisons. McGraw-Hill.
2. Newman, M. C., & W. H. Clements. (2008) Ecotoxicology- A comprehensive treatment, CRC press.
3. Wright, D. A., & P. Welbourn, (2002) Environmental toxicology, Cambridge University press.
4. Willium P. L., & Burson, J. L. (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, S. E. (2016) Ecotoxicology and Chemistry Applications in Environmental Management. CRC Press.
8. Lu, F. C., & Kacew, S. (2002) Lu's Basic Toxicology. CRC Press.
9. Santra, S. C. Environmental Science. New Central Book Agency.
10. Reese, C. D. (2015) *Occupational health and safety management: a practical approach*. CRC press.
11. Friis, R. H. (2015) *Occupational health and safety for the 21st century*. Jones & Bartlett Publishers.
12. Erickson, P. A. (1996) *Practical guide to occupational health and safety*. Elsevier.
13. Greenberg, M. I., 2003. *Occupational, industrial, and environmental toxicology*. Elsevier Health Sciences.

Minor Course:

Course Code: ENVS-MI- Course 2

Course Title: Basics of Biodiversity

Full marks: 40+10 (Internal Assessment) **Credits: 3(L) +1(P)=04** **No. of Lectures: 50**

Preamble: This course is aimed at helping students to understand and appreciate various concepts and issues concerning biodiversity and conservation at local, regional and global levels. The course will attempt at encouraging students to appreciate the paradigm "think globally, act locally" for a sustainable common future of humankind.

Unit 1: Levels of organization in living world: Biological hierarchy: from genes to ecosystems; tree of life; organic evolution through geographic time scale; species concept and speciation.

Unit 2: Introduction to Biodiversity: Biodiversity: Concept, Definition, Levels, types (alpha, beta and gamma diversity), patterns; Concept of species richness, frequency, abundance, evenness, diversity; biodiversity hotspots and mega biodiversity countries; India as a mega diversity nation; Importance of biodiversity.

Unit 3: Threats to Biodiversity: Natural and anthropogenic threats to biodiversity; man-wildlife conflicts; consequences of biodiversity loss; IUCN Red List categorization and Red Data book.

Unit 4: Biodiversity Conservation: Concept of conservation and preservation; *In situ* and *Ex situ* conservation strategies; Biodiversity management measures: People Biodiversity Register (PBR); role of local communities and traditional knowledge in conservation. Biodiversity conservation scenario in India; National Biodiversity Action Plan. Biological diversity Act & Rule (2002/ 2004).

Unit 5 Practical:

Biodiversity measurement; Biodiversity richness and diversity indices; IUCN Red List categorization.

Suggested Readings:

1. Gaston, K. J., & Spicer, J. I. (1998) *Biodiversity: An Introduction.* Blackwell Science, London, UK.
2. Krishnamurthy, K. V. (2004) *An Advanced Text Book of Biodiversity - Principles and Practices*. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
3. Jeffries, M. J. (2006) Biodiversity and Conservation. Routledge.
4. Singh, J. S., & Singh, S. P. (1987) Forest vegetation of the Himalaya. *The Botanical Review* 53: 80-192.
5. Singh, J. S., Singh, S. P., & Gupta, S. (2006) *Ecology, Environment and Resource Conservation.* Anamaya Publications, New Delhi.
6. Sodhi, N. S., & Ehrlich, P. R. (Eds). (2010) *Conservation Biology for All*. Oxford University Press.
7. Sodhi, N. S., Gibson, L., & Raven, P. H. (2013) *Conservation Biology: Voices from the Tropics.* Wiley-Blackwell, Oxford, UK.
8. Maity, P. K., & Maity, P. (2011) Biodiversity –Perception, Peril & Preservation. PHI.

Semester V

Major Course:

Course Code: ENVS-M-6
Course Title: Environmental Geoscience
Full marks: 75 Credits: 4(L) +2(P) = 06 No. of Lectures: 75

Preamble: The paper will introduce students to the basic structure and composition of the earth and will explore various surface processes and their impact and role in living systems. It will also deal with the interactive processes in the inner as well as outer Earth's surface.

ENVS-M-6-L Credits: 4(L) Full Marks: 40+10

Unit 1: Genesis of the Earth: Formation and composition of core, mantle, crust, atmosphere and hydrosphere; chemical composition of earth; geological time scale and major changes on earth's surface; holocene and the emergence of humans and anthropogenic, changes.

Unit 2: Earth System Processes: Movement of lithosphere plates; mantle convection, major plates and boundaries; plate tectonics, earthquakes; volcanic activities; orogeny; continental drift, Pangaea and present-day continents continental collision and mountain formation with specific example of the Himalaya.

Unit 3: Rocks and Minerals: Minerals and important rock forming minerals; rock cycle: lithification and metamorphism; rock laws; rock structure, types (igneous, sedimentary and metamorphic); weathering: physical, biogeochemical processes; erosion: factors, agents and processes.

Unit 4: Earth Surface Processes: Evolution of earth's atmosphere, physical and optical properties, circulation, interfacial (atmosphere–ocean, atmosphere–land and ocean–land) processes, fluvial and glacial processes, glacier dynamics, erosional and depositional processes, coastal processes.

Unit 5: Mountain Systems and Geomorphological Importance:: Formation of Peninsular- 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.

ENVS-M-6-P Credits: 2(P) Full Marks: 20+5

Unit 6: Practical

- Identification of geological specimens: rocks and minerals.
- Microscopic studies of thin section of rocks and minerals.
- Interpretation of Topographical sheets.

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.

Major Course:

Course Code: ENVS-M-6

Course Title: Biodiversity Management

Full marks: 75 **Credits: 4(L) +2(P) = 06** **No. of Lectures: 75**

Preamble:

This course is aimed to understand various concepts and issues related to biodiversity and its conservation at local, regional and global levels. The course will attempt at encouraging students to appreciate the paradigm "think globally, act locally" for a sustainable common future of humankind.

ENVS-M-6-L **Credits: 4(L)** **Full Marks: 40+10**

Unit 1: Levels of organization in living world: From genes to ecosystems; tree of life; history of character transformation; organic evolution through geographic time scale; species concept; concept and types of speciation.

Unit 2: Introduction to Biodiversity: Definition, levels, patterns (spatial and temporal) and types (alpha, beta and gamma). Biodiversity values and ecosystem services; biodiversity hotspots and megabiodiversity countries.

Unit 3: Biodiversity Estimation: Qualitative and quantitative methods: scoring, habitat assessment, richness, density, frequency, abundance, evenness, diversity, biomass estimation; community diversity estimation: alpha, beta and gamma diversity.

Unit 4: Threats to Biodiversity: Biodiversity loss and extinction; natural and anthropogenic drivers and threats; man-wildlife conflicts; consequences of biodiversity loss.

Unit 5: Biodiversity Conservation: Conservation vs. preservation; conservation strategies; In-situ conservation (biosphere reserves, national parks, wildlife sanctuaries) and ex-situ (botanical gardens, zoological gardens, gene banks, seed banks, pollen culture, tissue culture and DNA banks) approaches); conservation role of local communities and traditional knowledge in conservation; IUCN Red List categorization and; Red Data book; ecological restoration; afforestation; social forestry; agro-forestry; joint forest management.

Unit 6: Biodiversity in India: India as a mega diversity nation; phytogeographic and zoogeographic zones status of protected areas and biosphere reserves; National Biodiversity Action Plan. Biological Diversity Act (2002) & rules (2004).

ENVS-M-6-P **Credits: 2(P)** **Full Marks: 20+5**

Unit 8: Practical

1. Estimation of Biodiversity and indices: Frequency, Density, Abundance, Relative abundance, Shannon Weiner's index, Simpson's index of diversity, evenness index.

2. Categorization of species as per IUCN Red List.

3. Field visit in any geographical region (Forest/ Hills/ Coastal area/ Mangroves/ Wetlands/ Ecorestoration site) and assessment of biodiversity parameters & indices.

4. Preparation and submission Field Report and Laboratory Note Book.

Suggested Readings

1. Gaston, K. J., & Spicer, J. I. (1998) *Biodiversity: An Introduction.* Blackwell Science, London, UK.
2. Krishnamurthy, K. V. (2004) *An Advanced Text Book of Biodiversity - Principles and Practices*. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
3. Jeffries, M. J. (2006) Biodiversity and Conservation. Routledge.
4. Singh, J. S. & Singh, S. P. (1987) Forest vegetation of the Himalaya. *The Botanical Review* 53: 80-192.
5. Singh, J. S., Singh, S. P., & Gupta, S. (2006) *Ecology, Environment and Resource Conservation.* Anamaya Publications, New Delhi.
6. Sodhi, N. S., & Ehrlich, P. R. (Eds). (2010) *Conservation Biology for All*. Oxford University Press.
7. Sodhi, N. S., Gibson, L., & Raven, P. H. (2013) *Conservation Biology: Voices from the Tropics.* Wiley-Blackwell, Oxford, UK.
8. Maity, P. K., & Maity, P. (2011) Biodiversity –Perception, Peril & Preservation. PHI.

Minor Course:

Course Code: ENVS-MI-Course 3

Course Title: Occupational Health and Environmental Safety

Full marks: 40+10 (Internal Assessment) **Credits: 3(L) +1(P)=04** **No. of Lectures: 50**

Preamble: This course introduces the students to acquire knowledge about various occupational diseases and safety measures with particular attention to accident prevention in work place, safety education and training.

Unit 1: Introduction: Concept of occupational health and diseases: Occupation related diseases, mode, effects, risk, diagnosis and preventive measures. Case studies: textile, dye, bidi making and brick kiln factory/industry.

Unit 2: Occupational health hazards and devices: Evaluation of injuries; Medical services in industrial establishment, its function, action programs for work related diseases at the national level. Personal Protective Equipment (PPE): types, purpose, maintenance Respiratory and non-respiratory personal protective devices; requirements under factory acts and rules.

Unit 3: Introduction to Environmental Safety: concept; safety awareness; industrial accidents in India, legal and, humanitarian factors; safety audit.

Unit 4: Occupational Accidents and Prevention: accident and injury – definition, types, causes and remedial measures; principles and modes of accident prevention.

Unit 5: Safety Education and Training: Concept; Assessment of training needs; design and development of training programmes.

Unit 6: Demonstrative Exercise

1. Industry/ factory visit to assess the safety measures adopted for the workers in textile, dye, bidi making and brick kiln factory/ industry and fire incidence.
2. Occupational health study of small scale industry workers through survey and documentation.

Suggested Readings

1. Reese, C. D. (2015) *Occupational health and safety management: a practical approach*. CRC press.
2. Friis, R. H. (2015) *Occupational health and safety for the 21st century*. Jones & Bartlett Publishers.
3. Erickson, P. A. (1996) *Practical guide to occupational health and safety*. Elsevier.
4. Greenberg, M. I., 2003. *Occupational, industrial, and environmental toxicology*. Elsevier Health Sciences.

Semester VI

Major Course:

Course Code: ENVS-M-8

Course Title: Energy and Environment

Full marks: 75 **Credits: 4(L) +2(P) = 06** **No. of Lectures: 75**

Preamble: This course aims to provide students with a broad understanding of the existing energy resources, issues related to energy and the environment, challenges and possible paths to sustainable energy generation and use.

ENVS-M-8-L **Credits: 4(L)** **Full Marks: 40+10**

Unit 1: Introduction to Energy Resources: Energy- forms and importance; Global energy resources; types; renewable and non-renewable resources; conventional and non-conventional energy resources; Fossil fuels (classification, composition, physicochemical characteristics and energy content); distribution and availability of energy resources; sources and sinks of energy.

Unit 2: Global Energy Demand: Historical and current perspective; energy demand and use in different sectors (domestic, industrial, agriculture and transportation); energy generation and utilization in rural and urban environments; changes in demand in major world economies; energy security, energy subsidies; environmental costs.

Unit 3: Energy, Environment and Society: Energy production as driver of environmental change; nature, scope and analysis of local and global impacts of energy use on the environment; energy over-consumption and its impact on the environment, economy, and global change; social inequalities related to energy production, distribution, and use; energy conservation.

Unit 4: Energy Use and Conservation, Current Scenario and Future Trends: Current and future energy use patterns in the world and in India; evolution of energy use over time; alternative sources as energy – Principle and generation of solar energy (solar collectors, photo-voltaic modules, solar ponds); wind energy; geothermal energy; tidal energy; OTEC; nuclear energy; energy from biomass; biofuels; need for energy efficiency; energy conservation and sustainability; action strategies for sustainable energy management from a future perspective.

ENVS-M-8-P **Credits: 2(P)** **Full Marks: 20+5**

Unit 5: Practical

1. Calculation of energy efficiency from a given data.

2. Prepare worksheet of energy conservation based on site visit (*viz.* school/ office/ hospital/ municipality etc.), data analysis and interpretation.

3. Preparation of checklist for energy saving measures.

4. Preparation of energy audit of a domestic unit.

5. Preparation and submission of Field Report and Laboratory Note Book.

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. Earth Scan.

Major Course:

Course Code: ENVS-M-9

Course Title: Environmental Statistics and Modelling

Full marks: 75 **Credits: 4(L) +2(P) = 06** **No. of Lectures: 75**

Preamble: This paper introduces fundamental concepts in Environmental Statistics, encompassing data collection, sampling methods, and presentation techniques. It explores probability distributions, hypothesis testing, non-parametric statistics, and correlation/regression analyses, culminating in the application of mathematical modeling to ecological systems and population dynamics.

ENVS-M-9-L **Credits: 4(L)** **Full Marks: 40+10**

Unit 1: Data collection and sampling: Variables, Population and sample; Sampling methods; measurement of central tendency; parameters and statistics; Sampling error.

Unit 2: Presentation and location of data: Frequency distribution, Pie diagram, Bar diagram, Polygon, Histogram, Stem and leaf plot, Venn diagram, Measures of dispersion, Deviation, Variance.

Unit 3: Probability Distribution: Normal distribution, skewness, kurtosis, recognition of normal distribution, 't' distribution.

Unit 4: Testing of Hypothesis: Null hypothesis, level of significance, alternative hypothesis, one-tail and two-tail tests.

Unit 5: Non-parametric Statistics: Chi square test, Wilcoxon signed rank test, U test.

Unit 6: Correlation and regression**:** Product moment correlation, Spearman's rank correlation, simple regression analysis.

Unit 7: Mathematical Ecology: Classification of mathematical modelling, process of modeling, population growth model, population interactions, Lotka and Voltera prey predator system, Leslie's matrix model, energy flow in ecosystems.

ENVS-M-9-P **Credit: 2(L)** **Full Marks: 20+5**

Unit 13: Practical

1. Graphical presentation of data.
2. Frequency distribution of data.
3. Statistical fluctuations of data.
4. Regression analysis of data.
5. Use of statistical softwares.

Suggested Readings

1. Leach, C. Introduction to statistics – John Wiley New York, USA.
2. Rosenblatt, J., & and Bell, S. Mathematical Analysis for modeling, CRC Press London, UK.
3. Piegroschand, W. E., & Bailer, J. A. Statistics for Environmental biology and Toxicology, Chapman and Hall London, UK.
4. Chase, W., & Bown, F. General statistics, John Wiley New York, USA.

Major Course:

Course Code: ENVS-M-10
Course Title: Environmental Legislation and Policy
Full marks: 75 Credits: 4(L) +2(P) = 06 No. of Lectures: 75

Preamble: This paper introduces students to the legal structure of India and fundamentals of environmental legislation and policy making. Each unit will help the students to develop basic concepts of environmental legislation and policy making in India and around the world.

ENVS-M-10-L Credits: 4(L) Full Marks: 40+10

Unit 1: Introduction: Constitution of India; fundamental rights; fundamental duties; Union of India; union list, state list, concurrent list; legislature; state assemblies; judiciary; panchayats and municipal bodies.

Unit 2: History of environmental legislation and policy: Ancient period: worship of water, air, trees; Mauryan period: Kautilya's Arthashastra, Yajnavalkya smriti and Charaksamhita; Medieval period: forests as woodland and hunting resources during Mughal reign; British India: Indian Penal Code 1860, Forest Act 1865, Fisheries Act 1897; Independent India: Van Mahotsava 1950, National Forest Policy 1952.

Unit 3: Environmental legislation: Legal definitions (environmental pollution, natural resource, biodiversity, forest, sustainable development); Article 48A (The protection and improvement of environment and safeguarding of forests and wildlife); Article 51 A related to fundamental duties.

Unit 4: Legislative instruments: The Indian Forest Act, 1927; The Wildlife (Protection) Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; The Forests (Conservation) Act, 1980; The Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986; The Public Liability Insurance Act 1991; Noise Pollution (Regulation and Control) Rules, 2000; The Biological Diversity Act, 2002; The Schedule Tribes and other Traditional Dwellers (Recognition of Forests Rights) Act, 2006; The National Green Tribunal Act, 2010; scheme and labeling of environment friendly products, Ecomarks.

Unit 5: Government institutions: Role of Ministry of Environment, Forests & Climate Change in environmental law and policy making; role of central and state pollution control boards in environmental law and policy making.

Unit 6: Legal case studies: National Green Tribunal: Aditya N. Prasad vs. Union of India & Others; Ganga Tanneries Case: M.C. Mehta vs. Union of India 1988; environmental education case: M.C. Mehta vs. Union of India, WP 860/1991.

Unit 7: International laws and policy: Ramsar Convention, 1971; Stockholm Conference, 1972; United Nations Conference on Environment and Development, 1992; Rio Declaration (Agenda 21), 1992; Montreal Protocol, 1987; Kyoto Protocol, 1997; Copenhagen and Paris summits.

ENVS-M-10-P **Credits: 2(P)** **Full Marks: 20+5**

Unit 8: Practical

- Field visit for assessment of environmental policy adoption at local government level (Panchayat/ Municipality) and document preparation.
- Visit to industry for assessment of environmental safety policy adoption and document preparation.
- Survey on perception of environmental laws in communities/ societies and document preparation.

Suggested Readings

1. Agarwal, V. K. (2005) Environmental Laws in India: Challenges for Enforcement. *Bulletin of the National Institute of Ecology* 15: 227-238.
2. Divan, S. & Rosencranz, A. (2002) *Environmental Law and Policy in India: Cases, Materialsand Statues* (2nd edition). Oxford University Press.
3. Gupta, K. R. (2006) *Environmental Legislation in India*. Atlantic Publishers and Distributors.
4. Shastri, S. C. (2015) Environmental Law. Eastern Book Company.
5. Leelakrishnan, P. (2008) *Environmental Law in India* (3rd edition). Lexis Nexis India.
6. Venkat, A. (2011) *Environmental Law and Policy*. PHI Learning Private Ltd.