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)	6	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)	4	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)	3	10	35	45
ENVS-VA	**ENVIRONMENTAL EDUCATION**	Value Added Course	4 (L)	4	10	40	50
Total Credits/ Courses= 20/5			**20**	**20**	**55**	**210**	**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)	6	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)	4	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)	3	10	35	45
ENVS-SI-1	**SUMMER INTERNSHIP** (Additional for Certificate/Diploma Course)	Summer Internship	4	4			
Total Credits/ Courses= 20/5			**20**	**20**	**55**	**210**	**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	**WATER RESOURCES AND WASTEWATER MANAGEMENT**	Major Course	4(L) + 2(P)	6	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)	4	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)	3	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**	**20**	**55**	**210**	**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)	6	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)	6	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)	4	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	4	4			
Total Credits/ Courses= 20/4			**20**	**20**	**50**	**200**	**250**

Summary of Courses
(Semester I- Semester IV)

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:** Water Resources and Wastewater 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 - 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 (dB(A), 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 J. Jeffrey 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, Charles 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 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 (7^{th} 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, analysis of water and air quality 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. and 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. and 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. Trivedi, P. K. and Goel, P. K. (1984). Chemical and Biological Methods of Water Pollution Studies. Environmental Publication.
7. Zhang, C. (2007). Fundamentals of environmental sampling and analysis. John Wiley & Sons.
8. 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., and Common, M. (2003) Natural Resource and Environmental Economics. Pearson Education.
4. Chiras, D. D and 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 and Anthony D. (2015). Renewable Energy Sources, 3rd Edition, Weir Publisher.
6. William P.Cunningham and Mary A. (2015) Cunningham Environmental Science: A Global Concern, Publisher (Mc-Graw Hill, USA)
7. Gilbert M. Masters and 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, Charles 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, Shonil (Editor) (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, Louis (2021) Introduction to Environmental Management, 2nd Edition. CRC Press.
17. Kanchi Kohli and Manju Menon (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. Vehicular pollution and control strategies.

Unit 3: 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.

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Unit 4: Soil pollution: Causes of soil pollution and degradation; effect of soil pollution on plants, animals and human health; control strategies.

Unit 5: Noise pollution: sources; frequency, intensity and permissible ambient noise levels; effect on communication, impacts on life forms and humans - working efficiency, physical and mental health; control measures.

Unit 6: Radioactive: Radioactive material and sources of radioactive pollution; effect of radiation on human health (somatic and genetic effects).

Unit 7: Marine pollution: Marine resources and their importance; sources of marine pollution; oil spill and its effects; coral reefs and their demise; coastal area management; existing challenges and management techniques (planning, construction, environmental monitoring of coastal zones), London convention on the prevention of marine pollution.

Unit 8: 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 9: 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. and 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. and 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 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 (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 (dB(A), 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 J. Jeffrey 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, Charles 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-1-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. and 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. and Mc Carty, P. L. (1978). Chemistry for Environmental Engineering. Mc Graw – Hill International.
4. A text book of soil chemical analysis- P. R. Hesse CBS (2002).
5. Soil chemical analysis- M. L. Jackson- Scientific Publishers (2012).
6. Noise and vibration analysis- Anders Brandt (2011) Wiley.

Semester - III

Major Course:

Course Code: ENVS-M-3

Course Title: Water Resources and Wastewater Management

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

Preamble: Every human activity ends up in the generation of unwanted waste product. This paper throws light on the current scenario of waste and waste water generation, problems in handling and management. It also deals with the different governmental policies for proper management in order to minimize their effect on environment.

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

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

Unit 2: Properties of water - Physical: temperature, colour, odour, total dissolved solids and total suspended solids; Chemical: major inorganic and organic constituents, dissolved gases, DO, COD, BOD, acidity and alkalinity, electrical conductivity, sodium adsorption ratio; Biological: phytoplankton, phytobenthos, zooplankton, macro-invertebrates and microbes.

Unit 3: Surface and subsurface water: Introduction to surface and ground water; surface and ground water pollution; water table; vertical distribution of water; formation and properties of aquifers; techniques for ground water recharge; river structure and patterns; watershed and drainage basins; importance of watershed and watershed management; rain water harvesting in urban settings.

Unit 4: Wetlands and their management: Definition of a wetland; types of wetlands (fresh water and marine); ecological significance of wetlands; threats to wetlands; wetland conservation and management; Ramsar Convention (1971); major wetlands of India.

Unit 5: Marine resource management: Marine resources; commercial use of marine resources; threats to marine ecosystems and resources; marine ecosystem and resource management (planning approach, construction techniques and monitoring of coastal zones).

Unit 6: Water resource in India: Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources; water quality standards in India; hot spots of surface water; role of state in water resource management.

Unit 7: Wastewater treatment: Sources and generation of wastewater; physicochemical and biological properties; primary, secondary and advanced treatment strategies (domestic/municipal and industrial wastewater treatment). Standards for wastewater discharge; reuse and recycling.

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

Unit 8: Practical

- Field study related to rainwater harvesting / groundwater wells and document preparation.
- Field visit to wetland and document preparation.
- Water demand in domestic/ agricultural fields/ industrial areas through preparation of survey sheets followed by documentation.

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.

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. and 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-1-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-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. and 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), mole concept, 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, concept of radioactivity, radioactive decay and half-life of pollutants, 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 Mia scattering.

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} and LD_{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.

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

Unit 7: Practical

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

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.

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