CURRICULUM STRUCTURE OF

MASTER OF SCIENCE (2 Year 4 Semester) in ENVIRONMENTAL SCIENCES

(Applicable from the academic session 2021-22)

Maulana Abul Kalam Azad University of Technology,
West Bengal

(Formerly West Bengal University of Technology)

Haringhata-741249, Nadia, West Bengal, INDIA

Overview of the Program:

An exciting 2 Year (4 semester) Post graduate degree in Environmental Science combines the range of subjects including Systems Perspectives and Holism in Environment, Atmospheric Processes and Climate Cognition, Geo-Science and Environment, Energy & Environment, Forestry, Wildlife Conservation and Ecotourism etc. focuses on applied science and technology to the biggest environmental challenge of today and future. The aim of this course is to explore the sustainable solution to environmental problem and to offer a rewarding career in benefits involving energy management and conservation. There is ample scope of field work where a student can collect and analyse the data using GIS, Remote Sensing tools.

Program Outcome:

A student will be able to,

PO 1: Comprehend advanced principles and concepts of Environmental Science and different aspects of Environmental Concerns.
PO 2: Explore the relationship between natural and manmade systems.
PO 3: Learn data generation, interpretation and report writing skills
PO 4: Acquire sound digital skills in the field of Environment.
PO 5: Frame Environmental impact assessment and conservation guidelines and guiding towards sustainable development of green environment.
PO 6: Comprehend entrepreneurial prospects and future job opportunities.
PO 7: Offer Consultation on Environmental Legislation, Economics and Audit.
PO 8: Contribute significantly on innovative and modern R&D activities.

ELIGIBILITY REQUIREMENTS

Candidates who have passed B.Sc. and B.Voc. shall be considered eligible for admission to M.Sc. Course in Environmental Science.

General Guidelines

1. There shall be four semesters two in each year with total of 106 credits.
2. There shall be 18 core courses of theory papers with total of 54 credits.
   Lab work based on theory papers will have total 16 credits.
3. In the semester III, students will select two major elective (CBCC A & CBCC B) courses each out of six offered courses of total 6 credits.
4. There shall be two minor elective courses based on only theory papers of total 4 credits.

5. There shall be five sessional papers including industrial training, one mini & two major projects and grand viva voce having total 26 credits.

COURSE STRUCTURE

Sl. No.	Category	Subject Code	Subject Name	Total Number of Contact Hours			Credits
				L	T	P	
SEMESTER -I							
1	Core Material I	MENVS 101	Systems Perspectives and Holism in Environment	3	0	0	3
2	Core Material II	MENVS 102	Evolution of Earth-Environment Systems	3	0	0	3
3	Core Material III	MENVS 103	Atmospheric Processes and Climate Cognition	3	0	0	3
4	Core Material IV	MENVS 104	Environmental Geoscience	3	0	0	3
5	Core Material V	MENVS 105	Advanced Environmental Chemistry	3	0	0	3
6	Core Material VI	MENVS 106	Energy & Environment	3	0	0	3
7	Audit Course	AC107 A/B/C/D/E/ F	Audit Course I	0	0	0	0
			Total Theoretical Credit	18	0	0	18
Practical							
8	Laboratory I	MENVS 191	Practical Applications of Environmental Geoscience	0	1	3	4
9	Laboratory II	MENVS 192	Analytical and Instrumentation Techniques on Energy & Environment	0	1	3	4
Sessional							
10	Obligatory Course Program	MENVS 181	Field based study on Environmental Sustainability, Data Collection & Documentation	0	1	3	4
			Total Practical and Sessional Credit	1	3	8	12
			Total Semester I	19	3	8	30

Sl. No.	Category	Subject Code	Subject Name	Total Number of Contact Hours			Credits
				L	T	P	
SEMESTER -II							
1	Core Material VII	MENVS 201	Ecosystems and Challenging Ecological Realms	3	0	0	3
2	Core Material VIII	MENVS 202	Forestry, Wildlife Conservation and Ecotourism	3	0	0	3
3	Core Material IX	MENVS 203	Hydrology & Water Resources Management	3	0	0	3
4	Core Material X	MENVS 204	Environmental Risks, Vulnerability & Sustainability	3	0	0	3
5	Core Material XI	MENVS 205	Environmental Engineering and Pollution Control Technology	2	1	0	3
6	Minor Elective	MENVS 206	Natural Resources Management & Sustainability	2	0	0	2
7	Audit Course	AC 207 A/B/C/D/E/F	Audit Course II	0	0	0	0
			Total Theoretical Credit	16	1	0	17
Practical							
7	Laboratory I	MENVS 291	Pollution Assessment	0	1	3	4
Sessional							
8	Obligatory Course Programme	MENVS 281	Industrial Training at Chemical, Metallurgical, Ceramic, Water Treatment Plant & Submission of Report	1	1	2	4
9	Mini Project Work	MENVS 282	Mini Project on Pollution Assessment and Control with Seminar Presentation	0	1	1	2
			Total Practical and Sessional Credit	1	3	6	10
			Total Semester II	17	4	6	27

Sl. No.	Category	Subject Code	Subject Name	Total Number of Contact Hours			Credits
				L	T	P	
SEMESTER -III							
1	Core Material I	MENVS 301	Statistics & Environmental Modelling	3	0	0	3
2	Core Material II	MENVS 302	Remote Sensing and Geographical Information System	3	0	0	3
3	Core Material III	MENVS 303	Disaster Management	3	0	0	3
4	Elective A	MENVS 304A	Choice Based Credit Course-A	4	0	0	4
5	Elective B	MENVS 305B	Choice Based Credit Course-B	4	0	0	4
6	Minor Elective	MENVS 306	Ecological Restoration	2	0	0	2
			Total Theoretical Credit	19	0	0	19
Practical							
Sessional							
5	Major Project Work I	MENVS 381	RS-GIS and Environmental Systems Modelling	0	2	6	8
			Total Sessional Credit	0	0	8	8
			Total Semester III	19	0	6	27

Sl. No.	Category	Subject Code	Subject Name	Total Number of Contact Hours			Credits
				L	T	P	
SEMESTER -IV							
1	Core Material I	MENVS 401	Environmental Biotechnology, Eco-Toxicology and Bioremediation	3	0	0	3
2	Core Material II	MENVS 402	Environmental Legislation & Impact Assessment	3	0	0	3
3	Core Material III	MENVS 403	Environmental Economics & Audit	3	0	0	3
4	Core Material IV	MENVS 404	Wastes & Waste Management	3	0	0	3
			Total Theoretical Credit	12	0	0	12
Sessional							
5	Major Project Work II	MENVS 481	Environmental Research Project & Dissertation	0	2	6	8
6	Overall Assessment	MENVS 482	Grand Viva	0	0	2	2
			Total Sessional Credit	0	0	8	10
			Total Semester IV	12	2	8	22
						Total Credits for the Program	106

Choice Based Credit Course A
(Environmental Science Prospect)

1. Advanced Pollution Hazards and Environmental Controls (MENVS304A1)
2. Occupational Hazards, Environmental Health and Safety (MENVS304A2)
3. Oceanography & Coastal Management. (MENVS304A3)

Choice Based Credit Course B
(Life Science Prospect)

1. Pharmaceutical Biotechnology (MENVS305B1)
2. Environmental Biochemistry and Microbiology (MENVS305B2)
3. Conservation Biology (MENVS305B3)

Audit Course I & II

1. Research Methodology (AC107A / AC207A)
2. Pedagogy Studies (AC107B/ AC207B)
3. Constitution of India (AC107C/ AC207C)
4. Value Education (AC107D/ AC207D)
5. Stress Management by Yoga (AC107E/AC207E)
6. Innovation in Agriculture (AC 107 F/AC 207F)

DETAILED SYLLABUS

SEMESTER -I

Theory

1	Core Subject I	MENVS 101	Systems Perspectives and Holism in Environment	L-3	0	0	Credit-3

Concept of environment : Principle and scope of environmental science; Multidisciplinary approach of environmental science; Basic concepts and genesis of global environmentalism; Environmental education and awareness; Environmental ethics and global imperatives; Anthropocentric environmental view.

Environment-civilization interface: Human society and settlement; Process of cultural transmission; Gradual social changes in relation to environment; Nature vs. Nurture; Global environmental problems and initiatives; Global and Indian context of demography.

Current environmental issues in India: Environmental movements and related issues in India-Bishnoism, Silent valley movement, Narmada Dam, Teheri Dam, Almetti Dam, River Linking, Joint Forest Management, Chipko movement, Apikko movement, River cleaning initiatives; Ecological restorations: case studies from Ramsar wetlands and mines; Waste land and their reclamation; Desertification and its control.

Sustainability and Sustainability indices: Strategies and debates on Sustainable Development; Concept of Sustainable Agriculture; India's environment action programme: issues, approaches and initiatives towards Sustainability; Sustainable development in practice; Urbanization; Urban sprawling and urban growth; Concept and characteristics of smart city; Urban resources and environmental problems; Carrying capacity analysis; Concept of ecological footprint.

Text/Reference Books:

1. C. N. Sawyer, P. L. McCarty and G. F. Parkin. 2002. Chemistry for Environmental Engineering and Science. John Henry Press.
2. H. H. Rump. 2000. Laboratory Manual for the Examination of Water, Waste water and soil. Wiley-VCH.
3. R. K. Sapru. 1987. Environmental Management in India (Vol. I & II). Ashish Publishing House.
4. Ira. S. Richards. 2008. Principles and Practices of Toxicology in Public Health. Jones and Barlett Publications.

2	Core Subject II	MENVS 102	Evolution of Earth-Environment Systems	L-3	0	0	Credit-3

Origin of Earth and Geodynamic processes: Solar system formation and planetary differentiation; formation of the Earth: formation and composition of core, mantle, crust; chemical composition of Earth; geological time scale and major changes on the Earth's surface; Holocene and the emergence of humans. Concept of plate tectonics and continental drift theory, continental collision and formation of the Himalaya; ocean floor spreading; mantle convection and, major plates; earthquakes; volcanic activities; orogeny; isostasy; gravitational and magnetic fields of the earth; paleontological evidences of plate tectonics, Paleomagnetism.

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

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

Physiography: Development of landforms, land use pattern, land use policy of India; Glaciers: Physical and chemical aspects; Mass balance; Recession of Himalayan glaciers; Glaciers as index of climate change; Physiographic features and river basins in India.

Events of Anthropocene: Arrival of humans; evolution of Indus Valley civilization; progression of agriculture in the Indian subcontinent in Holocene; Industrialization effects, effect of urbanization on micro climate.

Text/Reference Books:

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.

3	Core Subject III	MENVS 103	Atmospheric Processes and Climate Cognition	L-3	0	0	Credit-3

Global Warming and Climate Change: Earth's climate through ages; Trends of global warming and climate change; Impact of climate change on atmosphere, weather patterns, sea level rise

Ozone Layer Depletion: Ozone layer or ozone shield; Importance of ozone layer; Ozone layer depletion and causes; Ozone depleting substances (ODS); Effects of ozone depletion; Mitigation measures and international protocols

Meteorology: Atmospheric stability; Inversion and mixing height; Wind roses; Climate and weather; Scales of meteorology, pressure, temperature, precipitation, humidity, radiation and wind.

Climatology: Fundamental principles; Earth's radiation balance; latitudinal and seasonal variation of insolation, temperature, pressure, wind belts and humidity; cloud formation and precipitation; water balance; air masses; monsoon system; jet streams; tropical cyclones; El-Nino and ENSO.

Atmosphere and its characteristics: Thermal structure and chemical composition of the atmosphere; atmospheric turbulence and boundary layer, lapse rate and stability, scale height, geo-potential; cloud formation and precipitation processes; basic laws of radiation; Rayleigh and Mie scattering and multiple scattering; Radiation from the sun, solar constant, effect of clouds and surface and planetary albedo; emission and absorption of terrestrial radiation, radiation windows, radiative transfer; greenhouse effect, net radiation budget; Air-sea interaction on different space and time scales.

Tropical meteorology: Trade wind inversion; ITCZ; Monsoon trough tropical cyclones, their structure and development theory; Monsoon depressions; Tropical Easterly jet stream; Monsoonal circulation in the Indian Ocean, Air and sea interaction.

Climate Change and Policy: Environmental policy debate; International agreements; Montreal protocol 1987; Kyoto protocol 1997; Convention on Climate Change

Text/Reference Books:

1. Barry, R. G. 2003. Atmosphere, Weather and Climate. Routledge Press, UK.
2. Gillespie, A. 2006. Climate Change, Ozone Depletion and Air Pollution: Legal Commentaries with Policy and Science Considerations. Martinus Nijhoff Publishers.
3. Hardy, J.T. 2003. Climate Change: Causes, Effects and Solutions. John Wiley & Sons.
4. Harvey, D. 2000. Climate and Global Climate Change. Prentice Hall.
5. Manahan, S.E. 2010. Environmental Chemistry. CRC Press, Taylor and Francis Group.
6. Maslin, M. 2014. Climate Change: A Very Short Introduction. Oxford Publications.
7. Mathez, E.A. 2009. Climate Change: The Science of Global Warming and our Energy Future.Columbia University Press.
8. Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. & Sen, K. 2004. Climate Change and India. Universities Press, India.

4	Core Subject IV	MENVS 104	Environmental Geoscience	L-3	0	0	Credit-3

Environmental Geoscience: Fundamental concept of environmental geosciences; Geological Time Scale, Space and time scales of processes in the solid Earth; Evolution, structure and composition of lithosphere, atmosphere hydrosphere and biosphere; Basic principles of stratigraphy; Fossil records; Earth's gravity and magnetic fields and its thermal structure: Geoid, spheroid; Isostasy.

Mineral deposits: Formation and classification; Environmental problems associated with extraction of mineral deposits; Geological characteristics in relation to mining; Impact of mining on environment; Acid mine drainage; Radioactive and stable isotopes.

Geo-environment and health: Medical Geology; Essential Elements in earth's crust, soil and plants; Concept of major, trace, and rare earth elements (REE); Geochemical pathways of essential elements; Intake and absorption of elements; Brief outline of medicinal uses of minerals and rocks. Etiology of Diseases

Pedology : Soil environment management for sustainable agricultural production

Natural Hazards and Disaster : Earthquakes, Landslides, Floods, Drought, Desertification and Tsunami

Text/ Reference Books:

1. Environmental Geology, Edward A. Keller, Prentice Hall, New Jersey.
2. Geology Environment Society ,K,.S.Valdiya, University press
3. Environmental metereology ,B.Padmanabha Murthy, I.K. International
4. Atmosphere, Weather and Climate, Roger G.Barry Richard J. Charley, Routledge (Taylor &Francis group)
5. Coping with natural hazards; Indian Context, K.S. Valdiya, Orient Longman .
6. Environmental Geology, C.W. Montgomery, Mc. Graw Hill International.

5	Core Subject V	MENVS 105	Advanced Environmental Chemistry	L-3	0	0	Credit-3

Basic Concepts: Classification of elements (emphasis on heavy metals); Biogeochemical cycles; Saturated and unsaturated hydrocarbons in environment; Stoichiometry; Gibb's energy; Chemical Potential and Chemical equilibrium; Mass and energy transfer across various interfaces; Material balance; Laws of thermodynamics, Heat transfer process, Acid - Base-reactions, Solubility products; Solubility of gases in water; Chemistry of hydrocarbons and its decay.

Environmental aspects of air-chemistry: Chemical composition of air; Particles, ions and radicals in atmosphere; Chemical processes for formation of inorganic and organic particulate matter; Thermochemical and Photochemical reactions in Atmosphere, Photochemical smog; Oxygen and ozone chemistry.

Environmental aspects of water-chemistry: Fundamentals of water chemistry; Concept of DO, BOD, COD, Total hardness, Redox potential; Carbonate system.

Environmental aspects of soil-chemistry: Soil formation, composition and classification; Soil profile; Soil erosion; Inorganic and Organic components of soil -Nitrogen pathways in soil; NPK in soils.

Principles of commonly used analytical methods in environmental quality assessment: Titrimetry; Gravimetry; Colorimetry; Spectrophotometry; Flame photometry; Atomic absorption spectrophotometry; Basic Chromatography; GC; GLC, HPLC; Electrophoresis; DTA, X-Ray fluorescence, X-Ray diffraction; Inductive coupled plasma spectroscopy.

Text/Reference Books:

1. Environmental Chemistry with Green Chemistry, Asim K Das, Books and Allied (P) Ltd., 2010
2. Geomorphology & Environment, Editors Savindra Singh, H S Sharma and Sunil K De, ACB Publications, 2004.
3. Green Chemistry (PB): Nova; Luque

6	Core Subject VI	MENVS 106	Energy & Environment	L-3	0	0	Credit-3

Energy resources: Concept of renewable, non-renewable, conventional and non-conventional energy resources; Energy and heat budget of the earth; Global energy use pattern, energy use and prospects in India; Energy security.

Global Energy Balance: Earth's energy balance; Energy transfers in atmosphere; Earth's radiation budget; Green house gases (GHGs); Greenhouse effect; Global conveyor belt

Conventional energy sources: Classification of Fossil fuels and their composition; Physio-chemical characteristics and energy values; Greenhouse gas, Global warming, Climate change: Global and Indian perspectives; Energy conservation; Energy efficiency: global and Indian perspectives

Solar energy: Sun as source of energy; Characteristics: irradiation, insolation etc.; solar ponds; Theory & practice of solar power generation; solar collectors, heliostats, PV cell, solar thermal, CSP; Energy phase change material and environmental impacts.

Bio-energy: Bio-mass characteristics; Different methods of extracting energy from bio-mass, their use, prospects and problems; Concept and use of bio-fuel and environmental impacts,

Alternative energy: Basic Principles, applications and environmental significance of Wind energy, Hydel Energy, Tidal energy, Wave energy, Ocean thermal energy, Geothermal energy, Nuclear energy (fission and fusion), Magneto hydrodynamic power, fuel cell and their techno-economic comparison.

Environmental impacts of energy use: Impacts of large scale exploitation of energy on ecosystem, land use etc.

Text/Reference Books:

1. M. Dayal (6^{th} Ed). 1997. Renewable Energy: Environment and Development. Konark Pub. Pvt. Ltd.
2. S. Vandana. 2002. Alternative Energy. APH Publishing Corporation.
3. S. K. Agarwal. 2003. Nuclear Energy: Principles Practice and Prospects. APH Publishing Corporation.
4. P. Chaturvedi. 1995. Bio-Energy Resources. Concept Publications.
5. V S. Mahajan. 1991. National Energy: policy, crisis and growth. Ashish Publishing House.
6. R.K.Rajput, Non-Conventional Energy Resources, S.Chand Publication.

Practical

8	Laboratory I	MENVS 191	Practical Applications of Environmental Geoscience	0	1	3	Credit-4

List of experiments:

1. Measurement and preparation of Oxygen Profile in aquatic ecosystem
2. Macroscopic identification of igneous, sedimentary and metamorphic rocks, common minerals; Study of fossils with reference to paleoenvironment
3. Meteorological parameters: Temperature, moisture, humidity, light intensity, Wind Speed, Atmospheric Pressure.
4. Physico-chemical analysis of Soil parameters: pH, organic matter, N, P, K, Plasticity, Swelling Volume
5. Physico-chemical analysis of Water parameters: DO, free and combined CO2, salinity, conductivity, turbidity (Secchi Disc method), sulfate, phosphate, nitrate-nitrogen, ammonical-nitrogen, residual chlorine, Ca & Mg Hardness.

9	Laboratory II	MENVS 192	Analytical and Instrumentation Techniques on Energy & Environment	0	1	3	Credit-4

List of Experiments:

1. Fuel Gas & Combustion gas analysis by Combustion Analyser.
2. Measurement Intensity of Noise Level using Noise Dosimeter.
3. Air pollution sampling monitoring and analysis of high volume sampler.
4. Estimation of Sodium and Potassium in water by flame photometer.
5. Estimation of Trace Metals like Fe, Cr, Pb, Cd, Hg, As in water by atomic absorption spectrophotometer
6. Proximate analysis of coal & determination of calorific value by MMF method.
7. Study of bioenergetics – Plants and animal tissues by calorimetric methods
8. Estimation of biomass by crop growth analysis
9. Characterization of wastes and waste water: MLSS;MLVSS
10. Quantitative estimation of indole acetic acid from plant material.
11. Studies on bioassay of wastewater

SEMESTER-II

1	Core Subject VII	MENVS 201	Ecosystems and Challenging Ecological Realms	L-3	0	0	Credit-3

Introduction to Ecosystem:: Concept of an ecosystem; abiotic and biotic components, Overlap between environment and ecosystem; Structure and function of an ecosystem; Producers, Consumers and Decomposers; Energy flow in the ecosystem; Ecological niche; Ecological succession; Food Chains, Food Web complexity, food-web patterns; Guild analysis; Keystone species; Productivity; primary and secondary production, gross and net production; methods of measuring productivity, ten percent law, net community' production, Thermodynamics and energy flow; Ecological Pyramids; Ecological Network; Microbial Ecology; Agricultural ecosystems.

Ecosystem Management : Introduction, types, characteristic features, structure and function & management of the following ecosystem: - (i) Forest ecosystem (ii) Grassland ecosystem (iii) Desert ecosystem (iv) Aquatic ecosystems (ponds, streams, lakes, rivers, marine including marine); Stressed habitats and communities and their management

Population ecology: Survivorship and life table; Population growth models; r and k selection; Concept of carrying capacity; Factors affecting human population size; Population age structure; Populations, adaptation and resilience; Population viability analysis; Metapopulation (Levin's model, metapopulation persistence time, correlated extinction).

Community Ecology: Community structure and dynamics; Theory of Island bio geography; Concept of diversity and stability; Intermediate disturbance hypothesis; Predator-prey-population oscillation; Function and numerical response model (Competition theory and modeling, competitive exclusion and coexistence); Community development: Connell and Slatyer's facilitation, inhibition and tolerance model, Tillman's resource ratio hypothesis. Study of pond biota – phytoplankton, zooplankton and macrophytes

Concept of Niche: Hutchinsonian concept; Niche overlapping; Niche breadth and width; Resource partitioning; Character displacement in Galapagos finches.

Landscape ecology: Landscape elements, Landscape geometry, Landscape sustainability; Urban-industrial-techno ecosystem.

Analysis of vegetation: Frequency, density, abundance, cover and basal area, dominance, Importance Value Index (IVI) and phytograph, determination of species diversity by diversity indices in plant community

Text/Reference Books:

1. Groom. B. & Jenkins. M. 2000.Global Biodiversity: Earth's Living Resources in the 21st Century. World Conservation Press, Cambridge, UK.
2. Gurevitch, J., Scheiner, S. M., & Fox, G. A. 2002. The Ecology of Plants. Sinauer associates incorporated.
3. Loreau, M. & Inchausti, P. 2002. Biodiversity and Ecosystem functioning: Synthesis and Perspectives. Oxford University Press, Oxford, UK.
4. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Sounders.
5. Pandit, M.K., White, S.M.& Pocock, M.J.O. 2014. The contrasting effects of genome size, chromosome number and ploidy level on plant invasiveness: a global analysis.

New Phytologist203: 697-703.
6. Pimentel, D. (Ed.). 2011. Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species. CRC Press.
7. Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications

2	Core Subject VIII	MENVS 202	Forestry, Wildlife Conservation and Ecotourism	L-3	0	0	Credit-3

Forestry & Human Wildlife Coexistence: Symbiotic relationship between tribals and forest, forest and development; Community participation in forest management, case study of Chipko movement, sacred groves forests, India's Bishnoi community and their conservation practices; Ecological-economic welfare and development; Man and biosphere programmes; Concept of conservation reserves and community reserves, importance of wildlife corridors

Wildlife Management: Need of environmental management; Wildlife conservation: moral obligation; Philosophy of wildlife management; Human wildlife conflicts; Role of government, wildlife biologists and social scientist

Wildlife Conservation Laws in India: Types of protected areas (Wildlife Sanctuaries, National Parks, Biosphere Reserves); IUCN categories of protected areas, Natural World Heritage sites; Concept of core and buffer area in a protected range; Brief introduction to Wildlife Protection Act of 1972; Forest Act of 1927; Environmental Protection Act of 1986; and Forest Conservation Act of 1920; Tiger task force, Status of current protected areas in India

Ecotourism : Elementary idea of Mass tourism and its Impact on environment and culture; Concept of Ecotourism, Guideline and policy (National and International) of ecotourism; Planning of ecotourism; Ecotourism circuit development; Types of Alternative Tourism, Elementary idea of Rural truism, Adventure tourism; Development, economical benefits and impacts of Ecotourism; Management of ecotourism; Ecotourism potentiality in India - Case study (ecotourism in Kenya, India and Australia)

Text/Reference Books:

1. Conover, M. 2001. Resolving Human Wildlife Conflicts, CRC Press.
2. Dickman, A. J. 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. Animal Conservation 13: 458-466.
3. Messmer, T. A. 2000. The emergence of human–wildlife conflict management: Turning challenges into opportunities. International Biodeterioration & Biodegradation 45: 97-102.
4. Paty, C. 2007. Forest Government and Tribe. Concept Publishing Company.
5. Treves, A. &Karanth, K. U. 2003. Human-carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology 17: 1491-1499.
6. Woodroffe, R. 2005. People and Wildlife: Conflict and Coexistence. Cambridge.
7. Woodroffe, R., Thirgood, S., & Rabinowitz, A. 2005. People and Wildlife, Conflict or Co-existence? (No. 9). Cambridge University Press.

Core Subject IX	MENVS 203	Hydrology & Water Resources Management	L-3	0	0	Credit-3

Hydrological cycle and processes: Systems concept of hydrological cycle; Precipitation; Evaporation and transpiration; Runoff; Base flow; Infiltration; Types of water; Origin and composition of sea water; Significant chemical distinction between sea water and river water; Global water balance; Global and Indian distribution of water resources;

Applied Hydrology: Surface and subsurface hydrology, Geomorphology and basin studies; Watershed Management; Applied Hydrological Problems

Introduction to Groundwater hydrology: Origin of ground water; Subsurface profile of groundwater; Water bearing characteristics of different types of rocks; Geomorphic and geologic controls of ground water; Ground water provinces in India; Water table and piezometric surface; Genetic classification of groundwater.

Hydrological characteristics of aquifer: Aquifers (unconfined, confined and semi-confined); Porosity, void ratio, permeability, transmissivity, storativity, specific yield, specific retention, diffusivity, velocity; Elasticity of confined aquifer.

Laws of ground water movement: Bernoulli's equation; Darcy's Law; Laplace equation; Flow rates, steady and unsteady unidirectional flow; radial flow.

Ocean and Coastal Management: Waves, Tides and Coastal Dynamics, Seafloor Mapping, Ocean acidification, energy resources, coastal erosion and flooding; marine renewable energy, marine conservation management, and hydrographic surveying; Managing Human Impacts in the Marine Environment

Groundwater Management: Human use of surface and ground water; Recharge and discharge areas; Safe yield and overdraft; Land subsidence; Rainwater harvesting and artificial recharge; Consumptive and conjunctive use of water; Watershed management.

Physical and Geological Oceanography: Oceanic features, resources, processes, exploration, Sea surface micro-layer and its impact on climate; Sea Surface Anomaly (SSA), Sea Surface Temperature (SST)

Chemical Oceanography : Sea water - physical and chemical properties, Study of marine aquatic environment – collection, preservation, and analyses of water samples (both on-shore and off-shore), Marine Pollution - Degradation of ocean environment

Text/Reference Books:

1. A.J. Schleiss and R.M. Boes. 2011. Dams and Reservoirs under Changing Challenges. CRC Press.
2. J.N. Parkinson, J.A. Goldenfum and C.E.M. Tucci. 2010. Integrated Urban Water Management. CRC Press.
3. A.N. Findikakis and K Saro. 2011. Groundwater Management Practices. CRC Press.

4	Core Subject X	MENVS 204	Environmental Risks, Vulnerability & Sustainability	L-3	0	0	Credit-3

Disasters: Definition, nature, scale and types of disasters; Causes and impacts of natural disasters: Flood, Drought, Landslides, Coastal Hazards, Earthquake, Volcanic eruption and Avalanche; Earthquake hazard zoning; Environment management of earthquake hazards; Slope failure, landslides and subsidence; Landslide hazard management; Tropical cyclones; Anthropogenic Disasters : industrial disasters, mine disasters, war and fire disasters; Few case studies: Chernobyl, Bhopal, Exon-Valdez, Minamata, Nepal earthquake, Aila etc.

Disaster management: Prediction and forecasting of natural disaster and brief outline of their management with special references to social and economic impacts of natural disaster; Protection against climate extremities; Role of Information systems and Technology in disaster management; Assessment of disaster vulnerability; Principles of disaster management, preparation of disaster management plans; Mitigation of different natural and anthropogenic disaster; Post Disaster Relief & Logistic Management; Community Participation at various stages of disaster management.

Risk analysis: Concept of Risk; Risk assessment methodologies; Hazard-risk evaluation and management; Environmental Safety measurements (on site and off site).

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

Text/Reference Books:

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

5	Core Subject XI	MENVS 205	Environmental Engineering and Pollution Control Technology	L-2	T-1	0	Credit-3

Environmental Engineering: Material cycling in ecosystems; Hydraulic gradient; Rain water harvesting, Water shed management; Municipal waste water and treatment processes; Point-source Gaussian Plume Model in air pollution; Global initiatives on atmospheric changes; Waste-to-Energy combustion

Environmental Modelling: Mathematical models; Steps in modelling approaches; Limitations of model application, fate of chemicals, sophistication levels in modelling

Pollution Management: Management of radioactive pollutants, Noise level measurement techniques, Instrumentation for environmental pollution, Monitoring and audit, Instrumentation setup for pollution abatement. Noise pollution and its effects, social and political involvement in the pollution management system

Pollution Control Technologies : Pollution control technology as an interdisciplinary approach. Process integrated pollution control in chemical industry. Unit operations/processes for water and wastewater treatment. Sludge treatment and disposal. Wastewater reuse. Control devices for particulate and gaseous air pollutants. Gravitational settling chambers, centrifugal collectors, wet collectors, fabric filters, electrostatic precipitators. Adsorption, absorbtion, condensation, combustion, automobile emission control.

Text/Reference Books:

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.

6	Minor Elective	MENVS 206	Natural Resources Management	L-2	0	0	Credit-2

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

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

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

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

Text/Reference Books:

1. Craig, J.R., Vaughan. D.J. & Skinner. B.J. 1996. Resources of the Earth: Origin, Use, and Environmental Impacts (2nd edition). Prentice Hall, New Jersey.
2. Freeman, A.M. 2001. Measures of value and Resources: Resources for the Future. Washington DC.
3. Freeman, A.M. 2003. Millennium Ecosystem Assessment: Conceptual Framework. Island Press.
4. Ginley, D.S. &Cahen, D. 2011. Fundamentals of Materials for Energy and Environmental Sustainability. Cambridge University Press.
5. Klee, G.A. 1991. Conservation of Natural Resources. Prentice Hall Publication.
6. Miller, T.G. 2012. Environmental Science. Wadsworth Publishing Co.
7. Owen, O.S, Chiras, D.D, &Reganold, J.P. 1998. Natural Resource Conservation – Management for Sustainable Future (7th edition). Prentice Hall.

Practical

7	Laboratory I	MENVS 291	Pollution Assessment and Control Techniques	0	1	3	4

List of Experiments:

1. Domestic wastewater quality assessment and treatment system.
2. Industrial wastewater quality assessment and treatment system.

Sessional

8	Obligatory Course Programme	MENVS 281	Industrial Training at Chemical, Metallurgical, Ceramic, Water Treatment Plant & Submission of Report	1	1	2	Credit-4
9	Mini Project Work	MENVS 282	Mini Project on Pollution Assessment and Control with Seminar Presentation	0	1	1	Credit-4

SEMESTER -III

1	Core Subject XII	MENVS 301	Statistics & Environmental Modelling	L-3	0	0	Credit-3

Environmental Modelling: Mathematical models; Steps in modelling approaches; Limitations of model application, fate of chemicals, sophistication levels in modelling

Statistical Concept: Concept of statistics, population, sampling, sampling area, sampling unit, types of data, types of sampling, advantages of sampling; Graphical representation of statistical data

Measurement: Mean, Median, Mode; Mean deviation, Standard deviation, Standard error; Correlation and Regression; Estimation of sample size, basic information on probability, testing of hypothesis, Null and alternate hypothesis, Skewness, Kurtosis, t – test, chi – square test, Multivariate Analyses, Principal Component Analyses

Text/Reference Books:

1. S. C. Gupta and V. K. 1986. Kapoor. Fundamentals of Mathematical Statistics. S. Chand & Co.
2. Aslam Mahmood. 1993. Statistical Methods in Geographical Studies. Rajesh Publications, New Delhi.
3. J. Medhi. Statistical Methods: 1992. An Introductory Text. New Age International Ltd. Publishers.
4. Gupta, S. P. 2000. Statistical Methods. Sultan Chand & Sons, New Delhi.

2	Core Subject XIII	MENVS 302	Remote Sensing and Geographic Information System	L-3	0	0	Credit-3

Aerial photography : Definition of aerial photography; Definition of Photogrammetry; Types of aerial photographs on the basis of film emulsion and scale; Determination of scale- various methods; Parallax and stereoscopic vision; Relief displacement; Uncontrolled mosaic; Flight line and flight planning

Remote Sensing : Definition of remote sensing; Concept of remote sensing; Difference between Photograph and Image; Characteristics of electromagnetic radiation; EME, EMR, EMS; Physical interactions between earth surface materials and EMR; Types of RS with respect to wave length region; Various kinds of resolution; Spectral reflectance of land cover;Black body concept, emissivity; Wien's displacement law; Planck's law; Types of sensors; Pushbroom scanner and Whiskbroom scanner; IRS system; Detector, FOV, IFOV; FCC and composition of standard FCC; Platform; Sun-synchronous polar orbit; Geo-synchronous orbit; Basic principles of remote sensing in VNIR, SWIR, TIR and microwave regions; Thermal conductivity, thermal capacity, thermal diffusivity, thermal inertia; Different regions of microwave remote sensing; Image interpretation and analysis; Image elements and terrain elements; Techniques of visual interpretation; Digital interpretation and digital image processing; Contrast stretching, density slicing, histogram equalization, band ratioing, PCT; Supervised and unsupervised classification; Application for environmental studies and EIA

GIS : Definition and basic concepts of GIS; Data types- spatial and non-spatial (attribute data); Data structure- vector and raster (spaghetti, topology); Data modeling- Quadtree, Run length encoding; GIS data base creation; Standardization of data; Rubber sheet transformation; GIS data base design and organization - conceptual, physical and logical; Application for environmental studies

GPS : Definition; Basic working principle; Application for environmental studies

Digital Image processing and Geological Information System.

Case Studies : Principle of Remote Sensing and its application to groundwater environment, mining of mineral resources, landslides, land subsidence and earthquakes, wasteland mapping, ecology, Environmental Impact Assessment.

Ocean Observation System / Satellite Oceanography

Text/Reference Books:

1. Burough, P.A. and McDonnel, R. 1998. Principles of Geographical Information Systems. Oxford University Press, NY.
2. Campbell, J.B. (2nd Ed), 1996. Introduction to Remote Sensing. Taylor and Francis.

3. Christopher, J. 1997. Geographical Information Systems and Computer Cartography. Longman.
4. Reeves, Robert G. 1999. Manual of Remote Sensing, (Vols. I & II). American Society of Photogrammetry and Remote Sensing, USA.
5. Rencz, A.N. (3rd Ed.) Remote Sensing for the Earth Sciences: Manual of Remote Sensing. John Wiley & Sons, Inc., New York.
6. Sabins, F. F. Jr. (2nd Ed). 1986. Remote Sensing: Principles and Interpretation. W.H. Freeman & Co.

3	Core Subject IV	MENVS 303	Disaster Management	L-3	0	0	Credit-3

Unit 1 : Understanding hazards and disasters, hazards to environment, risk Assessment, vulnerability analysis.

Unit 2 : Dimensions of disaster, disaster impact assessment; types of disaster impact; disaster trends and patterns; flood, drought, cyclone, tsunami, earthquake and volcanoes & its Management.

Unit 3: Understanding natural and man-made disaster; disaster preparedness; disaster responses; reducing the impacts of disaster.

Unit 4 : Biophysical hazards; disaster due to diseases; disaster in medicines; disaster aid; Community preparedness; forecasting and warning; rehabilitation; reconstruction and recovery; slope Instability and landslide hazard.

Text/Reference Books:

1. G. F. White (Ed). 1974. Natural Hazards – Local, National, Global. Oxford University Press.
2. V.T. Chow. 1964. Handbook of Applied Hydrology. McGraw-Hill.
3. A. N. Strahler and A. H. Strahler. 1973. Environmental Geoscience - Interaction between Natural Systems and Man . Santa Barbara, California: Hamilton Publishing.
4. P. Reining. 1978. Handbook of Desertification Indicators. Washington D.C.: American Association for the Advancement of Science.
5. K. S. Valdiya. 1987. Environmental Geology. Tata McGraw-Hill.

6	Minor Elective	MENVS 306	Ecological Restoration	L-2	0	0	Credit-2

Definitions and concept : Reclamation, remediation, restoration and rehabilitation.
Disturbance: Causes and impact on the structure and functioning of terrestrial and aquatic ecosystems.
Aims and strategies: Passive and active; habitat, species and ecosystem restoration; single vs. multiple end-points.
Ecosystem reconstruction: Acceleration of ecological succession, physical, chemical, biological and biotechnological tools.
Restoration of biological diversity: Augmentation, reintroduction and introduction of Species.
Degradation and restoration of natural ecosystems: Forests, grassland/savanna, wetlands and other aquatic ecosystems.
Restoration of degraded soils: Restoration of contaminated soils and soil fertility, mine spoil restoration.

Text/Reference Books:

1. Paul E Hardisty. 2010. Environmental and Economic Sustainability. CRC Press.
2. S.C. Santra. 2011. Environmental Science. New Central Book Agency.

Sessional

5	Major Project Work I	MENVS 381	RS-GIS and Environmental Systems Modelling	0	2	6	Credit-8

List of Experiments:

1. Digital image processing: Raw image data reading; image enhancement technique; histogram equalization technique; FCC and spectral signature of earth features
2. Lay out of experimental design (RBD; split-plot etc.,); Sampling techniques and statistical analysis of experimental design
3. Georeferencing and mosaicking of image
4. Image subset and export
5. Classification of image- supervised and unsupervised
6. Digitization and different types of vector layer generation
7. Cartographic representation
8. Analysis of environmental data and their digital modelling
9. Weather forecasting using remote sensing and meteorological instruments.
10. Preparation and submission of report (case studies on EIA)
11. Measurement of LC50/LD50 and safe concentration of toxicants
12. Preparation and analysis of Rainfall charts

SEMESTER -IV

1	Core Subject XV	MENVS 401	Environmental Biotechnology, Eco-Toxicology and Bioremediation	L-3	0	0	Credit-3

Ecotoxicology: Definition and Concept; mechanism of toxicity; Branches of toxicology; Types of interactions in toxicology; Concept of Dose-Response relationship, LD_{50}, LC_{50}, Threshold Limit Value (TLV), Therapeutic index; Basic concept on Bioaccumulation, Biomagnifications, Bio-concentration factor; Ames test, Bio assay technique

Environmental Biotechnology: Concept on Environmental biotechnology, Fermentation techniques, composting, vermicomposting, bioleaching; Application of biotechnology in environmental field

Biotechnological Approaches: Definition, types, applications and advantages of biofertiliser, biopesticide, biofuel, and biogas

Bioremediation: Current remediation practices, Bioremediation to treat contaminated soils and ground water. Advantages and disadvantages of bioremediation compared to non-biological processes. Factors affecting choice of in situ or ex situ processes. Assessment of biodegradability; biostimulation vs bioaugmentation; mineralization vs. partial degradation; factors affecting microbial activity (choice of electron acceptor, toxicity of pollutant, C/N/P ratio, co-substrates, soil humidity, pH and temperature); bioavailability of pollutant. Biodegradation of specific contaminants (e.g. diesel fuel, polychlorinated biphenyls, dyestuffs, aromatic and polyaromatic hydrocarbons) Solid phase bioremediation, Slurry phase bioremediation, Vapor phase bioremedation,

Text/Reference Books:

1. A. K. De. (3rd Ed). 2008 Environmental Chemistry. New Age Publications India Ltd.
2. I. C. Shaw and J. Chadwick. 1997. Principles of Environmental Toxicology. Taylor & Francis Ltd.
3. S.C. Santra. 2011. Environmental Science. New Central Book Agency.
4. Ira. S. Richards. 2008. Principles and Practices of Toxicology in Public Health. Jones and Barlett Publications.

2	Core Subject XVI	MENVS 402	Environmental Legislation & Impact Assessment	L-3	0	0	Credit-3

Laws and Acts regarding environmental concerns: Provision of Constitution of India regarding Environment; Environmental Policy Resolution; Enviro-Legal system in India: PIL and Public Hearing, National Green Tribunal; Public Policy Strategies in Pollution Control; Indian Forests Act, 1927; Wildlife (Protection) Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; Forest (Conservation) Act, 1980; Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986; Motor Vehicle Act, 1988; Hazardous Wastes (Management and Handling) Rules, 1989; Public Liability Insurance Act, 1991; Biological diversity Act, 2002; Disaster Management Act, 2005; Environmental Impact Assessment Notification, 2006; Coastal Regulation Zone Notification, 2011;

Environmental Impact Assessment: Scope and principle of Environmental Impact Assessment; Methodologies of Environmental Impact Assessment; Official guidelines for EIA; Basic mechanism required for data collection, subsequent analysis and report making for a proposed project; Different techniques adopted for impact evaluation; Concept and preparation of Environmental Impact statement (EIS) and Environment Management Plan (EMP).

Text/Reference Books:

1. Abraham, C.M. 1999. Environmental Jurisprudence in India. Kluwer Law International.
2. Agarwal, V.K. 2005. Environmental Laws in India: Challenges for Enforcement. Bulletin of the National Institute of Ecology 15: 227-238.
3. Divan, S. &Rosencranz, A. 2001. Environmental Law and Policy in India. Oxford University Press.
4. Divan, S. &Rosencranz, A. 2002. Environmental Law and Policy in India: Cases, Materials and Statues (2nd edition). Oxford University Press.
5. Gupta, K.R. 2006. Environmental Legislation in India. Atlantic Publishers and Distributors.
6. Leelakrishnan, P. 2008. Environmental Law in India (3rd edition). LexisNexis India.
7. Naseem, M. 2011. Environmental Law in India Mohammad. Kluwer Law International.

3	Core Subject XVII	MENVS 403	Environmental Economics & Audit	L-3	0	0	Credit-3

Environmental economics: Economics and Development; Economic efficiency and Cost benefit analysis; Concept of Consumerism; Poverty and globalization; Monitoring economic and environmental progress; Application of economics to improve environmental quality; Rural planning and development; Environmental valuation (Hedonic pricing, Contingent valuation and Travel cost method) and decision making; Theory of externalities and public good; International negotiations on climate change and North- South debate; Environment Kuznet Curve (EKC).

Dimensions of natural resources: Basic services of natural resources; Natural resource as national capital; Natural resource potential of India; Natural resources and sustainable development; Resource economics; Issues and challenges of SEZ and EEZ in India

Environmental audit: Concept of environmental audit; Guidelines of environmental audit; Methodologies adopted along with some industrial case studies; Environmental standards: ISO 14000 series; Scheme of labeling of environment friendly products (Ecomark); Life cycle analysis; Concept of energy and green audit.

Text/Reference Books:

1. Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C.S., Jansson, B.O., Levin, S., Maler, K.G., Perrings, C., Pimentel, D. 1995. Economic growth, carrying capacity, and the environment. Ecological Economics 15: 91-95.
2. Hanley, N., Shogren, J. F., & White, B. 2007. Environmental Economics: In Theory and Practice. Palgrave Macmillan.
3. Kolstad, C.D. 2010. Environmental Economics. Oxford University Press.
4. Perman, R. 2003. Natural Resource and Environmental Economics. Pearson Education.
5. Singh, K. &Shishodia, A. 2007. Environmental Economics: Theory and Applications. Sage Publications.
6. Thomas, J.M. & Callan, S.J. 2007.Environmental Economics. Thomson Learning Inc.
7. Tietenberg, T. 2004. Environmental and Natural Resource Economics (6th Edition). Pearson Education Pvt. Ltd.
8. Tietenberg, T. H. & Lewis, L. 2010. Environmental Economics and Policy. Addison-Wesley.

4	Core Material XVIII	MENVS 404	Wastes & Waste Management	L-3	0	0	Credit-3

Basic concept of waste management: Concept of waste management; Classification of wastes; Waste minimization technologies; Industrial waste water quality control and management; Reduce, reuse and recycle of waste; Integrated waste management.
Hazardous waste: Resource, conservation and recovery; Land disposal; Alternatives; Ocean dumping; Handling and management of radioactive waste; Environmental impacts.
Municipal solid waste management: Composition; Onsite disposal; Incineration; Open dumps; Sanitary land-fills; Environmental consequences.
Bio medical waste: Generation; Segregation; Colour codes; Disposal and treatments; Health consequences.
E-waste: Generation; Segregation; Disposal and treatments; Environmental impacts.
Waste to wealth: Energy from waste; Value added products from waste; Fly ash utilization and disposal Garbage farming; Sewage fed fisheries; Composting.
Waste Disposal: Criteria for waste disposal in riverine, marine and coastal system; Waste handling, transportation, compaction and disposal.

Text/Reference Books:

1. Asnani, P. U. 2006. Solid waste management. India Infrastructure Report 570.
2. Bagchi, A. 2004. Design of Landfills and Integrated Solid Waste Management. John Wiley & Sons.
3. Blackman, W.C. 2001. Basic Hazardous Waste Management. CRC Press.
4. McDougall, F. R., White, P. R., Franke, M., &Hindle, P. 2008. Integrated Solid Waste Management: A Life Cycle Inventory. John Wiley & Sons.
5. US EPA. 1999. Guide for Industrial Waste Management. Washington D.C.

Sessional

5	Major Project Work II	MENVS 481	Environmental Research Project & Dissertation	0	2	6	Credit-8
6	Overall Assessment	MENVS 482	Grand Viva	0	0	2	Credit-2

Choice Based Credit Course

A

(Core Environmental Science Prospect)

1. Advanced Pollution Hazards and Environmental Controls (MENVS304A1)

Air Pollution : Natural and Anthropogenic Sources; Primary and Secondary Pollutants and Causes of Their Generation; Transportation and Dispersion of Pollutants. Gas Laws Governing the Behaviour of Pollutants in Atmosphere; Adiabatic Lapse Rate and Nature of Dispersions; Dispersion Models; Air Pollution Climatology; Ground Level Concentrations; Effects and Management of Air Pollution; Control Measures of Air Pollution - Engineering Control Concepts, Pollution Specific Monitoring and Control Devices / Systems, Control of Stationary and Mobile Sources. Effects of Air Pollutants on Human Beings, Plants, Animals, Materials, and on Climate. Acid Rain.

Water Pollution : Chemistry of Hydrosphere : Freshwater, Sea Water and Groundwater Quality; Sources and Types of Water Pollutants. Groundwater and Surface Water Pollution. Effects and Management of Liquid Wastes - Municipal, Industrial, Radioactive / Hazardous and Biomedical in origin. Behaviour of Pollutants in Wastewater Stream; Control Measures – Their Conservation & Reuse; Design of Control Devices; Soaps, Detergents, Pesticides in Water.

Municipal Wastewater and Sludge Characteristics : Different Levels of Treatment, Sludge Disposal, Composting by Heat Drying or by Microbial Action; Preliminary Design & Planning for Sewage Treatment Plants

Characteristics of Industrial Wastewaters: Types of Treatment Processes : Physical Treatment Processes, Chemical Treatment Processes and Biological Treatment Processes; Preliminary Design & Planning for Industrial Pollutant Treatment Plant

Soil Pollution : Sources of Soil Pollutants. Effects and Consequences of Soil Pollution. Interaction of Soil Pollutants with Soil Components. Control of Soil Pollution. Interaction of Industrial Waste Effluent and Heavy Metals with Soil Components. Soil Micro-organisms and Their Functions, Degradation of different Insecticides, Fungicides and Weedicides in Soil. Different Kinds of Synthetic Fertilizers (N, P, and K) and Their Interactions with Different components of Soil.

Solid Waste Pollution : Types of Solid Wastes and Their Soil Pollution Potential; Solid Waste Management; Disposal Methodologies : Prospects and Concerns; Incineration, Pulverization, Organic Composting, Vermicomposting, Sanitary Landfills for Hazardous and Biomedical Wastes. Waste to Wealth Conversion

Noise Pollution : Concepts of Noise, Sources of Noise Pollution, Effects of Meteorological Parameters on Noise Propagation. Measurement of Noise and Noise Indices. Impacts of Noise on Human Health, Noise Control and Abatement Measures.

Marine Pollution : Natural and Anthropogenic Sources of Marine Pollution, Effects of Pollution on Marine Biota; Control of Marine Pollution and Control Management.

Radioactive and Thermal Pollution.

Vehicular Pollution and its Control.

Indoor Pollution.

Environmental Geochemistry : Scope and definition of Environmental Geochemistry; Geochemical classification of elements; association of elements, element distribution in minerals. Geochemical cycle; Anthropogenic sources of environmental pollution. Chemical weathering; chemical stability and dispersion of elements; secondary geochemical environment and prouducts of chemical weathering. Soil, soil horizons and profile, trace elements in soil profile. Importance of soils in environment in controlling bioavailability of elements. Medical Geology; scope and applications. Essentiality and toxicity of elements relating to Chromium, Lead, Mercury, Arsenic, Radon gas, radioactive waste disposal. Some Indian case histories. Use of isotopes in environmental monitoring of food chain.

Text/Reference Books:

1. Jeffrey Peirce, J. (1997). Environmental Pollution and Control, 4th Edition, Butterworth-Heinemann, Oxford, 1997.
2. Schnelle, Jr., K. B., Dunn, R. F. and Ternes, M. E. (2016). Air Pollution Control Technology Handbook, 2nd Edition, Routledge and CRC Press.
3. Spellman, F. R. (2021). The Science of Environmental Pollution, Taylor & Francis.
4. Chaudhery, M. H. Modern Environmental Analysis Techniques for Pollutants. 1st Edition, Elsevier Science Publishing Co Inc.

2. Occupational Hazards, Environmental Health and Safety (MENVS304A2)

Concept of Xenobiotics: Toxic materials; Xenobiotic induced oxidative stress; Cell injury; Mode of action: Types of exposure, Absorption, Distribution, Metabolism and Excretion of toxicants (Phase I and Phase II reaction).

Toxicity assay: Acute and chronic toxicity; Dose- Response Relationship- Median lethal concentration (LD50 and LC50); Sublethal concentration and safe concentration (NOEL, MATC); Whole Effluent Toxicity (WET) test; Bioassay - types, methodologies and application; Toxico Kinetics and toxicokinetic-analysis.

Ecotoxicology: Biomarkers; Bioaccumulation; Biomagnification; Bioconcentration factor; Risk assessment; Effects on population and ecosystems; Damage process and action *of* toxicants; Toxicity of heavy metal (Pb, Cd, Hg and As); Predictive toxicology and Quantitative Structured Activity Relationship (QSAR).

Cytotoxicity and Genotoxicity: Molecular mechanism of cell death; chromosomal aberration; sister chromatid exchanges; Micronucleus and Nuclear abnormalities; DNA damage and repair mechanism.

Carcinogenesis: Classification of carcinogens; Metastasis and metabolism *of* chemical carcinogens; cancer risk evaluation; Brief outline of cancer therapy.

Reproductive toxicology: Teratology; Reproductive toxicity; Invitro fertilization

Environmental health: Epidemiological issues: Goitre, Fluorosis, Arsenicosis and vector borne diseases; Etiology of diseases related to trace elements; Disease ecology: Air, water, soil; Exposure monitoring; Health monitoring.

Occupational hazards: Health consequences of different occupations- Anthracosis, Silicosis, Asbestosis; Concept of stress, Stress related diseases, Stress management, Stress, strain and

general adaptive syndrome; Industrial Environmental Psychology; Cardio-respiratory response during high altitude acclimatization; Effect of climate on performance.

Text/Reference Books:

1. Global Environmental Governance By James Gustave Speth and Peter M. Haas Washington, DC:Island Press, 2006. 179pp. ISBN: 1-59726-081-9
2. The Environment in Asia Pacific HarboursEricWolanski, ed.NewYork:Springer, 2007. 498 pp.ISBN: 978-1-4020-6566-8

3.Oceanography & Coastal Management (MENVS304A3)

Basics of Oceanography: Definition, nature, scope of oceanography and relationship with other subjects, Historical development of oceanography, Historical development of oceanography in India

Physical Oceanography: Salinity, conductivity, temperature, density, light and pressure, etc. of sea water, Waves: definition, classification and different types of waves, origin of surface waves, forms and characteristics, growth and dissipation ofwind waves, breakers and surfs, Tides: definition, classification, causes and types of tide, storm surges, seiches, and Tsunami, Currents: definition, classification, causes and types of current, major surface current system of the World Ocean, atmospheric circulation, global wind pattern, Ekman spiral, Ekman transport and upwelling

Chemical Oceanography: water molecule, dissolving power of Seawater, composition of sea water

Biological Oceanography: Plankton, Nekton, Benthos

Geological Oceanography: Marine sediments, types of sediment based on sources and origins

Coastal management : Indian Scenario - Classification of Harbours. Introduction - wind and waves - Sea and Swell - Introduction to small amplitude wave theory - use of wave tables- Mechanics of water waves - Linear (Airy) wave theory, Introduction to Tsunami

Wave properties and analysis : Behaviour of waves in shallow waters, Introduction to non-linear waves and their properties - Waves in shallow waters - Wave Refraction, Diffraction and Shoaling -Hindcast wave generation models, wave shoaling; wave refraction; wave breaking; wave diffraction random and 3D waves- Short term wave analysis - wave spectra and its utilities - Long term wave analysis- Statistics analysis of grouped wave data.

Coastal sediment transport : Dynamic beach profile; cross-shore transport; along shore transport (Littoral transport), sediment movement

Coastal defence : Models, groins, sea walls, offshore breakwaters, artificial nourishment - planning of coast protection works - Design of shore defence structures -Case studies.

Text/Reference Book

1. Pickard, GL 1963. Description Physical Oceanography. Pergamon Press, London.
2. Yasso, WE 1965. Oceanography. Holt, Rinehert and Winston, Inc., New York.
3. King. CAN 1966. An Introduction to Oceanography. McGraw Hill Book Co, New York.
4. Pickard GL and WJ Emery, 4th enlarged, 1982. Descriptive Physical Oceanography. Pergamon Press, Oxford.
5. Weisberg, J and H Parish. 1974. Introduction to Oceanography. McGraw-Hill Kogakusha, Ltd., Tokyo

Choice Based Credit Course
B
(Life Science Prospect)

1. Pharmaceutical Biotechnology (MENVS305B1)

Introduction History of pharmacy; the pharmaceutical industry & development of drugs; Economics and regulatory aspects; Quality management; GMP
Drug kinetics and bio-pharmaceutics Mechanism of drug absorption, distribution, metabolism and excretion – factors affecting the ADME process; Bioequivalence; Pharmacokinetics.
Principles of drug manufacture Liquid dosage forms – solutions, suspensions and emulsions; Topical applications – ointments, creams, suppositories; Solid dosage forms – powders, granules, capsules, tablets, coating of tablets; Aerosols; Preservation; Packing techniques
Advances in drug delivery Advanced drug delivery systems – controlled release; Transdermals, Liposomes and drug targeting
Biopharmaceuticals Understanding principles of pharmacology, pharmacodynamics; Study of a few classes of therapeutics like Recombinant therapeutics, Monoclonal Antibodies, Vaccines, Gene therapy, Antibiotics and Hormones

Text/Reference Books:

1. Biotechnology-The biological principles: MD Trevan, S Boffey, KH Goulding and P.F. Stanbury.
2. Immobilization of cells and enzymes: HosevearKennadycabral& Bickerstaff
3. Principles of Gene Manipulating: RW Old and S.B.Primrose.
4. Molecular Cell Biology: Harvey Lodish, David Baltimore, Arnold Berk, S LawenceZipursky, Paul Matsudaira, James Darnell.
5. Modern Biotechnology: S.B Primrose174

2. Environmental Biochemistry and Microbiology (MENVS305B2)

Environmental aspects of air-chemistry: Chemical composition of air; Particles, ions and radicals in atmosphere; Chemical processes for formation of inorganic and organic particulate matter; Thermochemical and Photochemical reactions in Atmosphere, Photochemical smog; Oxygen and ozone chemistry.
Environmental aspects of water-chemistry: Fundamentals of water chemistry; Concept of DO, BOD, COD, Total hardness, Redox potential; Carbonate system.
Environmental aspects of soil-chemistry: Soil formation, composition and classification; Soil profile; Soil erosion; Inorganic and Organic components of soil -Nitrogen pathways in soil; NPK in soils.
Fundamentals of Microbiology: Classification of microorganisms; Factors controlling growth of microbes; measurement, kinetics and characteristics of bacterial growth in natural and artificial system.
Microbiology of Air: Factors affecting the survival of microorganisms in air; Sources of microorganisms; Air-borne pathogens and its role on public health; Sampling techniques for microbiological air quality.
Microbiology of Water: Common microorganisms encountered in freshwater sources; Self-purification of water; Common sources of microbial pollution in water; Assessment of microbiological quality of water; Characteristics of pollution indicator microorganisms;

Selection and quantification of indicator organism in freshwater; Freshwater quality standard; purification of water for human use.

Microbiology of Soil: Beneficial and pathogenic microbes in agriculture; Soil as a microbial growth medium; Characteristics of soil microenvironment for microbes; Interaction of microorganisms and plant in soil; Role of microorganism in maintaining the soil fertility; Concepts of hemo organotroph and Chemolithotroph.

Text/Reference Books:

1. Raina M. Maier. 2000. Environmental Microbiology. Academic Press.
2. Pepper, I. and C. P. Gerba. 2004. Environmental Microbiology (2nd Edition). Academic Press.
3. Physical Chemistry, P.C. Rakshit, Sarat Book House, Calcutta.
4. Environmental Chemistry, A. K. De, New Age (p.) Ltd.
5. Fundamentals of Environmental Chemistry, Manban, S.E., Lewis Publishers.
6. Elements of Bioinorganic Chemistry, G. N. Mukherjee, Arabinda Das, U. N. Dhar & Sons Pvt. Ltd.
7. Atmospheric Chemistry & Physics, Sainfeld, John Wiley & Sons. Inc.

3. Conservation Biology (MENVS305B3)

Pollution Biology : Pollutants vs. resources; cycling of materials, tolerance ranges, carrying capacity, Bioaccumulation. Responses of plants and animals to air pollution:, monitoring air pollution by plants (for example, lichens); control of air pollution by plants. Responses of plants and animals to water pollution; distribution of plants in relation to pollution (microphytes; phytoplankton, periphyton and moorophytes); Biological monitoring of pollution in water, Biological control. Responses of plants to soil pollution.

Ecology and Sustainable Development : Ecosystem concept in space and time; Ecosystem level processes and landscape level processes; the concept of sustainable development temporal and spatial dimensions; currencies for evaluations of sustainable development – Biophysical measurements; Biological invasion, Bio-diversity concerns; Ecosystem and social processes in: (a) Rehabilitation of degraded rural landscape, (b) Rehabilitation of unbalanced soils, (c) Rehabilitation of specialized habitats, for example, water bodies, mangroves; (d) Mined area rehabilitation participatory research and education environmental decision making with people initiates.

Agriculture and Environment : Agro-forestry; Agriculture, Rural Development and Environment; Agro/Rural Ecosystem; Optimal Harvesting;

Conservation Biology : Commonness and Rarity of Species, Biological Diversity – Different Levels and Influencing Factors, Environmental conservation ; Threats to Conservation of Biodiversity, Uncertainty and Risks, Global Pattern of Biodiversity, Biodiversity Conservation Approaches, Mega Diversity Counting and Hot Spots, Biodiversity Profiles of India, Strategies for Biodiversity Conservation and Sustainable Use, Application and Impacts of Biotechnology on Biodiversity and Conservation, Population dynamics, extinction vortex, metapopulation, island syndrome, Structure, dynamics and resilience of perturbed ecosystems

Text/Reference Books

1. Fred Dyke , Conservation Biology: Foundations, Concepts, Applications; Springer.
2. Malcom.L.Hunter, James P. Gibbs, Fundamentals of Conservation Biology, 3rd Edition, Wiley.
3. Richard B. Primack, Essentials of Conservation Biology, Oxford University Press.

Audit Course I & II

1. Research Methodology (AC107A / AC207A)
2. Pedagogy Studies (AC107B/ AC207B)
3. Constitution of India(AC107C/ AC207C)
4. Horticulture (AC107D/ AC207D)
5. Stress Management by Yoga (AC107E/AC207E)
6. Innovation in Agriculture (AC 107 F/AC 207F)