CURRICULUM

UNDER CHOICE BASED CREDIT SYSTEM

(w.e.f session 2021-2022)

MASTER OF SCIENCE (M.SC) PROGRAMME IN

Environmental Science

(For SEM I, SEM II, SEM III & SEM IV)

SIDHO-KANHO-BIRSHA UNIVERSITY
PURULIA, WEST BENGAL

SIDHO-KANHO-BIRSHA UNIVERSITY

Curriculum

MASTER OF SCIENCE (M.SC) PROGRAMME IN

ENVIRONMENTAL SCIENCE

(w.e.f academic session: 2021-2022)

	Course Code	Course Title	Credit	Marks
SEM I	MENVCCT101	Fundamentals of Environment	4	40+10
	MENVCCT102	Physical Environment	4	40+10
	MENVCCT103	Environmental Biology	4	40+10
	MENVCCT104	Environmental Microbiology	4	40+10
	MENVCCS105	Practical on Physical Environment	4	50
	MENVCCS106	Practical on Environmental Biology	4	50
SEM II	MENVCCT201	Ecotoxicology & Physiological Processes	4	40+10
	MENVCCT202	Environmental Geoscience	4	40+10
	MENVCCT203	Energy Resource & Environmental Statistics	4	40+10
	MENVCCT204	Environmental Pollution & Degradation	4	40+10
	MENVCCS205	Practical on Environmental Problems	4	50
	MENVCCS206	Practical on Ecotoxicological Measurements	4	50
SEM III	MENVCCT301	BIODIVERSITY CONSERVATION AND SUSTAINABLE DEVELOPMENT	4	40+10
	MENVCCT302	EMERGING ENVIRONMENTAL PROBLEMS, HEALTH HAZARDS & GENETIC ENGINEERING	4	40+10
	MENVCCT303	REMOTE SENSING & GIS	4	40+10
	MENVOET304	OPEN ELECTIVE	4	50
	MENVCCS305 (ANY ONE)	MENVCCS305-1 (DE) PRACTICAL on RS & GIS, EIA & DISEASES	4	50
		MENVCCS305-2 (DE) ECOLOGICAL MODELLING AND GIS FOR ENVIRONMENTAL APPLICATIONS	4	50
		MENVCCS305-3 (DE) ECOTOXICOLOGY & INDUSTRIAL	4	50

		MICROBIOLOGY		
	MENVCOP306	COMMUNITY ENGAGEMENT ACTIVITIES	4	50
SEM IV	MENVCCT401	ENVIRONMENTAL IMPACT ASSESSMENT & ENVIRONMENTAL LAWS	4	40+10
	MENVCCT402	ENVIRONMENTAL TOXICOLOGY& BIOTECHNOLOGY	4	40+10
	MENVMET403 (ANY ONE)	MENVMET403-1 ENVIRONMENTAL ISSUES, ECONOMICS & ENVIRONMENTAL MANAGEMENT	4	40+10
		MENVMET403-2 ENVIRONMENTAL ENGINEERING AND SCIENCE	4	40+10
	MENVCCS404 (ANY ONE)	MENVCCS404-1 PRACTICAL ON TOXICOLOGICAL TESTING	4	50
		MENVCCS404-1 PRACTICAL ON SPATIAL DATA ANALYSES AND ECOLOGICAL MODELLING	4	50
	MENVACT405	ADD-ON COURSE	4	50
	MENVMEP406	Project /Dissertation/Internship	4	50

Programme Outcomes (POs)

After completion of the PG Programme master program (M.Sc.) students will

- be able to understand and develop the concepts, ideas and responsibility pertaining to higher studies
- have good understanding about modern tools and techniques and their uses
- be able to use their analytical skill to interpret and solve the individual and social problems
- be able to develop themselves as good researchers, teachers as well as a human being
- to act as a catalyst to bridge the gap between science and society

Programme Specific Objectives (PSOs)

The objectives of the outcome-based learning after completion of M.Sc. in Environmental Science are:

- to develop the fundamental concepts and principles of environment and its conservation among the students
- develop the skill regarding field techniques, sample collection, mapping and analysis
- to develop the skill of the students as environment professional
- to motivate the students to take up research and teaching in environmental science
- to develop the knowledge as an environment expert to guide the manufacturing industries, non-government

organizations (national and international), policy-making bodies

- to create awareness among common people regarding environmental issues and its sustainability like climate change, pollution, degradation, human and planet health

Semester I

MENVCCT101
Total lecture hours: 40
Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

FUNDAMENTALS OF ENVIRONMENT

Course objectives

- to introduce fundamentals of environment and ecology

I. Environmental awareness: Definition, Principles and scope of environmental science; Environmentalism; Environmental ethics and philosophy; Environmental education and awareness; Ecofeminism; Green govt. politics [10]

II. Components of environment: Lithosphere, hydrosphere, atmosphere and biosphere; Physical and biological environments
Socio-Cultural Environment: Human civilization processes (man-Environment relationship), society, class, gender; Human settlements [10]

III. Ecology and Biomes: Concept of ecosystem; Ecological energetics; Food chain & webs; Ecosystem structure and functional aspects;

Landscape ecology & ecological interactions; Ecosystem services; Biomes and biome types: forest, grassland, tundra, desert biomes; Concept of Gaia Hypothesis [10]

IV. Population ecology and Human ecology: Population properties and dynamics of population growth, factors controlling population growth, metapopulation; Mechanism of population equilibrium

Human population growth, expansion and itscauses; Consequences of population growth andaffluence; Human demography, promotion and development, demographic transition; Future of human population

[10]

Course out comes:

- Students will be able to understand basics of environment and ecology, human ecology

MENVCCT102

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

PHYSICAL ENVIRONMENT

Course objectives

- To develop the understanding about fundamentals of earth, its origin
- To develop an idea regarding climatology
- To develop the knowledge of environmental chemistry and various analytical techniques

I. Fundamentals of Earth processes: Origin and evolution of the Earth; Geological time scale; Continental drift and mountain building with reference to plate tectonics

External geomorphic processes: Weathering and erosion; Soil - origin, nature and classification of parent material for soil formation, classification of soil; Landforms developed due to various geomorphic agents i.e., water, wind and glacier [8]

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II. Fundamentals of climatology: Scale of meteorology; Elements of climate – solar radiation, atmospheric temperature, pressure, wind, moisture, fog & dews, clouds and precipitation; Global atmospheric circulation; Weather analysis and forecasting; Climatic classification; Climatic regions of India, Indian monsoon [8]

III. Environmental chemistry: Chemical bonds and chemical reactions; Rate of reaction, rate law, adsorption - physisorption and chemisorption, adsorption-isotherms, organic compounds – hydrocarbons and polymer chemistry; Biological chemistry – chemistry of carbohydrate, nucleic acids, enzymes; Green chemistry – concept, green catalyst; Material life cycle and application of green chemistry [12]

IV. Principles of analytical methods: Design of sampling techniques (air, soil, biological matters); Principles of analytical methods – Chromatography, HPLC, GC-MS; Atomic absorption spectroscopy, Flame photometry; Spectrophotometry, Electrophoresis, TGA, XRF,

XRD, NMR, FTIR, SEM & TEM [12]

Course outcomes

- Students will be able to learn origin of Earth along with various geologic and geomorphic processes, including fundamentals of climatology
- Students will be able to develop skill on various analytical techniques and their applications

MENVCCT103
Total lecture hours: 40
Credits: 4 (4T) : Marks: 50 [I.A.(10) + E.T. (40)]

ENVIRONMENTAL BIOLOGY

Course objectives

- To develop the fundamentals of evolutionary biology, taxonomic importance and community structure
- To develop the basic concepts of ecological modelling

I. Evolution: Fundamentals of evolutionary processes; Origin of life; Modern synthesis: Role of natural selection, genetic drift, evolutionary divergence, patterns of speciation, population genetics [08]

II. Biological diversity: Brief accounts of microbes (air, water & soil), plants and animals; Principles of taxonomy – nomenclature, an outline of classification and identification [07]

III. Community ecology: Community structure, factors influencing the structure of communities, community dynamics, species diversity in communities, pattern in communities; Ecological succession – causes, trends, of succession, basic types of succession, general process of succession, climax concept, community restoration, chaos and limit cycles, community stability [15]

IV. Systems based modelling techniques: Types of models,dynamic (SIR model, prey-predator models) and static models (ENA); Introduction to basic software on modeling; Optimal foragingtheory, chaos and limit cycles, community stability [10]

Course outcomes

- Students will be able to gain the basic knowledge on evolutionary processes
- Students will be able to understand the taxonomic characterization, systematics, and basics of nomenclature
- Students will be able to acquire detailed knowledge on community ecology
- Students will be able to develop an understanding on concepts of ecological modelling and its applications

MENVCCT104

Total lecture hours: 40

Credits: 4 (4T): Marks: 50 [I.A. (10) + E.T. (40)]

ENVIRONMENTAL MICROBIOLOGY

Course objectives

- To improve the knowledge on fundamentals of microbiology and its applications

I. General microbiology: General idea about bacterial morphology -- shape, size, structure; Chemistry and function of capsule, pilus, membrane, cell wall, plasmid and chromosome, replication of bacterial nucleus; fungal morphology; Distinctive properties of virus, nucleicacids, life cycle pattern of bacteriophages; Major waterborne and airborne diseases [15]

II. Food Microbiology: Contamination and microbial spoilage of fresh food and its preservation; Food adulteration; Fermented food; Food poisoning; Bacterial infections and intoxications, viral food borne illness, types of microorganisms used, pasteurization [05]

III. Microbial transformations of pesticides: Fundamental reactions of pesticide metabolism; Major steps of biotransformation, e.g., B-oxidation, oxidative dealkylation, decarboxylation, epoxidation, etc.; Hydrolysis, halogen reactions, nitro reactions; Basic ideas on microbial kinetics [10]

Microbial transformations of potentially toxic metals (PTMs): Microbes in metal containing habitat, metal-microbes interactions, microbial immobilization and transformation of metals, microbial application of metal removal [10]

Course objectives

- Students will acquire the knowledge about fundamentals of microbiology
- Students will be able to understand the different applications

of microbiology in food science, microbial transformations of pesticides, metals etc.

MENVCCS105

Total lecture hours: 40
Credits: 4 (8P):: Marks: 50 [I.A.(10) + E.T. (40)]

PRACTICAL ON PHYSICAL ENVIRONMENT

1. Measurement and preparation of Oxygen Profile in aquatic ecosystem
2. Macroscopic and microscopic identification of igneous, sedimentary and metamorphic rocks, common minerals; Study of fossils with reference to paleoenvironment
3. Morphometric analysis of drainage system
4. Handling of meteorological data recording equipment; Construction of wind rose
5. Physicochemical analysis of water and soil parameters
   a) Meteorological parameters: Temperature, moisture, humidity, light
   b) Soil parameters: pH, organic matter, N, P, K; Cation Exchange Capacity (CEC)
6. Laboratory Note book

7. Viva-voce

MENVCCS106

Total lecture hours: 40
Credits: 4 (8P) :: Marks: 50 [I.A.(10) + E.T. (40)]

PRACTICAL ON ENVIRONMENTAL BIOLOGY

1. Estimation of abundance: Quadrate counts, line transects and distance method
2. Spatial pattern analysis and indices of dispersion

3. Determination of species diversity by diversity indices
4. Collection, isolation and population study of microorganism in air, water and soil
5. Study of pond biota – phytoplankton, zooplankton and macrophytes; and staining of plankton
6. Laboratory Note book
7. *Viva-voce*

Suggested Book list for Environmental Science in M. Sc.

Semester I

Environmental Science — S. C. Santra, New Central Book Agency.
Environmental Science; Cunningham & Saigo WCB McGraw Hill, 1999-5th Den.
Environmental Science: Enger & Smith. *7th Den*, McGraw Hill
Fundamental of Ecology, E.P. Odum, W.B. Sauders Company, USA.
Concept of Ecology, E. J. Kormondy, Prentice Hall of India Pvt. Ltd.
Environmental Biology, Biswarup Mukherjee, Tata McGraw Hill Co. Ltd., New Delhi.
Ecology a bridge between science & society, by E. P. Odum, Sinauer associates
Environmental Geology, Edward A. Keller, Prentice Hall, New Jersey.
Physical Chemistry, P.C. Rakshit, Sarat Book House, Calcutta.
Environmental Chemistry, A. K. De, New Age (p.) Ltd.
Fundamentals of Environmental Chemistry, Manban, S.E., Lewis Publishers.
Elements of Bioinorganic Chemistry, G. N. Mukherjee, Arabinda Das, U. N. Dhar & Sons Pvt.Ltd.
Atmospheric Chemistry & Physics, Sainfeld, John Wiley & Sons. Inc.
Chemistry for Environmental Engineering, Sway, Mcarthy &Parkin ; Tata Mc. Graw-Hill.
The Chemistry of Nanoparticles: synthesis, properties and application C. N. R. Rao, A Muller, A. K. Cheetham, Wiley-VCH, Verlag GMBH, Germany.
Principles of Systematic Zoology, E. Mayr and Peter D Ashlock,

McGRAW-HILL, INC
Principles of Animal Taxonomy, G G Simpson, Columbia University Press
Elements of Ecology, Smith and Smith, Pearson Publication
Ecology: Experimental analysis of Distribution and Abundance, C. J. Krebs, Harper-Row
Ecology, Ricklefs and Miller, Freeman 4th Ed.
Microbiology, *Pelzer*, M. J. Chan, E.C.S. and Kreig, N. R. McGraw-Hill Publishing Company.
Wastewater Microbiology, Bitton, G., John Wiley, NY.

Semester II

MENVCCT201
Total lecture hours: 40
Credits: 4 (4T) : Marks: 50 [I.A.(10) + E.T. (40)]

ECOTOXICOLOGY & PHYSIOLOGICAL PROCESSES

Course objectives

- To develop the fundamental knowledge on ecotoxicology and physiological responses, biochemical targets etc.
- To develop knowledge about enzymology, immunology and immunotoxicology

I. Toxicology: Principles of toxicology; Elements and areas of toxicology; Acute and chronic toxicology; Dose-response relationship; Statistical concept of LD_{50} and LC_{50}; Chemical and biological factors and their influences, bioassay methods, routes of entry of toxicants; Interaction of toxicants [12]

II. Biochemical aspects of heavy metals: Sources, distribution, mechanism of action, effects and remedial measures of some heavy metals like arsenic, cadmium, lead, mercury, aluminium, chromium [08]

III. Biochemical aspects of some specific industrial toxicants: Sources,

distribution, mechanism of action, effects and remedial measures of some specific toxicants like MIC, pharmaceutical active compounds (PACs) . [8]

IV. Enzymology and Immunology & Immunotoxicology: Basic concepts of enzyme kinetics; Mechanism of enzyme action
Properties of immune response; Innate and acquired immunity; Cells and organs of immune system; Concepts of antigens; Concept of antibodies with special reference to structure, function, classification; Antigen antibody interaction, major histocompatibility complex; Cell mediated and humoral immunity; Effects of toxicants on immune system, toxicant-induced autoimmunity & immunosuppression [12]

Course outcomes

- Students will gain fundamental knowledge of ecotoxicology
- Students will be able to understand biochemical aspects of different xenobiotics, industrial toxicants etc.
- Students will be able to understand the basics of enzymology, immunology and immunotoxicology

MENVCCT202

Total lecture hours: 40

Credits: 4 (4T): Marks: 50 [I.A. (10) + E.T. (40)]

ENVIRONMENTAL GEOSCIENCE

Course objectives

- To build up the fundamental knowledge of geoscience and its application in identifying natural resources and natural hazards and their consequences as well as minimization
- To develop the knowledge on different aspects of environmental meteorology and climatology

I. Land resources and management: Land resources, landdegradation cycle, land-use pattern, land reform, land use plan, soil surveys in relation to land use planning; methods of site selection and evaluation [06]

II. Water resources management and its environment*:* World water balance, surface water and groundwater and their interaction; Environmental factors affecting groundwater level fluctuations, water

quality, use of water, conservation of water resources, climate change impacts on water resource management [06]

III. Mineral resources and environment: Geology and mineral resources; Distribution of mineral resources in India; Environmental impact of mineral development; Recycling of mineral resources; Minerals and sustainability [08]

IV. Environmental meteorology: Atmospheric stability, adiabatic character; Turbulence and diffusion, application of meteorology to air pollution study [06]

V. Environmental climatology: Climatic change in of recent times; Identification and characteristics of bio-climatic and agro-climatic regions of India; Urban Climate: Concept of Heat Island; Climate and human comfort [08]

Natural hazards: Earthquakes, Landslides, Cyclones & Tornedos,Floods and Lightening – Origin, effects and minimization and perception of hazards in Indian context [06]

Course outcomes

- The students will be able to build the fundamental knowledge of geoscience to identify all natural resources
- The students will be able to develop the skill on different aspects of environmental meteorology and climatology
- The students will be able to understand different types of natural hazards and their consequences, and mechanism of minimization of different natural hazards

MENVSCCT203

Total lecture hours: 40

Credits: 4 (4T) : Marks: 50 [I.A.(10) + E.T. (40)]

ENERGY RESOURCE & ENVIRONMENTAL STATISTICS

Course objective

- To develop an understanding of energy resources and its management
- To get know-how of statistics for ecological and environmental data analysis

I. Energy and environment: Energy budget of the earth; Earth's thermal environment and seasons; Sun as a source of energy, solar radiation and its spectral characteristics

Conventional energy sources: Fossil fuels; Nuclear energy - fission and fusion; non-conventional energy sources: Solar, hydropower wind, geothermal and ocean energy, energy from biofuels, biogas and biomass, energy use patterns in different parts of the world and India and its impact on the environment [16]

II. Energy management: Energy consumption; Energy conservation, increased efficiency, and cogeneration, energy policy, integrated energy management (energy-audit & green-audit), management of nuclear energy wastes, some conservation factors, research and development on renewable energy. [08]

III. Environmental statistics: Basic elements and tools of statistical data analysis, bivariate and multivariate data; Statistical measures - mean, median, standard error and deviation; Testing of hypothesis: Null and alternative hypothesis, parametric and nonparametric test; Level of significance, degree of freedom, t-test; probability; ANOVA [16]

Course outcomes

- Students will be able to understand about of energy resources, the impacts and its management
- Students will be able to apply knowledge of statistics for ecological and environmental data analysis

MENVCCT204

Total lecture hours: 40

Credits: 4 (4T):: Marks: 50 [I.A.(10) + E.T. (40)]

ENVIRONMENTAL POLLUTION & DEGRADATION

Course objectives

- To have a better understanding and knowledge of different types of pollution, causes and mitigation strategies

I. Air Pollution: Criteria pollutants; National Ambient Air Quality Standard; Motor vehicle emissions; Status of air pollution in Indian cities; Different control measures; Indoor air quality - exposure assessment, infiltration and ventilation; Indoor air quality model [08]

II. Water pollution: Sources, types and consequences; Inorganic and organic pollutants; Concept of eutrophication, DO, BOD, COD; Sewage and groundwater pollution; Status 50of water pollution in different water bodies with reference to Indian context; Water purification techniques [07]

III. Noise pollution: Sources of noise, types of noise; Noise and health; Sonic boom; Noise measurement; Measurement of noise indices (Leq, L10, L90, L50, LDN, TNI); Control of noise pollution; Noise mapping and modelling; Impact of noise and vibrations on human health [08]

IV. Radiation pollution: Radioactivity in the environment; Radiation exposure and radiation standards, radiation protection; Biological effects of radiations; Pollution from electric power generation plant and nuclear plants, thermal pollution – Sources, causes and consequences . [07]

V. Soil pollution: Sources, effect of soil pollution on biota, surface water and groundwater regimes; Impact of different pesticides (herbicides, insecticides, fungicides, nematicides, rodenticides *etc*.); Synthetic fertilizer (NPK) [10]

Course outcomes

- Students will be able to understand about the types of pollutions, sources, impacts and the mitigation practices.

MENVCCS205
Total lecture hours: 40
Credits: 4 (8P)
Marks: 50 [I.A.(10) + E.T. (40)]

PRACTICAL ON ENVIRONMENTAL PROBLEMS

1. Analysis of Water parameters: Salinity, conductivity, sulfate, phosphate, nitrate-nitrogen, ammoniacal-nitrogen, residual chlorine, sodium and potassium
2. Ambient air sampling, monitoring and analysis
3. Measurement of noise level by noise meter in different zones (as per CPCB guidelines)
4. Laboratory Note book
5. *Viva-voce*:

MENVCCS206
Total lecture hours: 40
Credits: 4 (8P)
Marks: 50 [I.A.(10) + E.T. (40)]

PRACTICAL ON ECOTOXICOLOGICAL MEASUREMENTS

1. Measurement of LC_{50}/LD_{50} and safe concentration of xenobiotics/toxicants
2. Impact of agrochemicals on hydrophytes, xerophytes and mesophytes
3. Effect of pesticides on total sugar content of different crops
4. Effect of pesticides and heavy metals on total protein content of different crops and aquatic vertebrates
5. Lay out of experimental design (RBD; split-plot etc.,); Cluster analysis; Sampling techniques and statistical analysis of experimental design
6. Laboratory Note book
7. *Viva-voce*

Suggested Book list for Environmental Science in M. Sc.

Semester II

Toxicants in the aquatic ecosystem, T. R. Crompton, John Wiley & Sons, NY.

Casarett & Doull's Toxicology, The basic Science of poisons, 2nd Den, Editors, J. Doull, C.D. Klaassen, M.O. Amdur, Macmillan Publishing Co. Inc., NY.

Statistics for environmental Biology and Toxicology, W. W. Piegorsh & A. J. Bailer.

Environmental Geology, Edward A. Keller, Prentice Hall, New Jersey.

Geology Environment Society, K,.S.Valdiya, University press

Environmental Metereology, B. Padmanabha Murthy, I.K. International

Atmosphere, Weather and Climate, Roger G.Barry Richard J. Charley,Routledge (Taylor &Francis group)

Coping with natural hazards: Indian Context, K.S. Valdiya,Orient Longman .

Environmental Geology, C.W. Montgomery , Mc. Graw Hill International.

Environmental Statistics and data analysis, Ott, W. R., Lewis Publishers, New Jersey.

Statistical Methods, G. W. Snedecor & W. G. Cochran.

Statistics for environmental Biology and Toxicology, W. W. Piegorsh & A. J. Bailer.

Soils – their properties & management, Peter E. V. Charman, Oxford Univ. Press.

Introductory Soil Science, D.K.Das , Kalyani Publishers.

Environmental Noise Pollution and Its Control, Chhatwal, Mehra Katyal, Satake Katyal, Nagahiro, Anmol Publications (Pvt.) Ltd., New Delhi.

Environmental radiation and thermal pollution and their control, G. R. Chhatwal *et al*., Anmol Publications (Pvt.) Ltd., New Delhi.

Elements of the nature & properties of soils, Nyle C Bardy, Prentice Hall, New Jersey.

Understanding environmental pollution, Marquita K. Hill, Cambridge

Uniersity Press, 1997.
Air pollution and climate change, Alan Wellburn-2nd Edn., Longman, 1998.

ENVIRONMENTAL SCIENCE

SIDHO-KANHO-BIRSHA UNIVERSITY

DRAFT M. Sc. SYLLABUS

SEMESTER III & IV

[CHOICE BASED CREDIT SYSTEM]

Prepared by

Department of Environmental Science

SKBU

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Semester III

MENVCCT 301 [Core]

Total lecture hours: 40

Credits: 4 (4T):: Marks: 50 [I.A.(10) + E.T. (40)]

BIODIVERSITY CONSERVATION & SUSTAINABLE DEVELOPMENT

Course objectives

- To acquire knowledge on different aspects of biodiversity
- To understand the importance of sustainable development
- To get an overall knowledge and technique on applications of bioremediation

I. Biodiversity: α β, γ biodiversity; Genetic species and ecosystem diversity; Biological diversity and biogeography; Bioprospecting and biopiracy; CITES; 'Hotspots' of biodiversity; Strategies for biodiversity conservation; Conventions on Biodiversity; National Biodiversity Authority; Indian board on Wildlife; Values of biodiversity; Principles and strategies of protected area network, sacred groves, sanctuary, national park, biosphere reserve, zoological and botanical gardens, wild life tourism and wildlife refuges; Ecotourism, Wildlife Protection Act, 1972 amended 1993; IPR and IPP in biodiversity; Climate change and biodiversity, Concept of restoration ecology, Conservation of livestock biodiversity, Biodiversity Act 2002, The Biodiversity rules 2004.

[20]

II. Sustainable development: Concept, theories and principles, sustainable management practices in agriculture, forestry, aquaculture, industrial development, urban development; Sustainable development goals

[05]

III. Bioremediation: Concept, practices and applications; Factors influencing bioremediation; Microbial process of bioremediation; Phyco- and Phytoremediation; types, mechanism and case studies, Microbial removal of nitrogen and phosphorus; Bioremediation of contaminated water: Case studies on Water hyacinth pond, Algae fish pond, the duckweed pond and the reed beds; specific bioremediation technologies.

[15]

Course outcomes

- Students will be able to understand the different levels biodiversity, different strategies of biodiversity conservation
- Students will be able to understand the fundamentals of sustainable development and its importance and practices
- The students will be able to understand the concept of bioremediation
- They will learn about factors, microbial process of bioremediation, phytoremediation, an some typical cases studies

MENVCCT 302 [Core]

Total lecture hours: 40

Credits: 4 (4T):: Marks: 50 [I.A.(10) + E.T. (40)]

EMERGING ENVIRONMENTAL PROBLEMS, HEALTH HAZARDS & GENETIC ENGINEERING

Course objectives

- To develop an understanding on different emerging environmental problems
- To impart knowledge on different environmental health issues and safety
- to develop the basic understandings of genetic engineering, environmental mutagens & genetic disorders

I. Emerging Environmental Problems: Environmental problems in developing countries – High-rise buildings, urban slum; Rural and urban sanitation problems, Greenhouse gases and global warming, carbon trading and sequestration; ODS and its impact on global climate; Nuclear winter - Concept and prediction; Chemistry of nanoparticles- synthesis, characterization, application and environmentalhealth impacts

[10]

II. Environmental health and safety: Concept of health and disease; health impacts of hazardous waste, Principles of epidemiology; Epidemiology of communicable (AIDS, TB) and non- communicable diseases (Cancer, Diabetes, CVD) – Brief notes; occupational health; Communication for health education; Health planning and management, Health risks for industrial workers, safety of industrial workers-health insurance, policy issues and welfare programs [10]

III. Principle of genetic engineering: Concept, cell cycles, gene cloning; genetics responses of microorganisms with reference to pollutants; GMO and its merits and demerits; Conservation of gene resources; Recombinant DNA technology and its applications and limitations; Biological nitrogen fixation and its associated molecular mechanisms

[10]

IV. Environmental mutagenic and genetic disorders: Mutagenesis mechanism: UV-induced (cyclo-butane type pyrimidine dimmers), single strand DNA breaks, chemical induced DNA alkylation,abduct formation, intra- and inter-strand cross-linking; Enzyme mediated photo repair and excision repair; environmental carcinogens-categories, actions and toxic effects

[10]

Course outcomes

- students will be able to understanding the different emerging environmental issues and their possible impacts
- the knowledge on possible mitigation strategies
- students will be able to understand the different environmental health issues including communicable and non-communicable diseases, occupational health, safety & its management
- students will be able to learn the basics of genetic engineering, mutagens & different genetic disorders

MENVCCT 303 [Core]

Total lecture hours: 40

Credits: 4 (4T): Marks: 50 [I.A. (10) + E.T. (40)]

REMOTE SENSING & GIS

Course Objectives

- To develop the conceptual understanding on Remote sensing & GIS, their uses/applications through software, digital image processing techniques
- To make the students aware about environmental applications of RS & GIS

I. Concept of map, coordinate and projection: Classification of map; map scale; Spatial referencing system; Map projections; Commonly used map projections; grid systems [10]

II. Basic principles of remote sensing-: Electromagnetic remote sensing process; Physics of radiant energy; Energy source sources and radiation principles; Energy interactions in the atmosphere; Energy interaction with earth surface materials; An ideal remote sensing system [10]

III. Remote sensing platforms and sensors: Satellite system parameters; Resolutions; Imaging sensor systems - Active and passive; Different types of satellite with special emphasis on Indian remote sensing satellites; Drone based remote sensing
[08]

IV. Digital image processing: Basic character of digital image; Importance of image processing; Basic image enhancement techniques; Colour representations and transformations; Geometric and atmospheric corrections; Saptial filtering technique; Image classification - Unsupervised and supervised
[08]

V. Fundamentals of Global Navigation Satellite System (GNSS) and Geographic Information System (GIS) [06]

VI. Environmental Application of Remote sensing and GIS: Land use/landcover mapping; Agricultural, water resource, disaster management and forestry application [03]

Course outcomes

- the students will learn about the basics of Remote sensing and GIS with some open source of GIS software for effective applications
- students will be able to develop the skill on digital image processing, GNSS, etc.
- the students will be aware about environmental applications of RS & GIS in different fields

Semester III (GE: General Elective)

MENVOET304 [GE]

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

ENVIRONMENTAL PERSPECTIVES

I. Environmental Issues: Basic ideas on ecosystem and community; Environmental issues; Conservation and environmentalism; Environmental ethics and philosophy; Environmental education; Ecofeminism, environmental agenda; Concept on climate change and its Conventions [06]

II. Medical Geology: Perspectives and concepts; Geological sources of nutrients, mineral elements needed for good health; Dietary sources of essential mineral elements; Pathways and exposure with reference to arsenic and fluoride in groundwater [08]

III. Environmental Health and Diseases: Fundamentals of health and diseases; Principle of communicable and non-communicable diseases; Chemicals in food-preservatives, artificial sweetening agents, elementary idea of antioxidants, antibiotics, antacids; Health programmes in India; Hospital waste management
[08]

IV. Medical Microbiology: Concept of pathogens; Infection and intoxication; Epidemics & Pandemics; Causative agents, symptoms, mode of transmission, prevention and treatment [08]

V. Environmental regulations: Constitutional provisions and Rules & Regulations; Statutory boards of pollution control, *viz*., CPCB, SPCB, Green Tribunal [04]

MENVCCS305-1 (DE)

Total lecture hours: 40

Credits: 4 (8P)

Marks: 50 [I.A.(10) + E.T. (40)]

PRACTICAL on RS & GIS, EIA & DISEASES

1. Georeferencing and mosaicing of images/Toposheets
2. Digital image processing: Image enhancement technique; FCC, NDVI
3. Classification of image
4. Digitization and Cartographic representation
5. Characterization of wastes and waste water: BOD; COD; MLSS; MLVS
6. Identification (with characters) of some parasitic and other pathogenic diseases
7. Laboratory Note book
8. Viva-voce

or

MENVCCS305-2 (DE)

Total lecture hours: 40

Credits: 4 (4T/8P) :: Marks: 50 [I.A. (10) + E.T. (40)]

ECOLOGICAL MODELLING AND GIS FOR ENVIRONMENTAL APPLICATIONS

Course objectives

- To instruct the students about the basics of GIS and ecological modelling
- To teach environmental application of GIS & ecological modelling

I. Spatial analysis: Scope of spatial analysis and modelling; Spatial query and Reclassification; Geometric and distance measurement; Overlay analysis and map algebra; Spatial interpolation [10]

II. Spatial data exploration with statistics: Exploratory spatial data analysis; Spatial sampling; Measures of spatial distributions; Analysis of spatial patterns; Detection of spatial clusters; Modelling of spatial relationships [10]

III. Modelling concept: Model as a management and scientific tool; Modelling elements; Modelling procedure; Sensitivity analysis; Calibration and validation of model [10]

IV. Types of models: Dynamic models; Static models; Population models; Biogeochemical models [10]

Course outcome

- Students will be able to develop different ecological model using GIS & other software's
- Students will be able to apply the ecological models in prediction, forecasting of environmental pollutions, environmental hazards, ecological issues etc.

or

MENVCCS305-3 (DE)

Total lecture hours: 40

Credits: 4 (4T):: Marks: 50 [I.A. (10) + E.T. (40)]

ECOTOXICOLOGY & INDUSTRIAL MICROBIOLOGY

COURSE OBJECTIVES

- To develop an understanding on ecotoxicology and various environmental contaminants and their effects at molecular and community levels
- To develop a detailed concept on Environmental Microbiology and Industrial microbiology

I. Ecotoxicology: Historical background, objectives and need of ecotoxicology. Environmental contaminants: Scientific and technological goal of study of environmental contaminants, major classes of contaminants; Emerging contaminants of concern *e.g.,* PBDE or BDE, halogenated and phenols, POPs, PCB, dioxins; Chemical mutagenesis: Base substitutions, insertions and deletions, spontaneous mutations [10]

II. Molecular effects: General cytotoxicity and histopathology; DNA modification; Oxidative stress and antioxidant response; Biochemical mechanism of toxicity; Immuno-toxicology; Behavioural toxicology, pharmaceutical toxicology, phytotoxicology [10]

III. Community ecotoxicology: Definition, historical perspective; biotic and abiotic factors; biomonitoring and the responses of communities to contaminants [10]

IV. Environmental Microbiology: Microbial flora of soil, interactions among soil microorganisms, biogeochemical role of soil microorganisms, microbiology of domestic water and wastewater - determining sanitary quality [05]

V. Industrial microbiology: Microorganisms and industry, industrial uses of bacteria, yeasts, molds; Petroleum microbiology, microbiology and mining, deterioration and materials like paper, textiles and cordage, painted surfaces

[05]

Course outcome

- Students will be able to understand the principles of ecotoxicology and different ~~various~~ environmental contaminants
- Students will be able to know toxicity of various xenobiotics at molecular levels and community involvement
- Students will be able to understand the environmental microbiology, industrial microbiology and its different applications

MENVCOP306

Credits: 4

Marks: 50 [I.A. (10) + E.T. (40)]

COMMUNITY ENGAGEMENT ACTIVITIES

Preparation of report on field visit (Industrial effluent treatment plants/ water treatment plants/ waste

disposal systems/ waste disposal systems/ waste water treatment plants/ recycling systems/ power generation plants etc.). Student has to prepare a field report for submission after visit and necessary evaluation at the end of Sem III. Preparation of field work copy [10]

For outreach programme students have go with respective mentor to nearby school/college with proper presentation for creating/generating awareness among the students. Authority of school/college will provide a certificate of performance of each student participated in the programme. [10]

Semester IV

MENVCCT401

Total lecture hours: 40

Credits: 4 (4T): Marks: 50 [I.A. (10) + E.T. (40)]

ENVIRONMENTAL IMPACT ASSESSMENT & ENVIRONMENTAL LAWS

Course objectives

- to develop the concept of EIA, different methods of evaluation
- to make the students familiar with different international & national laws pertaining to ~~of~~ environmental protection

I. Environmental Impact Assessment: Concept, aims and objectives of EIA; Environmental Impact Statement (EIS) and Environmental Management System (EMS); Environmental audit; EIA guidelines, 1994 &2006; Notification of GoI; Revised notification, Sept. 2006; Life cycle assessment

[10]

II. EIA techniques and methods: Evaluation of methodologies, different methods - Ad Hoc, Checklist, Overlay, Matrix, use of Computers & Expert system; EIA and planning and management; Prediction and assessment of impacts on the air, water, soil, and noise environment; Process of reviewing EIA of developmental projects

[10]

III. Environmental protection & Laws – Issues and problems; International and National efforts for Environment Protection; Provisions in constitution of India regarding Environment (Article 48A and 58A); Principles and objectives; Air (Prevention and Control of Pollution) Act, 1981; The Water (Prevention and Control of Pollution) Act, 1974 as amended up to 1988; The Environment (Protection) Act, 1986 and Rules 1986; Public Liability Insurance Act, 1991 and Rules 1991; Role of Supreme

Court and Green Bench of High Court on environment protection in India; Plastic waste (management rules) 2016; e-waste (management rule) 2016; the construction and demolition (management rule) 2016 [12]

Course out comes

- students will be able to develop the concept on EIA and its evaluation methods through different techniques and methods
- students will be able to learn the different international & national laws for environment protection and safety

MENVCCT402 [Core]

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

ENVIRONMENTAL TOXICOLOGY& BIOTECHNOLOGY

Course objective

- to study the source, origin and effects of various toxic materials on biological systems
- to study the impacts of different industrial effluents on environment
- to study the importance of hazardous wastes, different disposal methods, and valorization techniques
- to study different applications of environmental biotechnology

I. Toxicology and Toxic responses: General toxic responses of cell, organs, nervous system, gastrointestinal tract, liver, kidney; Bioaccumulation and biomagnifications of toxicants in ecosystem; Genetic toxicology; Food additives; Synthetic dyes; PAHs, PAN, VOC and POP; Microplastics & microbeads; Chemical carcinogens; Mutagenicity; Teratogenicity [20]

II. Impacts of industrial effluents: General impacts of some effluents discharged from paper and pulp industry, sugar, distillery, tannery, mining, sponge-iron on ecosystem with special reference to occurrence, environmental sources, biochemical effects, and remedial measures [08]

III. Hazardous wastes: Waste & waste types - Solid waste, Municipal solid waste, agricultural, industrial & mining; Hazardous waste - nature, categories, & threat; Waste problems & solutions: Sources, reduction, recycling; Methods of disposal; Waste to energy; Waste valorization [08]

IV. Environmental Biotechnology: Concept and overview of application areas in environmental biotechnology; biofertilizers, bio-composting, vermicomposting, biopesticides [04]

Course out comes

- students will be able to understand the fate of xenobiotics from source to biological body and final disposal
- students will be able to understand the impacts of different industrial discharges, their mitigation measures
- students will be able to understand the types, impacts and management techniques of different hazardous wastes and their best and appropriate uses
- students will be able to understand the importance of different applications of environmental biotechnology

MENVMET403-1 [DE]

Total lecture hours: 40

Credits: 4 (4T): Marks: 50 [I.A. (10) + E.T. (40)]

ENVIRONMENTAL ISSUES, ECONOMICS & ENVIRONMENTAL MANAGEMENT

Course Objectives

- to develop the knowledge regarding theories and issues of environmental economics, EMS
- to make the students conversant with disaster management and waste management techniques

I. Environmental Economics: Concept of ecological economics; Environmental economics and principles; Cost-benefits analysis; Economics of environmental quality; Concept of green fund and green subsidy, Polluter pays principles; Carbon trading; Trade and environment; Externalities, green policies, common resource management systems [10]

II. Environmental Management System: Environmental system principles, tools and management strategies; Environmental management systems & standards (ISO 9001 & 14000 series); Perspectives of environmental management policy in India; Eco-labelling schemes, Ecological foot print and emission trading [12]

III. Natural disaster management: Major global disaster framework - IDNDR, HUGO, MDG, SDG, SFDRR, COP 26, PMTPA; HVCR; DM Act, plan and policies in India [08]

IV. Waste management: Methods of disposal and management of wastes (Municipal, Bio-medical, hospital wastes, sewage and Hazardous e-waste); Composting, vermicomposting, pyrolysis, biomethanation; Electrical energy generation from solid wastes (Fuel pallets, refuse derived fuels) [08]

Course outcome

- the students will understand how to apply theories of economics in sustainable development
- the students will learn different tools and techniques of environmental management, disaster management, waste management
- students will be able to develop the concept on disposal, uses and recycling methods of wastes

OR

MENVMET403-2 [DE]

Total lecture hours: 40

Credits: 4 (4T) :: Marks: 50 [I.A.(10) + E.T. (40)]

ENVIRONMENTAL ENGINEERING AND SCIENCE

Course Objectives

- to develop the knowledge regarding water quality, waste water engineering, air pollution engineering
- to make the students familiar with different techniques of air pollution control & monitoring of air pollution
- to make the students aware about engineering aspects of wastewater treatment, air pollution control and monitoring

I. Water quality and regulation: Potable water, surface water, waste water, groundwater; Water quality assessment: Physico-chemical and biological surveillance, biological indices, pollution indices, diversity indices, chemical indices [10]

II. Drinking water contamination: Problems derived from resources, water quality problems derived from water treatment, -from distribution, -from home plumbing situations [07]

III. Waste water engineering: Properties of waste water, composition, sewage collection, charging; Waster-water treatment: Requirement of treatment, pre-treatment, design of wastewater treatmentplants; Biological aspects of secondary sewage treatment and other biological treatment processes; Anaerobic treatment; Physico-chemical treatment process; Activated sludge and sludge treatment; Household treatment systems [15]

IV. Air Pollution and Control Engineering: Ambient air quality and standards, Climatic and Meteorological effect on air pollution, formation of smog and fumigation, Introduction to air pollution control, Control of gaseous contaminants [08]

Course outcome

- the students will be able to understand the methods of measurement of water quality parameters, different standards & regulations of water quality
- the students will be able to learn different techniques of wastewater treatment with its engineering aspects
- students will be able to learn different techniques of air pollution control and monitoring with its engineering aspects

MENVCCS404-1 [DE]

Total lecture hours: 40

Credits: 4 (8P)

Marks: 50 [I.A.(10) + E.T. (40)]

PRACTICAL ON TOXICOLOGICAL TESTING

Course objectives

- to develop the analytical skills for different environmental and biological parameters
- to develop ~~offer~~ the hands-on experience of environmental impact assessment procedure and preparation of report

1. Measurement of LC_{50}/LD_{50} and safe concentration of toxicants

2. Quantitative estimation of residual heavy metals in the tissue of aquatic vertebrates with special reference to fish by Atomic Absorption Spectrometer

3. Study on chronic toxicity

4. Study on toxicological biomarkers *viz*., Histopathological, Morphoanatomical (GaSI, GSI, HIS, RLG, Fecundity)

5. Study on toxicological response through biochemical tests *viz*., amylase, lipase, protease activity etc.

6. Preparation of report (Case Studies on EIA).

Course outcomes

- students will be able to analyses different environmental as well as biological parameters
- students will be able to prepare the draft EIA report

OR

MENVCCS404-2 [DE]

Total lecture hours: 40

Credits: 4 (8P)

Marks: 50 [I.A.(10) + E.T. (40)]

PRACTICAL ON SPATIAL DATA ANALYSES AND ECOLOGICAL MODELLING

Course objectives

- to develop the analytical skills of the students
- to teach different software's related to data analysis & ecological modelling

1. Query build up; Reclassification
2. Buffer; Overlay and Dissolve operation
3. Spatial interpolation
4. Nearest neighbor analysis
5. Tools in STELLA software
6. Construction of Conceptual diagram
7. Application of models in Environmental processes

Course outcomes

- analytical skill of the students will be developed
- students will be able to learn different software's related to data analysis & ecological modelling
- students will be able to apply their knowledge in research

Semester IV

MENVACT405 (add on course)

Credit: 4

Marks: 50 MENVMEP406

[Project/Term paper]

DISSERTATION WORK/PROJECT WORK/INTERNSHIP

Credits: 04

Marks: 50

Course objectives

- to develop the research outlook, research skill and data evaluation through research methodology
- to develop the analytical skill of the students
- to enhance the employability skill of the students

Internal assessment: 10

Grand viva: 10

Submission of Dissertation/Project report/Internship report: 30

Suggested Book list for Environmental Science in M. Sc.

Semester III & IV

1. Environmental Science: S.C. Santra, New Central Book Agency
2. Ecology and Environment: P.D. Sharma., Rastogi Publication.
3. Fundamental of Ecology: E.P.Odum,W.B.Sauders Company,USA
4. Agrawal, Sikdar and Deb (2002): A Text book of Environment; MacMillan
5. Botkin & Keller (1998): Environmental Science: Earth as a Living Planet; John Wiley & Sons
6. Elements of Ecology: Thomas M Smith & Robert Leo Smith; LPE, Pearson Education
7. Principles of Environmental Science: Inquary and Applications: William P Cunningham & Mary Ann Cunningham; The McGraw-Hill Companies, 4th Edn.
8. Cell and Molecular Biology: Concept and Experiments, 3rd Edn, Gerald Karp, John Willey & Sons, INC, New York, 2002
9. Cell and Molecular Biology, EDP De Robertis, EMF De Roberts, Jr, 8th Edn, Lea & Febiger, International Edition, 1988
10. Clean technology, Johansson, A., Lewis Publishers.
11. Phytoremediation: Methods & Reviews (HB): Springer Humana; Willey
12. Fischer (1984): Resources and Environment Economics, CUP Dasgupta (1982): The Control of Resources; Basil Blackwell
13. Georgeacus-Roger (1971): The Entropy Law and Economic Process; HUP
14. Concard and Clerk (1987): Natural Resources Economics; CUP
15. Fundamental of Physical Geography, Majid Husain, Rawat publications
16. Remote sensing and GIS, Basudeb Bhatta, Oxford publisher
17. Basic of Remote sensing and GIS, S.Kumar
18. Remote sensing and image interpretation, Lillesand, Kiefer and Chapman, Wiley publisher
19. Fundamental of Remote Sensing, George Joseph, University Press
20. Environmental Impact Assessment, Canter, L. McGraw Hill
21. Barrow (1997): Environmental and Social Impact Assessment: An Introduction, John Wiley & Sons
22. Canter (1996): Environmental Impact Assessment; McGraw-Hill, Inc
23. Casarett and Doull's Toxicology: The Basic Science of Poisons, 2nd Edn. John Doull, Curtis D Klaassen and Mary O Amdur; Macmillan Publishing Co. Inc. Canada
24. Fundamentals of Ecotoxicology, 3rd Edn., Michael C Newman, CRC Press, Taylor & Francis Group, London,, 2010
25. Principles of Biochemical Toxicology, 3rd Edn, Jogh Timbrell, Taylor & Francis , 2000
26. Environmental Toxicology, David A Wright, and Pamela Welbourn, Cambridge University Press, 2002
27. Environmental Impact Assessment: A Guide to Best Professional Practices (HB) Taylor & Francis (CRC)

28. Environmental Biotechnology (PB): CBS; Allen, K

29. Introduction to Environmental Engineering and Science: Gilbert M Masters; Pearson Edition, 2007
30. Textbook of Environmental Biotechnology: Pradipta K Mohapatra, I K International Publishing house, Bangalore, 2006
31. Economics of Environment, Dorfman and Dorfmann
32. Souvorov, A.V. 1999. *Marine Ecologonomics: The Ecology and Economics of Marine Natural Resource 33. Management*. Elsevier Publications.
33. Wainwright, M. 1999. *An Introduction to Environmental Biotechnology*. Springer.