

**UNIVERSITY DEPARTMENTS**  
**ANNA UNIVERSITY CHENNAI :: CHENNAI 600 025**  
**REGULATIONS - 2009**  
**CURRICULUM I TO IV SEMESTERS (FULL TIME)**  
**M.Sc. ENVIRONMENTAL SCIENCE**  
**SEMESTER – I**

Sl.No.	Code No.	Course Title	L	T	P	C
<b>THEORY</b>						
1	MA9113	<a href="#">Statistical Methods</a>	3	1	0	4
2	ES9112	<a href="#">Environmental Policies and Legislation</a>	3	0	0	3
3	ES9113	<a href="#">Microbiology of Environment</a>	3	0	0	3
4	ES9114	<a href="#">Applied Ecology</a>	3	0	0	3
5	ES9115	<a href="#">Principles of Sustainable Development</a>	3	0	0	3
6	ES9116	<a href="#">Air Pollution Control</a>	3	0	0	3
<b>PRACTICAL</b>						
7	ES9117	<a href="#">Practical I (Microbiology)</a>	0	0	4	2
<b>TOTAL</b>			<b>18</b>	<b>1</b>	<b>4</b>	<b>21</b>

**SEMESTER – II**

Sl.No.	Code No.	Course Title	L	T	P	C
<b>THEORY</b>						
1	ES9121	<a href="#">Chemistry of Environment</a>	3	0	0	3
2	ES9122	<a href="#">Principles of Water and Wastewater Treatment</a>	3	0	0	3
3	ES9123	<a href="#">Environmental and Socio Impact Assessment</a>	3	0	0	3
4	ES9124	<a href="#">Environmental Toxicology</a>	3	0	0	3
5	ES9125	<a href="#">Operation and Maintenance of Effluent Treatment Plants</a>	3	0	0	3
6	ES9126	<a href="#">Solid and Hazardous Waste Management</a>	3	0	0	3
7	ES9127	<a href="#">Global Warming and Climate Change</a>	3	0	0	3
<b>PRACTICAL</b>						
8	ES9128	<a href="#">Practical II (Chemistry)</a>	0	0	4	2
<b>TOTAL</b>			<b>21</b>	<b>0</b>	<b>4</b>	<b>23</b>

**SEMESTER – III**

Sl.No.	Code No.	Course Title	L	T	P	C
<b>THEORY</b>						
1	ES9131	<a href="#">Environmental Analytical Techniques</a>	3	0	0	3
2	ES9132	<a href="#">Environmental Management Systems and Auditing</a>	3	0	0	3
3	E1	Elective – I	3	0	0	3
4	E2	Elective – II	3	0	0	3
5	E3	Elective - III	3	0	0	3
6	ES9133	Project Seminar	0	0	2	1
<b>TOTAL</b>			<b>15</b>	<b>0</b>	<b>2</b>	<b>16</b>

### SEMESTER – IV

Sl.No.	Code No.	Course Title	L	T	P	C
<b>THEORY</b>						
1	E4	Elective – IV	3	0	0	3
	<b>E5</b>	<b>Elective – V</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
2	ES9141	Project Work	0	0	20	10
TOTAL			<b>3</b>	<b>0</b>	<b>20</b>	<b>16</b>

**TOTAL CREDITS : 76**

### ELECTIVES

Sl.No.	Code No.	Course Title	L	T	P	C
<b>Theory</b>						
1	ES9151	<a href="#">Marine Resources and Management</a>	3	0	0	3
2	ES9152	<a href="#">Geo-Informatics for Environmental Monitoring</a>	3	0	0	3
3	ES9153	<a href="#">Occupational Health and Industrial Safety</a>	3	0	0	3
4	ES9154	<a href="#">Disaster Management and Mitigation</a>	3	0	0	3
5	ES9155	<a href="#">Bio Energy</a>	3	0	0	3
6	ES9156	<a href="#">Biotechnology for Environmental Remediation</a>	3	0	0	3
7	ES9157	<a href="#">Nuclear Waste Management</a>	3	0	0	3
8	ES9158	<a href="#">Sustainable Aquaculture</a>	3	0	0	3
9	ES9159	<a href="#">Ecotourism</a>	3	0	0	3
10	ES9160	<a href="#">Biodiversity Conservation</a>	3	0	0	3

**OBJECTIVE:**

To impart knowledge on the policies, legislations, institutional frame work and enforcement mechanism for environmental studies

**UNIT I INTRODUCTION 9**

Indian Constitution and Environmental Protection – National Environmental policies – Precautionary Principle and Polluter Pays Principle – Concept of absolute liability – multilateral environmental agreements and Protocols – Montreal Protocol, Kyoto agreement, Rio declaration – Environmental Protection Act, Water (P&CP) Act, Air (P&CP) Act – Institutional framework (SPCB/CPCB/MoEF)

**UNIT II WATER (P&CP) ACT, 1974 8**

Power & functions of regulatory agencies - responsibilities of Occupier Provision relating to prevention and control Scheme of Consent to establish, Consent to operate – Conditions of the consents – Outlet – Legal sampling procedures, State Water Laboratory – Appellate Authority – Penalties for violation of consent conditions etc. Provisions for closure/directions in apprehended pollution situation.

**UNIT III AIR (P&CP) ACT, 1981 8**

Power & functions of regulatory agencies - responsibilities of Occupier Provision relating to prevention and control Scheme of Consent to establish, Consent to operate – Conditions of the consents – Outlet – Legal sampling procedures, State Air Laboratory – Appellate Authority – Penalties for violation of consent conditions etc. Provisions for closure/directions in apprehended pollution situation.

**UNIT IV ENVIRONMENT (PROTECTION) ACT 1986 13**

Genesis of the Act – delegation of powers – Role of Central Government - EIA Notification – Siting of Industries – Coastal Zone Regulation - Responsibilities of local bodies mitigation scheme etc., for Municipal Solid Waste Management - Responsibilities of Pollution Control Boards under Hazardous Waste rules and that of occupier, authorisation – Biomedical waste rules – responsibilities of generators and role of Pollution Control Boards

**UNIT V OTHER TOPICS 7**

- (a) Relevant Provisions of Indian Forest Act, Public Liability Insurance Act, CrPC, IPC
- (b) Public Interest Litigation - Writ petitions - Supreme Court Judgments in Landmark cases.

**REFERENCES**

1. CPCB (1997) "Pollution Control acts, Rules and Notifications issued there under "Pollution Control Series – PCL/2/1992, Central Pollution Control Board, Delhi.
2. Shyam Divan and Armin Roseneranz "Environmental law and policy in India "Oxford University Press, New Delhi (2001).
3. Greger I.Megregor (1994) "Environmental law and enforcement", Lewis Publishers, London.

**OBJECTIVE:**

To educate the students in the area of air, water and soil microbiology and the applications of microorganisms in wastewater treatment and reclamation of pollutants.

**UNIT I INTRODUCTION 5**

Classification and Culturing of microorganisms, Isolation of microorganisms – Pure culture technique – Enrichment culture – Preservation of microorganisms – Identification – Biochemical and Molecular Biology Techniques - Microbial nutrition – Carbon, nitrogen, sulfur – Effective Microbial Solution..

**UNIT II MICROBIAL PHYSIOLOGY 10**

Microbial enzymes – Classification, Characteristics, Nomenclature, nature and metabolism of enzyme action, Regulation of enzymes – Principles of Bioenergetics – Respiration – aerobic, Anaerobic – Energy production by aerobic processes – Biochemical Calculations.

**UNIT III MICROBIOLOGY OF ENVIRONMENT 10**

Distribution of microorganisms in contaminated sites - soil, air, water – Interaction of Microorganisms - Characteristics – Factors affecting Microbial Population –Algae in water supply systems – Problems and control — Extremophiles – Adaptation and survival

**UNIT IV MICROBIOLOGY OF WASTEWATER TREATMENT 10**

Microbial Growth Kinetics - Pollutants in Wastewater – Organic, inorganic —  $\alpha$ -oxidation,  $\beta$ -oxidation, nitrification, denitrification – Degradation of toxic pollutants.

**UNIT V APPLICATION OF MICROORGANISMS FOR RECLAMATION 10**

Microorganisms as sources of protein – Biofertilizer – Bacterial, fungal, algal – Biocontrol agents – Enzyme production by microorganisms, chemotherapeutic agents – Redox reactions in Microbial degradation of macromolecules – Soil, water and air.

**REFERENCES**

1. Maier.R.M., Pepper I.L. and Gerba C.P., Environmental Microbiology Academic Press Inc.- 1999.
2. Pelczar, Jr.M.J., Chan., E.C.S., Krieg, R.Noel and Pelczar Merna Foss, Microbiology, 5<sup>th</sup> Edn., Tata Mc Graw Hill Publishing company Ltd., New Delhi – 1996.
3. Dubey, R.C. and Maheshwari, D.K. A text book of Microbiology, Chand and Company Ltd., New Delhi – 2002.

**OBJECTIVE:**

To provide students with an overview of applied ecology from the level of the individual organism to populations, communities and ecosystems.

**UNIT I INTRODUCTION 8**

Concepts of ecology, Structural and Functional Analysis of ecosystems, Community Structure, Ecosystem Productivity, Biogeochemical Cycles – Energy flow through ecosystems, Ecological succession and disturbance – Invasive species.

**UNIT II ECOSYSTEMS OF THE WORLD 10**

Terrestrial ecosystems – Forests – Grasslands – Deserts. Aquatic ecosystems – Freshwater – Marine – Estuarine. Biogeography of Ecosystems. Population Ecology – Properties of Populations – population Growth and Regulation – Inter and intraspecific Competition – Life History Patterns. Human Impact on ecosystems.

**UNIT III ECOLOGICAL ECONOMICS 10**

Valuing ecosystems – Market and non market valuation – Environmental Accounting – Environmental indicators.

**UNIT IV RESTORATION ECOLOGY 9**

Principles of restoration ecology – Disturbance and recovery – Restoring damaged sites Role of Protected Areas – International conventions and their role in ecorestoration.

**UNIT V ECOLOGICAL ENGINEERING AND ECOTECHNOLOGY 8**

Ecosystem modeling – Natural systems of waste water treatment – Ecological effects of waste treatment – Ecological remediation, Landscape Ecology.

**L : 45****TEXT BOOKS:**

1. Smith, R.L. and Smith, T.M. Elements of Ecology Benjamin Cummings 2003.
2. Odum, E.P. Fundamentals of Ecology, 1991, Indian Edition – Nataraj Publishers.
3. Roger Perman, Yu Ma and James McGilvray, 1997, Natural Resources and Environmental Economics, Second Edition, Addison Wesley Longman Ltd., Singapore.

**REFERENCES:**

1. Jorgensen, SE, 1986, Fundamentals of Ecological Modelling.

**OBJECTIVE:**

To introduce the concept of sustainable development and principles of environmental management to establish functional linkages among the social, economic and environmental spheres.

**UNIT I CONCEPT OF SUSTAINABLE DEVELOPMENT 9**

Definition of sustainability - History and emergence of the concept of sustainable development – Our Common Future - Objectives of Sustainable Development - Millennium Development Goals - Environment and Development linkages – Globalization and environment - Population, Poverty and Pollution – Global, Regional and Local environmental issues – Resource Degradation – Greenhouse gases and climate Change – Desertification – Industrialization – Social insecurity.

**UNIT II SUSTAINABILITY AND THE TRIPLE BOTTOM LINE 9**

Components of sustainability – Complexity of growth and equity - Social, economic and environmental dimensions of sustainable development – Environment – Biodiversity – Natural Resources – Ecosystem integrity – Clean air and water – Carrying capacity – Equity, Quality of Life, Prevention, Precaution, Preservation and Public participation.- Structural and functional linking of developmental dimensions – Sustainability in national and regional context

**UNIT III SUSTAINABLE DEVELOPMENT AND INTERNATIONAL RESPONSE 9**

Role of developed countries in the development of developing countries – International summits – Stockholm to Johannesburg – Rio Principles – Agenda 21 - Conventions – Agreements – Tokyo Declaration-Doubling statement-Transboundary issues – Integrated approach for resource protection and management

**UNIT IV SUSTAINABLE DEVELOPMENT OF SOCIO-ECONOMIC SYSTEMS 9**

Demographic dynamics of sustainability – Policies for socio-economic development – Strategies for implementing eco-development programmes – Sustainable development through trade – Economic growth – Action plan for implementing sustainable development – Urbanization and Sustainable Cities – Sustainable Energy and Agriculture – Sustainable Livelihoods – Ecotourism

**UNIT V FRAMEWORK FOR ACHIEVING SUSTAINABILITY 9**

Sustainability indicators - Hurdles to Sustainability - Operational guidelines – Interconnected prerequisites for sustainable development – Empowerment of Women, Children, Youth, Indigenous People, Non-Governmental Organizations, Local Authorities, Business and Industry - Science and Technology for sustainable development –Performance indicators of sustainability and Assessment mechanism – Constraints and barriers for sustainable development.

L = 45

**REFERENCES:**

1. Sayer, J. and Campbell, B., The Science of Sustainable Development : Local Livelihoods and the Global Environment (Biological Conservation, Restoration & Sustainability), Cambridge University Press, London, 2003.
2. Kirkby, J., O'Keefe, P. and Timberlake, Sustainable Development, Earthscan Publication, London, 1993.
3. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publications, London, 1998.
4. Bowers, J., Sustainability and Environmental Economics – An Alternative Text, Longman, London, 1997.

**OBJECTIVE:**

To impart knowledge on the principles and design of control of indoor / particulate / gaseous air pollutant and its emerging trend

**UNIT I BASIC CONCEPTS 12**

The structure of atmosphere – Definition, Scope and Scales of Air Pollution – Sources of air pollution – Natural and Artificial, Classification of Pollutants, Quantity and Composition of particulate and gaseous pollutants – Effect of different air pollutants on man, animals, vegetation, property, aesthetic value and visibility, Air Pollution Episodes, Air Pollution monitoring and regulatory control, Ambient Air Quality standards, Emission limits, Ambient Air and stack sampling, Equipment for Ambient Air and stack sampling, Methods of sampling.

**UNIT II METEOROLOGY AND AIR POLLUTION 8**

Different Meteorological factors – Lapse rate and stability of atmosphere – Inversion, Wind patterns, direction, speed – Models of diffusions and dispersion plume behaviour, stack height.

**UNIT III CONTROL OF PARTICULATE AND GASEOUS POLLUTANTS 12**

Working principle of various types of particulate control equipment – settling chamber, cyclone separators and scrubbers, fabric filters and electrostatic precipitators, Working principles of various types of gaseous pollutant equipment – incineration, absorption, adsorption, condensation and bio filters.

**UNIT IV EMERGING TRENDS 8**

Indoor Air Quality Management – Sources, Types and control of Indoor Air Pollutants – Radon Pollution and its control – Vehicular pollution and its control – UV Photolysis – Membrane Process.

**UNIT V NOISE CONTROL 5**

Sources and effects of Noise Pollution – Noise standards – Measurement – Modeling – Preventive and Control Measures.

**L:45****REFERENCES:**

1. Lawrence K. Wang, Norman C. Pareira, Yung Tse Hung, Air Pollution Control Engineering, Tokyo, 2004
2. Arthur C. Stern, 'Air Pollution (Vol.I – Vol.VIII)', Academic Press, 2006.
3. Wayne T. Davis, 'Air Pollution Engineering Manual', John Wiley & Sons, Inc., 2000.
4. Anjaneyulu Y, 'Air Pollution & Control Technologies', Allied Publishers (P) Ltd., India, 2002.

**1. EMPIRICAL STATISTICS 9**

Types of Sampling – Description of discrete and continuous data – Measures of central tendency and dispersion for grouped and ungrouped data – Measures of position – Box and Whisker plot.

**2. ONE DIMENSIONAL RANDOM VARIABLES 9**

Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions.

**3. ESTIMATION THEORY 9**

Unbiased Estimators – Method of Moments – Maximum Likelihood Estimation - Curve fitting by Principle of least squares – Regression Lines.

**4. TESTING OF HYPOTHESIS 9**

Sampling distributions - Type I and Type II errors - Tests based on Normal,  $t$ ,  $\chi^2$  and F distributions for testing of mean, variance and proportions – Tests for Independence of attributes and Goodness of fit.

**5. DESIGN OF EXPERIMENTS 9**

Analysis of variance – One-way and two-way classifications – Completely randomized design – Randomized block design – Latin square design.

**L +T: 45+15 = 60**

**BOOKS FOR REFERENCE:**

1. R.E. Walpole, R.H. Myers, S.L. Myers, and K. Ye, "Probability and Statistics for Engineers and Scientists", Pearson Education, Asia, 8<sup>th</sup> Edition, 2007.
2. R. A. Johnson and C. B. Gupta, "Miller & Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 7<sup>th</sup> Edition, 2007.
3. J. Medhi, "Statistical methods: an introductory text", New Age International (P) Limited, New Delhi, 2000.
4. J. N. Kapur & H. C. Saxena, "Mathematical Statistics", S. Chand & Company Limited, 20<sup>th</sup> Edition, 2001.

**OBJECTIVE:**

To educate and train the students in experiments related to microbiological analysis of air, water, soil and wastewater.

**LIST OF EXPERIMENTS:**

1. Study of instruments and equipments used in the Microbiology Laboratory.
2. Isolation and enumeration of microorganisms from air
3. Isolation and Enumeration of microorganisms from water
4. Isolation and Enumeration of microorganisms from soil
5. Determination of growth curve of bacteria
6. Identification of bacteria by staining techniques
7. Developing mutants by Physical Methods
8. Developing mutants by Chemical Methods.
9. Isolation of anaerobic bacteria
10. Estimation of DNA by spectrophotometer
11. Determination of molecular weight of DNA by electrophoresis.
12. Determination of Total coliforms and Faecal Coliforms by MPN technique.
13. Determination of coliforms by Membrane Filter Technique
14. Determination of Streptococcus faecalis.

**L = 60****REFERENCES**

1. Sukyta, B. Techniques in Applied Microbiology, Elsevier Science Publication, New York, USA 1995.
2. Salle, A.J., Fundamental Principles of Bacteriology, Tata Mc Graw Hill Publishing Co. Ltd., New Delhi, 1998.
3. Dubey, R.C. and Maheshwari, D.K., Practical Microbiology, S. Chand and Company Ltd., New Delhi, 2002.

**OBJECTIVE:**

To educate the students in the area of water, air and soil chemistry

**UNIT I GENERAL 10**

Stoichiometry – First and Second law of Thermodynamics – Gibb's free energy – Chemical potential – Oxidation and Reduction, Nernt equation pH-pE diagrams, Chemical Equillibria, Acid – Base reactions – Solubility product ,Application in heavy metals removal– Solubility of gases in water — Chemical kinetics – Colloids and Coagulation, water treatment- Sorption- Radio nuclides and nuclear energy.

**UNIT II AQUATIC CHEMISTRY 10**

Transport and transformation of chemicals – Phase Interactions Degradation of food stuffs(carbohydrates, proteins), Detergents, Pesticides, hydrocarbons(aliphatic and aromatic) – Photolysis – Volatility – Classification of elements — Complex formation — Hydrophobic interactions – Chemical speciation.

**UNIT III ATMOSPHERIC CHEMISTRY 9**

Photochemical reactions in the atmosphere- Degradation of VOCs– Chemical process for the formation of inorganic and organic particulate matter – Oxygen and Ozone chemistry.-Photochemical smog.

**UNIT IV SOIL CHEMISTRY 8**

Soil classification– Inorganic and organic components of soil –physical and chemical properties of soil- Acid -base and ion exchange reactions-Leaching-Salt affected soil.

**UNIT V GREEN CHEMISTRY 8**

Principles of green chemistry – Clean synthesis, – Atom economy – Environmental factor 'E' and Quotient 'Q', Nano materials, CNT,  $T_iO_2$ .

**L:45****REFERENCES:**

1. Manahan, S.E., Environmental Chemistry 7<sup>th</sup> Edition, Lewis publishers 2000.
2. Sawyer, C.N., MacCarty, P.L. and Parkin, G.F., Chemistry for Environmental Engineering and Science, Tata McGraw-Hill, fifth edition, 2003.
3. De, A.K. Environmental Chemistry, New Age International (P) Ltd, Publishers, Fourth Edition, (2001) New Delhi.
4. Gary W. Vanloon & S.J. Duffy, Environmental chemistry – A Global perspective, Oxford University Press, 1999.
5. Anastas, P.T. Warner, J.C. Green Chemistry Theory and Practice, Oxford University Press: New York, 1998.

## ES9122 PRINCIPLES OF WATER AND WASTEWATER TREATMENT

L T P C  
3 0 0 3

### OBJECTIVE:

To educate the students on the working principles of various physical, chemical and biological treatment systems for water and wastewater.

### UNIT I INTRODUCTION 3

Pollutants in water and wastewater -characteristics, Standards for performance - Significance and need for treatment.

### UNIT II PHYSICAL TREATMENT METHODS 12

Principles of Equalisation- Sedimentation - Filtration- Separation - vaporation- .Incineration - Adsorption- Gas transfer- Applications in water and wastewater treatment – Flowcharts - Adsorption - Principles, equilibria and kinetics - Reactors - regeneration, membrane separation, RO, ultra filtration and hyper filtration - electro dialysis, principles and applicability of distillation - stripping and crystallization - applications – Recent developments.

### UNIT III CHEMICAL TREATMENT METHODS 12

Principles of Chemical treatment - Precipitation - processes, hydroxide, Sulphide precipitation of complexed metals, solidification and stabilization - Photolysis, photochemical principles, application - chemical oxidation and reduction - Disinfection - Application in water and wastewater treatment - Ion exchange, Electrolytic Methods, soil remediation - ion-exchange, technology, applicability - Solvent extraction - Liquid membrane - photolysis- Advanced Oxidation Reduction methods - Applications.

### UNIT IV BIOLOGICAL PROCESSES IN WASTEWATER TREATMENT 6

Rationale of Biological Control of environmental Pollution – Role of Microorganisms  
0- Bacterial growth and Biological oxidation – Kinetics of Biological growth.

### UNIT V BIOLOGICAL POLLUTION CONTROL SYSTEM 12

Aerobic treatment processes – Suspended and attached growth processes. Activated sludge process, including variation Tricking filters, Rotating biological contactors Packed bed reactors and stabilization ponds, Anaerobic treatment processes- Anaerobic digester, septic tank, anaerobic filter, Upflow anaerobic sludge blanket reactor (UASB) and Anaerobic ponds- Biological Nutrient Removal - Nitrogen removal – Biological Phosphorous removal- Residual measurement – Sludge digestion – Sludge dewatering and disposal

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### REFERENCES

1. Metcalf and Eddy, Wastewater Engineering, Treatment and Reuse, Tata McGraw Hill, New Delhi 2003.
2. Eckenfelder, Jr., W.W. Industrial Water Pollution Control, McGraw- Hill, New York 2000.
3. Industrial Wastewater Treatment, Hand book Frank Woodard, Butter worth- Heinmann, New Delhi 2001.
4. Aceivala, S.J. "Wastewater Treatment for Pollution Control" Second Edition, Tata McGraw Hill New Delhi, 1998.
5. Narayana Rao. M. and Datta, A.K., "Wastewater Treatment ", Third Edition, Oxford and IBH Publication Co., New Delhi. 1998.

**OBJECTIVE:**

To expose the students to the need, methodology, documentation and usefulness of environmental impact assessment and to develop the skill to prepare environmental management plan.

**UNIT I INTRODUCTION 7**

Historical development of Environmental Impact Assessment (EIA). EIA in Project Cycle. Legal and Regulatory aspects in India. – Types and limitations of EIA – Cross sectoral issues and terms of reference in EIA – Public Participation in EIA. Eia process- screening – scoping - setting – analysis – mitigation

**UNIT II COMPONENTS AND METHODS FOR EA 10**

Matrices – Networks – Checklists – Connections and combinations of processes - Cost benefit analysis – Analysis of alternatives – Software packages for EIA – Expert systems in EIA. Prediction tools for EIA – Mathematical modeling for impact prediction – Assessment of impacts – air – water – soil – noise – biological — Cumulative Impact Assessment – Documentation of EIA findings – planning – organization of information and visual display materials – Report preparation. EIA methods in other countries.

**UNIT III SOCIO-ECONOMIC IMPACT ASSESSMENT 8**

Definition of social impact assessment. Social impact assessment model and the planning process. Rationale and measurement for SIA variables. Relationship between social impacts and change in community and institutional arrangements. Individual and family level impacts. Communities in transition - neighborhood and community impacts. Selecting, testing and understanding significant social impacts. Mitigation and enhancement in social assessment. Environmental costing of projects.

**UNIT IV ENVIRONMENTAL MANAGEMENT PLAN 10**

Environmental Management Plan - preparation, implementation and review – Mitigation and Rehabilitation Plans – Policy and guidelines for planning and monitoring programmes – Post project audit – Ethical and Quality aspects of Environmental Impact Assessment.

**UNIT V SECTORAL EIA 10**

EIA related to the following sectors - Infrastructure –construction and housing Mining – Industrial - Thermal Power - River valley and Hydroelectric – coastal projects- Nuclear Power. EIA for coastal projects.

**L: 45****REFERENCES:**

1. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, Wiley-Interscience, New Jersey. 2003
2. Petts, J., Handbook of Environmental Impact Assessment, Vol., I and II, Blackwell Science London. 1999
3. Canter, L.W., Environmental Impact Assessment, McGraw Hill, New York. 1996
4. World Bank –Source book

**OBJECTIVE:**

To impart knowledge on toxicology, risk assessment and remediation.

**UNIT I BIOCHEMICAL TOXICOLOGY 12**

Toxicants, Distribution, Metabolism of toxicants, sites of action, classification of toxicity – acute and sub-acute toxicity bioassay, Factors influencing toxicity, Elimination of toxicants, Methods of toxicity testing – Evaluation - statistical assessment, sediment toxicity, Bio- chemical markers/indicators, Toxicokinetics, Bioconcentration, Bio-accumulation and Bio magnification in the environment.

**UNIT II GENETIC TOXICOLOGY 12**

Xenobiotics – Chemical carcinogenesis – Genotoxicity assays – Neurotoxicity, Skin toxicity, Immunotoxicity. Renal toxicity, Endocrine disruptors, hormones, receptors.

**UNIT III INDUSTRIAL TOXICOLOGY 8**

Toxicity of monomers, solvents, intermediates, products – toxic substrates – Metals and other inorganic Chemicals, Organic Compounds – Persistent chemicals.

**UNIT IV RISK ASSESSMENT AND REMEDIATION 8**

Procedures for assessing the risk – Risk measurement and Mitigation of environmental disorders – Factors in risk assessment.

**UNIT V CASE STUDIES IN RISK ASSESSMENT 5**

Pharmaceutical, Petroleum, Carbide industry, Textile and Leather Industry Case study.

**L = 45****REFERENCES**

1. Crosby, D.G.1998. Environmental Toxicology and Chemistry, Oxford University Press, New York.
2. Hodgson, A. 2004, A text book of Modern Toxicology, John Wiley and Sons, Inc.NJ.
3. Walker, C. H. et al., 1996. Principles of Ecotoxicology, Taylor and Francis, Inc, ISBN 074803557.
4. Ballantyne, B. Marrs, T. M and Syversen, T. 1999. General and Applied Toxicology 2<sup>nd</sup> ed. Mac Millan Reference Ltd.
5. Hodson, E. and R.C. Smart, 2001, Introduction to Bio-chemical toxicology, Wiley Interscience, New York.

**ES9125 OPERATION AND MAINTENANCE OF COMMON EFFLUENT TREATMENT PLANTS**

**L T P C**  
**3 0 0 3**

**OBJECTIVE:**

To educate the student on the various Operation & Maintenance aspects of Common Effluent Treatment Plants.

**UNIT I ELEMENTS OF OPERATION AND MAINTENANCE OF WASTEWATER TREATMENT PLANTS 6**

Introduction - Plant operation roles - Plant Maintenance program- Knowledge of process and equipment - Proper and adequate tools - Spare units and parts - Laboratory control- Records and Reports- House keeping - Safety measures - Corrosion prevention and control – Industrial effluent management units – Effluents - Effluent management - Waste minimization - Process modification - Clean technology developments - Effluent treatment scheme

**UNIT II COMMON EFFLUENT TREATMENT PLANTS (CETPS) – SUSTAINABILITY 6**

Operation - disposal of effluent and residues - Constraints - Number and type of contributing units - Plant capacity – Location - Ownership and management - Management structure - Influent and effluent characteristics - Collection and conveyance system- -Effluent treatment plant - Treatment process at CETPs – Case Studies.

**UNIT III SAMPLING AND ANALYSIS OF EFFLUENTS 12**

Introduction - Sampling procedures - Analysis of samples of effluents - Determination of pH using pH meter – Colour – Conductivity – Solids - Estimation of dissolved oxygen (D.O) – winkler’s method - Estimation of biochemical oxygen demand (BOD) - Estimation of biochemical oxygen demand (COD) - Estimation of chloride (Mohr’s method) - Estimation of Sulphate (turbidimetric method) - Code of practice for analytical laboratories - Work tables – Glassware – Safety - Handling in laboratory - Pipetting and others - Laboratory equipment and glassware’s – Equipments - Glassware’s – Case Studies.

**UNIT IV OPERATION AND MAINTENANCE OF TREATMENT UNITS 12**

Screening - Bar screens - Equalisation - Equalisation basins - Strategy for operation – Physico-chemical treatment- processes- Chemical storage and mixing equipment - Chemical metering equipment - Positive displacement pumps - Flash mixer – Clarifiers - Operation guidelines for clarifier - Operation and maintenance - Start-up and maintenance inspection – General - Motors and Divers – Pumps - Chemical feed systems - Rapid mix and flocculators – Clarifiers - Normal operation - Chemical feed system - Flash mixer - Flocculation tanks – Clarifiers - Abnormal operation - Safe working habits - Jar test for selection of coagulant and their dosages- Sludge management – Case Studies.

## **UNIT V OPERATION AND MAINTENANCE OF COLLECTION AND CONVEYANCE SYSTEMS 9**

Operation and Maintenance of wastewater collection and conveyance systems - Functions of collection system – Components of collection system – Conduits or pipes – Manholes – Ventilating shaft – Maintenance of collection system – Problems generally faced – Clogging of pipes – Hazards – Precautions – Precautions against gas hazards – Precautions against infections – Devices for cleaning the conduits – Preventive maintenance – Corrective maintenance – Case Studies.

**L = 45**

### **REFERENCES:**

1. Ghose D.N. (1991) "Operation and Maintenance of Sewage treatment plants CBS publishers and distributors, Delhi.
2. Kenneth D. Kerri, Bill B. Dendy, John Brady and Willam Crooks (1996) "Industrial Waste Treatment – A field study training program" Third edition, prepared by California sate University in Cooperation with the California water pollution on control association for the USEPA.
3. Metcalf and Eddy (1996) "Wastewater Engineering – Treatment – Disposal – Reuse" Tata McGraw Hill. 3rd Edition.
4. Sawyer C.N. Mccarty P.L. and Parkin G.F. (1994) "Chemistry for Environmental Engineering" McGraw Hill publishers.
5. UNIDO (1999) "Manual on Design, Operation and Maintenance of Tannery Effluent Treatment Plant" UNIDO, regional workshop, 13 – 14 October

**OBJECTIVE:**

To impart knowledge on the elements of managing solid waste from municipal and industrial sources and application of principles related to these topics including design criteria, methods and equipments.

**UNIT I SOURCES , CLASSIFICATION AND REGULATORY FRAMEWORK 9**

Types and Sources of solid and hazardous wastes - Need for solid and hazardous waste management – Elements of integrated waste management and roles of stakeholders - Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, lead acid batteries, electronic wastes , plastics and fly ash – Financing waste management.

**UNIT II WASTE CHARACTERIZATION AND SOURCE REDUCTION 8**

Waste generation rates and variation - Composition, physical, chemical and biological properties of solid wastes – Hazardous Characteristics – TCLP tests – waste sampling and characterization plan - Source reduction of wastes –Waste exchange - Extended producer responsibility - Recycling and reuse

**UNIT III STORAGE, COLLECTION AND TRANSPORT OF WASTES 9**

Handling and segregation of wastes at source – storage and collection of municipal solid wastes – Analysis of Collection systems - Need for transfer and transport – Transfer stations Optimizing waste allocation– compatibility, storage, labeling and handling of hazardous wastes – hazardous waste manifests and transport

**UNIT IV WASTE PROCESSING TECHNOLOGIES 10**

Objectives of waste processing – material separation and processing technologies – biological and chemical conversion technologies – methods and controls of Composting - thermal conversion technologies and energy recovery – incineration – solidification and stabilization of hazardous wastes - treatment of biomedical wastes

**UNIT V WASTE DISPOSAL 9**

Waste disposal options – Disposal in landfills - Landfill Classification, types and methods – site selection - design and operation of sanitary landfills, secure landfills and landfill bioreactors – leachate and landfill gas management – landfill closure and environmental monitoring – closure of landfills – landfill remediation

**L=45****REFERENCES**

1. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, "Integrated Solid Waste Management, Mc-Graw Hill International edition, New York, 1993.
2. CPHEEO, "Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organisation , Government of India, New Delhi, 2000.
3. Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans and Environmental Resources Management, Hazardous waste Management, Mc-Graw Hill International edition, New York, 2001.
4. Vesilind P.A., Worrell W and Reinhart, Solid waste Engineering, Thomson Learning Inc., Singapore, 2002.

**OBJECTIVE:**

To educate the students, to understand the earth climate systems and global warming, the impact of climate change on society and the adaptation and mitigation measures of climate change impacts.

**UNIT I EARTH'S CLIMATE SYSTEM. 9**

Introduction-Climate in the spotlight - The Earth's Climate Machine – Climate Classification - Global Wind Systems – Trade Winds and the Hadley Cell – The Westerlies - Cloud Formation and Monsoon Rains – Storms and Hurricanes - The Hydrological Cycle – Global Ocean Circulation – El Nino and its Effect - Solar Radiation –The Earth's Natural Green House Effect – Green House Gases and Global Warming – Carbon Cycle.

**UNIT II OBSERVED CHANGES AND ITS CAUSES. 9**

Observation of Climate Change – Changes in patterns of temperature, precipitation and sea level rise – Observed effects of Climate Changes – Patterns of Large Scale Variability – Drivers of Climate Change – Climate Sensitivity and Feedbacks – The Montreal Protocol – UNFCCC – IPCC –Evidences of Changes in Climate and Environment – on a Global Scale and in India – climate change modeling.

**UNIT III IMPACTS OF CLIMATE CHANGE. 9**

Impacts of Climate Change on various sectors – Agriculture, Forestry and Ecosystem – Water Resources – Human Health – Industry, Settlement and Society – Methods and Scenarios – Projected Impacts for Different Regions– Uncertainties in the Projected Impacts of Climate Change – Risk of Irreversible Changes.

**UNIT IV CLIMATE CHANGE ADAPTATION AND MITIGATION MEASURES 9**

Adaptation Strategy/Options in various sectors – Water – Agriculture -- Infrastructure and Settlement including coastal zones – Human Health – Tourism – Transport – Energy – Key Mitigation Technologies and Practices – Energy Supply – Transport – Buildings – Industry – Agriculture – Forestry - Carbon sequestration – Carbon capture and storage (CCS)- Waste (MSW & Bio waste, Biomedical, Industrial waste – International and Regional cooperation.

**UNIT V CLEAN TECHNOLOGY AND ENERGY. 9**

Clean Development Mechanism –Carbon Trading- examples of future Clean Technology – Biodiesel – Natural Compost – Eco- Friendly Plastic – Alternate Energy – Hydrogen – Bio-fuels – Solar Energy – Wind – Hydroelectric Power – Mitigation Efforts in India and Adaptation funding.

**L: 45**

## REFERENCES

1. IPCC Fourth Assessment Report – The AR4 Synthesis Report,
2. IPCC Fourth Assessment Report – Working Group I Report, “The Physical Science Basis”,
3. IPCC Fourth Assessment Report – Working Group II Report, “Impacts, Adaptation and Vulnerability”,
4. IPCC Fourth Assessment Report – Working Group III Report, “Mitigation of Climate Change”.
5. Dash Sushil Kumar, “Climate Change – An Indian Perspective”, Cambridge University Press India Pvt. Ltd, 2007
6. Jan C. van Dam, Impacts of “Climate Change and Climate Variability on Hydrological Regimes”, Cambridge University Press, 2003.

**OBJECTIVE:**

To train the students in the laboratory in the determination of pollutants present in air, water, wastewater and soil.

**LIST OF EXPERIMENTS:**

1. Calibration of Pipette
2. Measurement of pH of water & sludge soil sample using pH meter
3. Measurement of Electrical Conductivity of aqueous solution using conductivity meter
4. Measurement of turbidity of water sample – Nephelometry
5. Determination of alkalinity of water sample by titrimetry
6. Determination of hardness of water sample by titrations (EDTA)
7. Determination of chloride of water sample by titrations (Mohr's method)
8. Determination of sulphate of water sample using colorimeter
9. Determination of phosphate of water sample using colorimeter
10. Determination of nitrite of water sample by azo dye method
11. Determination of ammonia in waste water sample
12. Determination of DO by Winkler's method
13. Determination of BOD of wastewater sample
14. Determination of COD of wastewater sample
15. Determination of SO<sub>2</sub> in air by spectrophotometric method
16. Determination of SPM using High volume sampler
17. Determination of potassium in soil.
18. Determination of surface area of activated carbon by acetic acid method
19. Determination of partition co-efficient of acetic acid between water & CCl<sub>4</sub>
20. Determination of rate constant of a wastewater treatment method

**L = 60****REFERENCES**

1. APHA, Standard methods for the Examination of Water and Wastewater, 20<sup>th</sup> Edition, Washington, 1998.
2. Rump, H.H., and H. Krist, Laboratory Manual for the Examination of water, wastewater and soil – Second Edition, VCH, Germany, 1992.
3. WHO, Selected Methods of Measuring Air Pollutants, Geneva, 1996.
4. Warren, J.Lyman, William F. Reehi and D.H. Rosen Blaff, 'Handbook of Chemical property Estimation Methods', ACS, 1990.

**OBJECTIVE:**

To educate the students on the analytical techniques of environmental disturbances with reference to air, water and soil.

**UNIT I INTRODUCTION****7**

Objectives of monitoring-Monitoring net work, Planning ,system design- Sampling devices, preservation ,Classification of analytical methods– Selection of a suitable method - Reliability of analytical data-Statistical analysis- Quality control and assurance, .

**UNIT II ELECTROANALYTICAL METHODS****8**

Principle, instrumentation and environmental applications of conductometry, potentiometry, coulometry, electrophoresis and polarography – Field Instruments.

**UNIT III SPECTROSCOPIC METHODS****12**

Principle, instrumentation and environmental applications of atomic emission, absorption and fluorescence spectroscopy – Molecular UV, visible, IR spectroscopy and scattering methods.

**UNIT IV CHROMATOGRAPHIC METHODS****6**

Principle, instrumentation and environmental applications of GC, HPLC and Ion chromatography.

**UNIT V OTHER METHODS****12**

Principle, instrumentation and environmental applications of NAA, XRF, XRD, SEM,TGA and Mass spectrometry, Continuous monitoring analysis – fluorescent analyzer for SO<sub>2</sub>, chemiluminescent analyzer for NO<sub>x</sub>, NDIR for CO, Flow injection analyzer.

**L : 45****REFERENCES**

1. Willard. H., Merritt, L., Dean, D.A. and Settle F.A., 'Instrumental Methods of Analysis', 7<sup>th</sup> edition, Wordsworth, New York, 1998.
2. Galen. W. Ewing, 'Instrumental Methods of Chemical Analysis 5<sup>th</sup> edition, McGraw Hill, New York., 1995.
3. Roger Reeve,Introduction to Environmental Analysis, John Wiley & Sons Ltd,2002
4. Fundamentals of Analytical chemistry, D.A. Skoog, D.M. West and F.J.Holler, Harcourt Asia PTE. Ltd., 7<sup>th</sup> edition, New Delhi,2001.

**OBJECTIVE:**

To impart an understanding of systems approach as per ISO 14001 and skills for the management of Environmental issues.

**UNIT I ENVIRONMENTAL MANAGEMENT STANDARDS 9**

Development, trade and environment linkages – Environmental guidelines - Business and Citizen Charters for Sustainable Production and Consumption - National policies on environment, abatement of pollution and conservation of resources - Environmental quality objectives – Environmental standards - Concentration and Mass standards- Effluent and stream standards – Emission and ambient standards - Minimum national standards - Measuring performance evaluation: Indicators, Benchmarking - Systems approach to environmental management

**UNIT II PREVENTIVE ENVIRONMENTAL MANAGEMENT 9**

Pollution control *vis a vis* Pollution Prevention - Opportunities and Barriers – Cleaner production and Clean technology, closing the loops, zero discharge technologies - source reduction, raw material substitution, toxic use reduction and elimination, process modification – Cleaner Production Assessment- Material or resource balance – CP option generation and feasibility analysis

**UNIT III ENVIRONMENTAL MANAGEMENT SYSTEM 10**

EMAS, ISO 14000 - EMS as per ISO 14001– benefits and barriers of EMS – Concept of continual improvement and pollution prevention - environmental policy – initial environmental review – aspect and impact analysis – legal and other requirements- objectives and targets – environmental management programs – structure and responsibility – training awareness and competence- communication – documentation and document control – operational control – monitoring and measurement – management review

**UNIT IV ENVIRONMENTAL AUDIT 8**

Environmental management system audits as per ISO 19011- – Roles and qualifications of auditors - Environmental performance indicators and their evaluation – Non conformance – Corrective and preventive actions -compliance audits – waste audits and waste minimization planning – Environmental statement - Due diligence audit

**UNIT V APPLICATIONS 9**

Applications of EMS , Waste Audits and Pollution Prevention opportunities in Textile , Sugar, Pulp & Paper, Electroplating, Mining, petroleum refining, Tanning industry, Dairy, Cement, Chemical industries, etc

**L= 45****REFERENCES:**

- 1 Christopher Sheldon and Mark Yoxon, "Installing Environmental management Systems – a step by step guide" Earthscan Publications Ltd, London (1999)
- 2 Paul L Bishop 'Pollution Prevention: Fundamentals and Practice', McGraw-Hill International, Boston (2000).
- 3 ISO 14001/14004: Environmental management systems – Requirements and Guidelines – International Organisation for Standardisation, 2004
- 4 Is/ISO 19011: 2002, " Guidelines for quality and/or Environmental Management System auditing , Bureau of Indian Standards, New Delhi, 2002
- 5 Environmental Management Systems:An Implementation Guide for Small and Medium-Sized Organizations, Second Edition, NSF International, Ann Arbor, Michigan, January 2001

**OBJECTIVE:**

The course focuses primarily on marine resources. Particular emphasis will be given to teaching methodology for monitoring, managing and conserving marine resources in coastal environment.

**UNIT I MARINE ENVIRONMENT AND COASTAL PROCESS 8**

Seas and oceans, Continental area, Coastal zone, Properties of sea water, Coastal eco system, Communities of the marine environment, Marine Bio-diversity, Importance of Coastal Environment – food, transportation, recreation, Coastal hydrodynamics, Interaction between water and coastal sediments, shore line changes, sea level rise

**UNIT II MARINE RESOURCES 12**

Food web and energy fluxes, Nutrient enrichment, Biomass, Economic Importance of marine biota – Microbes, Benthos., Algae, Seaweeds Seagrass, Coral reef , Mangroves – importance, interaction of mangroves with other allied and nearby coastal ecosystems – estuaries, lagoons, salt marshes etc.

**UNIT III ENERGY RESOURCES 8**

Non living resources of the sea for human welfare, Energy – Tides, Waves, and Thermal, Exploration of minerals – Hydrocarbons, Manganese nodules, Heavy mineral deposition, Desalination of sea water.

**UNIT IV ENVIRONMENTAL AND SOCIO-ECONOMIC ISSUES 8**

Human intervention on marine resources, Marine pollution sources and effects, Need for conservation, Resource allocation conflicts, Coastal threats – Indian scenario, Coastal economic concepts, Issues in ecological security of coast - Protecting livelihood of coastal communities, stake holders.

**UNIT V COASTAL ZONE MANAGEMENT 9**

Ocean policy and legal issues – acts- Issues on EIA of coastal zone development, Need for conservation, Applications of Remote Sensing and GIS techniques in monitoring marine resources – Integrated coastal zone management, Exclusive Economic Zone, Marine bioreserves.

**L = 45****REFERENCES**

1. Newman, M.C., Roberts Jr. M. H., Male, R.C., (2002), 'Coastal and Estuarine Risk Assessment', Lewis Publishers. Washington , D.C
2. Maarten Bavinck, 'Marine Resources Management', Sage Publications India Private Limited, 1 edition (Mar 5 2001), M-32, Market , Greater kailash part 1, New Delhi -48.



**OBJECTIVE:**

To educate the students the health hazards expected and the safety measures to be followed in the industry.

**UNIT I INTRODUCTION****9**

Need for developing Environment, Health and Safety systems in work places. Status and relationship of Acts, Regulations and Codes of Practice. Role of trade union safety representatives. International initiatives. Ergonomics and work place.

**UNIT II OCCUPATIONAL HEALTH AND HYGIENE****9**

Definition of the term occupational health and hygiene. Categories of health hazards. Exposure pathways and human responses to hazardous and toxic substances. Advantages and limitations of environmental monitoring and occupational exposure limits. Hierarchy of control measures for occupational health risks. Role of personal protective equipment and the selection criteria. Effects on humans, control methods and reduction strategies for noise, radiation and excessive stress.

**UNIT III WORKPLACE SAFETY AND SAFETY SYSTEMS****9**

Features of the satisfactory design of work premises HVAC, ventilation. Safe installation and use of electrical supplies. Fire safety and first aid provision. Significance of human factors in the establishment and effectiveness of safe systems. Safe systems of work for manual handling operations. Control methods to eliminate or reduce the risks arising from the use of work equipment. Requirements for the safe use of display screen equipment. Procedures and precautionary measures necessary when handling hazardous substances. Contingency arrangements for events of serious and imminent danger.

**UNIT IV TECHNIQUES OF ENVIRONMENTAL SAFETY****9**

Elements of a health and safety policy and methods of its effective implementation and review. Functions and techniques of risk assessment, inspections and audits. Investigation of accidents- Principles of quality management systems in health and safety management. Relationship between quality manuals, safety policies and written risk assessments. Records and other documentation required by an organisation for health and safety. Industry specific EHS issues.

**UNIT V EDUCATION AND TRAINING****9**

Requirements for and benefits of the provision of information, instruction, training and supervision. Factors to be considered in the development of effective training programmes. Principles and methods of effective training. Feedback and evaluation mechanism.

**L = 45****REFERENCES**

1. Environmental and Health and Safety Management by By Nicholas P. Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995
2. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, Culinary and Hospitality Industry Publications Services 2005
3. The Facility Manager's Guide to Environmental Health And Safety by Brian Gallant, Government Inst Publ., 2007.



**OBJECTIVE:**

To impart knowledge on principles, technologies and economics of Bio-energy for Energy and environmental conservation.

**UNIT I INTRODUCTION 9**

Energy fundamentals- Biomass: Types – Advantages & Drawbacks – Indian Scenario - Potentials of solid and liquid wastes - agriculture - industrial - human origin (municipal and kitchen wastes) - quantities and characteristics- Bio Conversion Mechanisms. Fuel cells

**UNIT II BIOMETHONATION 9**

Microbial Systems – Phases in Biogas production – Parameters affecting gas production -Physical, chemical and engineering aspects of biogas - pressure, volume, temperature interaction. Anaerobic digestion - Biodegradation and Biodegradability of Substrate and layer stratification - distribution - pH, C/N ratio, retention period - Methanol, Ethanol Production - Fermentation - Anaerobic Digestion - Hydrogen and diesel Generation from Algae- Effect of additives on Biogas yield - alternate feedstock materials

**UNIT III COMBUSTION & GASIFICATION 9**

Strategies for bio-products production- Perfect, Complete & Incomplete combustion – Equivalence ratio – Fixed Bed, Fluid Bed – Fuel & Ash handling –Briquetting– Feed requirements & Preprocessing – Advantages – Drawbacks Types of Gasification – Comparison – Application – Performance Evaluation – Dual fuel engines – 100 % Gas Engines – Engine characteristics on gas mode – Gas cooling & cleaning train- Wood Gasifier- Operation and Maintenance

**UNIT IV PYROLYSIS & CARBONISATION 9**

Types – process governing parameters – Thermo gravimetric analysis – Differential thermal analysis – Differential scanning calorimetry – Typical yield rates and Liquefaction

**UNIT V ECONOMICS OF BIOENERGY 9**

Computational Tools for bioenergy (modeling, simulation, GIS) Commercialization of bioenergy technologies -Industrial Application - Viability of Energy Production - Environmental Aspects of Bioenergy Conversion -Socio-economic aspects - cost-benefit analysis.

**L: 45****TEXT BOOKS:**

1. G D Rai, Non Conventional Energy Sources, Khanna Publishers, New Delhi

**REFERENCES:**

1. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood, ichester, 1984
2. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986
3. Mahaeswari, R.C.Bio Energy for Rural Energisation, Concepts Publication, 1997
4. Tom B Reed, Biomass Gasification – Principles & Technology, Noyce DataCorporation, 1981
5. Best Practices Manual for Biomass Briquetting, I R E D A, 1997
6. Eriksson. S & M. Prior, The Briquetting of Agricultural Wastes for Fuel, FAO Energy & Environment Paper, 1990

**ES9156 BIOTECHNOLOGY FOR ENVIRONMENTAL REMEDIATION**  
**L T P C**  
**3 0 0 3**

**OBJECTIVE:**

To educate the students on the principles and application of biotechnology in remediation of pollutants.

**UNIT I BASIC CONCEPTS 5**

Principles and concepts of environmental biotechnology – Cell physiology – Important Microorganisms - Applications – Current status.

**UNIT II BIODEGRADATION OF TOXIC WASTES 8**

Xenobiotic compounds and recalcitrance – Biodegradation of Xenobiotics – adaptation of microorganisms for nutrients removal – microbial systems – cell and enzyme immobilization – degradation of toxic pollutants – hydrocarbons: non halogenated and halogenated – industrial application and concerns.

**UNIT III MECHANISM OF DETOXIFICATION 8**

Environmental fate of organic pollutants – mechanisms of detoxification – oxidation, reduction, and dehydrogenation – Microbial system for Heavy metal accumulation - Biotransformation of metals – Biosorption - Microbial leaching of metals – role of extracellular polymers to detect pollutants.

**UNIT IV BIO REMEDIATION 12**

Biotechnological remedies for environmental pollution – soil, water and air remediation – reclamation concepts bioremediation – biogas technology – Energy and fuel using microorganisms – utilization of energy – waste recovery – microalgal biotechnology and applications in agriculture – alternative strategies, Air Pollution and Deodorization process in Industry – Applications - Case study success stories.

**UNIT V RECOMBINANT DNA TECHNOLOGY AND INTELLECTUAL PROPERTY 12**

Concepts of rDNA technology, Isolation of DNA, Hybridization, Nucleic acid labeling – Plasmids, Cosmids – Expression vectors – cloning of DNA – transformation and expression – Mutation – Protoplast – isolation – purification – Growth and division of protoplast – protoplast fusion – applications, intellectual property rights – patents and trade marks.

**L : 45**

**REFERENCES**

1. Martin, A.M. (Ed.), Biological degradation of wastes, Elsevier Applied Science, London, 1991.
2. Purchit, S.S., Biotechnology – Fundamentals and Applications, Student Edition, India, 2004.
3. Manahan, S.E., Environmental Science and Technology, Lewis Publ., New York, 1997.
4. Foster, C.F. and D.A.J. Wase, Environmental Biotechnology,
5. Jogdand Environmental Biotechnology.

ES9157

**NUCLEAR WASTE MANAGEMENT**

**L T P C**  
**3 0 0 3**

**OBJECTIVE:**

To educate the students about the management and treatment of nuclear waste

**UNIT I GENERAL 9**

Nuclear Decay – Nuclear fuel cycle & Power generation Radiation sources, exposure & health effects – Regulation and standards of nuclear activities and regulatory agencies- Naturally occurring Radioactive Material.

**UNIT II RADIOACTIVE WASTES 9**

Classification, sources of LLW, 1LW, HLW and transuranic waste – Nature and signification -Pharmakinetics.

**UNIT III TREATMENT OF NUCLEAR WASTE 9**

Initial treatment of waste, conditioning process: Ion-Exchange, Vitrification, synthetic rock, volume reduction systems.

**UNIT IV LONGTERM MANAGEMENT OF WASTE 9**

Packaging and transportation storage, Geological disposal, transmutation, Reuse of waste, space disposal – Decontamination and decommissioning.

**UNIT V RADIATION MONITORING 9**

Radiation protection, control measures Dose limitation units, Determination of radiation exposure; Risk analysis Accidents involving radioactive waste.

**L : 45**

**REFERENCES**

1. Saling, James H and Audeen W. Fentiman, Radioactive Waste Management; 2<sup>nd</sup> Edn. Taylor and Francis. 2002
2. An introduction to nuclear waste immobilization M.I.Oiovan & W.E.Lee, Elsevier, 2005.

ES9158

**SUSTAINABLE AQUACULTURE**

**L T P C**  
**3 0 0 3**

**OBJECTIVE**

To impart knowledge on sustainable aquaculture practices and environmental and ecological concerns associated with it.

**UNIT I INTRODUCTION 8**

Aquaculture basics and history – historical practices and patterns, Role of aquatic resources in food and nutrition. Current trends in global and Indian aquaculture. Farming systems – types and their features – Structures and equipment types of ponds used and construction techniques.

**UNIT II ISSUES IN AQUACULTURE 10**

Environmental issues – Exotic species introduction; escapement; contamination of indigenous gene pool, Salinization of soil and water – over exploitation of wild stocks – mangrove deforestation. Socio-economic issues – Conflicts over water and land use – conflicts of interest between aqua farmers and fishermen and public

**UNIT III AQUACULTURE TECHNOLOGY 12**

Fishing methods and gears – Remote Sensing / Echo sounder system – Design of water supply and pond – Cage culture (open water system) – Closed water system – Hatchery operation – Harvesting methods – Oxygen and aeration – Biological filtration in aquaculture – Sterilization and disinfection – Design of production systems.

**UNIT IV AQUACULTURE ECONOMICS 8**

Economics and financing and aquaculture facilities – Economic factors of production Costs of production – Income and profit, measuring performance – Accounts and records – Fish marketing. Economic implications of integrated systems.

**UNIT V SUSTAINABLE AQUACULTURE 7**

Strategies for sustainability; Sustainability concept; food security; biosecurity; organic farming; integrated farming; responsible aquaculture; rotational aquaculture; bioremediation; role of biotechnology, traceability. Application of renewable energy in aquaculture – solar energy, wind, and tidal energy.

**L : 45 Periods**

**REFERENCES:**

1. Aquaculture: Farming Aquatic Animals and Plants, 2003, John S.Lucas (Editor), Paul.C, Southgate, Blackwell Publ. Co.
2. A Text Book of Aquaculture 1999 Srinivasulu Reddy. M and Sambasiva Rao, K.R.S., Discovery Publishing House, New Delhi.
3. Jorgensen, SE, 1986, Fundamentals of Ecological Modelling.

**OBJECTIVE**

To make the students understand and appreciate environmentally responsible travel to relatively undisturbed natural areas that promotes biodiversity conservation, and provides for socio-economic benefits to the local stakeholder communities.

**UNIT I INTRODUCTION****9**

Types of tourism – Cultural, Ethnic, Historical. Concept of ecotourism- definitions of Ecotourism □ Ecotourism and related sub-sectors of the tourism industry- Ecotourism criteria. Protected Areas - definition, categories and roles. advantages and disadvantages of ecotourism.

**UNIT II ECOTOURISM AND THE ENVIRONMENT****9**

Ecotourism and the environment, □ Ecotourism and conservation, Ecotourism and economic benefits, □ Ecotourism and socio economic benefits, □ □ □ □ Ecotourism and local community. Ecotourism and education, alternative versus mass tourism, influences of environmental organizations on tourism industry behavior

**UNIT III ECONOMICS OF ECOTOURISM****9**

Ecotourism in the national/global context- multiplier concept, direct, indirect and induced economic effects. Impacts of globalization of tourism and tourism industry. Total Quality Management (TQM) of Ecotourism Resorts, ecotourism initiatives and joint projects

**UNIT IV MANAGEMENT AND MARKETING OF ECOTOURISM****9**

Organisation policy versus tourism policy. Ecotourism typologies. Ecotourism products, Development of appropriate strategies, Management issues in ecotourism. Eco-branding and Eco-labeling. Ecotourism-based/related employment: Scope and areas of employment

**UNIT V SUSTAINABLE TOURISM DEVELOPMENT****9**

Millennium Development Goals, strategies and tools in eco-tourism and sustainable tourism concepts and main principles of ecotourism, - cultural conflicts in global tourism, - ecotourism initiatives and joint projects, the role of ethics in ecotourism. The future of ecotourism- key trends and future developments.

**L = 45****TEXT BOOK:**

1. Megan Epler Wood, 2002. Ecotourism: Principles, practices and policies for sustainability. UNEP Publication

**REFERENCES:**

1. Fennell A David 2003 Ecotourism. An Introduction. Routledge, London and New York
2. Wearing and Neil, 2000, Ecotourism Impacts, potentials and possibilities. Butterworth & Heinemann
3. Mowforth M, Munt I. 2003. Tourism and Sustainability. Development and New Tourism in the Third world. Routledge, London and New York

**OBJECTIVE:**

To provide a conceptual framework for a thorough understanding of the causes for biodiversity decline and measures to conserve it.

**UNIT I INTRODUCTION 10**

History of Life on Earth – evolution of cellular diversity, the origin of species – the fossil evidence, natural selection and microevolution – Evidence for macroevolution – the intelligent design controversy, DNA diversity, Environment – Biodiversity Linkage, Human Evolution and Human diversity, Levels of biodiversity.

**UNIT II ISSUES IN AQUACULTURE 10**

Biodiversity Values, Methodology for Assessment Biodiversity, Molecular Tools for Assessing Genetic Diversity, Essential Taxonomy – Methods for measuring genetic, species and ecosystem biodiversity.

**UNIT III AQUACULTURE TECHNOLOGY 10**

Biodiversity hotspots of the world. Sustainable use and management of biodiversity – traditional ecological knowledge of the indigenous people in utilization of aquatic resources, utilization of terrestrial bio resources – traditional land use systems – socio-cultural and economic dimensions, access and benefit sharing.

**UNIT IV AQUACULTURE ECONOMICS 8**

In situ and Ex situ conservation, traditional methods of conservation, protected areas. Conservation and Management Strategies: Restoration Technologies – Conservation Strategies in Different Countries, Industrial initiatives.

**UNIT V SUSTAINABLE AQUACULTURE 7**

Current threats to biodiversity – Social, ethical and policy issues in biodiversity conservation – CBD and its ramifications on biodiversity conservation.

L : 45

**REFERENCES:**

1. William K Purves, David Sadava, Gordon H Orians, 2003, Life, the Science of Biology, 7<sup>th</sup> Edition Sinauer Associates, Inc./W.H. Freeman, inc.
2. Primack, R, 2002, Essentials of Conservation Biology, Sinauer Associates, Inc., 3<sup>rd</sup> edition.
3. Biodiversity Utilisation and Conservation/edited by A.Arunachalam and K.Arunachalam, jaipur, Aavishkar Publishers, 2008.