

**UNIVERSITY DEPARTMENTS**  
**ANNA UNIVERSITY CHENNAI :: CHENNAI 600 025**  
**REGULATIONS - 2009**  
**CURRICULUM I TO IV SEMESTERS (FULL TIME)**  
**M.E. ENVIRONMENTAL MANAGEMENT**

**SEMESTER I**

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1	MA 9102	<a href="#">Statistics for Environmental Engineers</a>	3	1	0	4
2	EN 9101	<a href="#">Environmental Chemistry</a>	3	0	0	3
3	EN 9102	<a href="#">Environmental Microbiology</a>	3	0	0	3
4	EM 9101	<a href="#">Principles of Sustainable Development</a>	3	0	0	3
5	EM 9102	<a href="#">Environmental Policies and Legislation</a>	3	0	0	3
6	EN 9104	<a href="#">Principles and Design of Physico-Chemical Treatment Systems</a>	3	0	0	3
<b>TOTAL</b>			<b>18</b>	<b>1</b>	<b>0</b>	<b>19</b>

**SEMESTER II**

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1	EN 9121	<a href="#">Principles and Design of Biological Treatment Systems</a>	3	0	0	3
2	EM 9121	<a href="#">Environmental Risk Assessment and Management</a>	3	0	0	3
3	EM 9122	<a href="#">Environmental Economics</a>	3	0	0	3
4	EN 9123	<a href="#">Solid and Hazardous Waste Management</a>	3	0	0	3
5	E1	<a href="#">Elective I</a>	3	0	0	3
6	E2	<a href="#">Elective II</a>	3	0	0	3
7	E3	<a href="#">Elective III</a>	3	0	0	3
<b>TOTAL</b>			<b>21</b>	<b>0</b>	<b>0</b>	<b>21</b>

**SEMESTER III**

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1	EM 9131	<a href="#">Environmental Management Systems and Auditing</a>	3	0	0	3
2	EM 9132	<a href="#">Environmental and Socio-Economic Impact Assessment</a>	3	0	0	3
3	E4	<a href="#">Elective IV</a>	3	0	0	3
<b>PRACTICAL</b>						
1	EM 9133	Project Work (Phase-I)	0	0	6	3

2	EM 9134	Practical Training (4 weeks)	-	-	-	1
3	EM 9135	Seminar	0	0	2	1
		<b>TOTAL</b>	<b>9</b>	<b>0</b>	<b>8</b>	<b>14</b>

#### SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
	<b>PRACTICAL</b>					
1	EM 9141	Project Work (Phase-II)	0	0	30	15
		<b>TOTAL</b>	<b>0</b>	<b>0</b>	<b>30</b>	<b>15</b>

**TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 69**

#### ELECTIVES

SL. NO.	CODE	COURSE TITLE	L	T	P	C
1	EM 9151	<a href="#">Energy Management in industries</a>	3	0	0	3
2	EM 9152	<a href="#">Industrial Ecology</a>	3	0	0	3
3	EM 9153	<a href="#">Life Cycle Assessment</a>	3	0	0	3
4	EM 9154	<a href="#">Environment, Health and Safety in Industries</a>	3	0	0	3
5	EM 9155	<a href="#">Natural Resources Management</a>	3	0	0	3
6	EN 9154	<a href="#">Environmental Quality Monitoring</a>	3	0	0	3
7	EM 9156	<a href="#">Remote Sensing and GIS Applications in Environmental Management</a>	3	0	0	3
8	EM 9157	<a href="#">Climate change and Adaptation</a>	3	0	0	3
9	EN 9155	<a href="#">Marine pollution and Control</a>	3	0	0	3
10	EN 9156	<a href="#">Membrane Technologies for Water and Wastewater Treatment</a>	3	0	0	3
11	EN 9122	<a href="#">Air Pollution Control</a>	3	0	0	3
12	EN 9151	<a href="#">Industrial Wastewater Pollution - Prevention and Control</a>	3	0	0	3

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**REGULATIONS - 2009**  
**CURRICULUM I TO VI SEMESTERS (PART TIME)**  
**M.E. ENVIRONMENTAL MANAGEMENT**

**SEMESTER I**

SL. NO.	CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1	MA 9102	<a href="#">Statistics for Environmental Engineers</a>	3	1	0	4
2	EN 9101	<a href="#">Environmental Chemistry</a>	3	0	0	3
3	EN 9102	<a href="#">Environmental Microbiology</a>	3	0	0	3
4	EN 9104	<a href="#">Principles and Design of Physico-Chemical Treatment Systems</a>	3	0	0	3
<b>TOTAL</b>			<b>12</b>	<b>1</b>	<b>0</b>	<b>13</b>

**SEMESTER II**

SL. NO.	CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1	EN 9121	<a href="#">Principles and Design of Biological Treatment Systems</a>	3	0	0	3
2	EM 9121	<a href="#">Environmental Risk Assessment and Management</a>	3	0	0	3
3	EM 9122	<a href="#">Environmental Economics</a>	3	0	0	3
<b>TOTAL</b>			<b>9</b>	<b>0</b>	<b>0</b>	<b>12</b>

**SEMESTER III**

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1	EM 9101	<a href="#">Principles of Sustainable Development</a>	3	0	0	3
2	EM 9102	<a href="#">Environmental Policies and Legislation</a>	3	0	0	3
3	EM 9132	<a href="#">Environmental and Socio-Economic Impact Assessment</a>	3	0	0	3
4	EM 9135	Seminar	0	0	2	1
<b>TOTAL</b>			<b>9</b>	<b>0</b>	<b>2</b>	<b>10</b>

**SEMESTER IV**

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1	EN 9123	<a href="#">Solid and Hazardous Waste Management</a>	3	0	0	3
2	E1	<a href="#">Elective I</a>	3	0	0	3

3	E2	<a href="#">Elective II</a>	3	0	0	3
<b>TOTAL</b>			<b>9</b>	<b>0</b>	<b>0</b>	<b>9</b>

#### SEMESTER V

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>THEORY</b>						
1	EM 9131	<a href="#">Environmental Management Systems and Auditing</a>	3	0	0	3
2	E3	<a href="#">Elective III</a>	3	0	0	3
3	E4	<a href="#">Elective IV</a>	3	0	0	3
<b>PRACTICAL</b>						
4	EM 9133	Project Work (Phase-I)	0	0	6	3
5	EM 9134	Practical Training (4 weeks)				1
<b>TOTAL</b>			<b>0</b>	<b>0</b>	<b>6</b>	<b>13</b>

#### SEMESTER VI

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
<b>PRACTICAL</b>						
1	EM 9141	Project Work (Phase-II)	0	0	30	15
<b>TOTAL</b>			<b>0</b>	<b>0</b>	<b>30</b>	<b>15</b>

**TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 69**

#### ELECTIVES

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1	EM 9151	<a href="#">Energy Management in industries</a>	3	0	0	3
2	EM 9152	<a href="#">Industrial Ecology</a>	3	0	0	3
3	EM 9153	<a href="#">Life Cycle Assessment</a>	3	0	0	3
4	EM 9154	<a href="#">Environment, Health and Safety in Industries</a>	3	0	0	3
5	EM 9155	<a href="#">Natural Resources Management</a>	3	0	0	3
6	EN 9154	<a href="#">Environmental Quality Monitoring</a>	3	0	0	3
7	EM 9156	<a href="#">Remote Sensing and GIS Applications in Environmental Management</a>	3	0	0	3
8	EM 9157	<a href="#">Climate change and Adaptation</a>	3	0	0	3
9	EN 9155	<a href="#">Marine pollution and Control</a>	3	0	0	3
10	EN 9156	<a href="#">Membrane Technologies for Water and Wastewater Treatment</a>	3	0	0	3
11	EN 9122	<a href="#">Air Pollution Control</a>	3	0	0	3
12	EN 9151	<a href="#">Industrial Wastewater Pollution -Prevention and Control</a>	3	0	0	3

**OBJECTIVE:**

- To train the students in the analysis of environmental data using statistical tools.

**UNIT I EMPIRICAL STATISTICS 9+3**

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.

**UNIT II ESTIMATION THEORY 9+3**

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

**UNIT III TESTING OF HYPOTHESES 9+3**

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.

**UNIT IV DESIGN OF EXPERIMENTS 9+3**

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

**UNIT V STATISTICAL QUALITY CONTROL 9+3**

Statistical quality control – Statistical process control –  $\bar{x}$  and R or S control chart – Attribute control charts – P Chart and U chart – Control chart performance.

**TOTAL (L:45+T:15): 60**

**REFERENCES:**

1. Montgomery, D.C. and Runger, G.C., “Applied Statistics and Probability for Engineers”, Wiley Student Edition, 2007.
2. Walpole, R.E., Myers,R.H., Myers,S.L. and Ye K, “Probability and Statistics for Engineers and Scientists” Pearson Education, Asia, 8<sup>th</sup> edition, 2007.
3. Mann. P.S., “Introductory Statistics”, John Wiley and Sons, Inc 5<sup>th</sup> edition, 2004.
4. Johnson, R.A. and Gupta, C.B, “Miller and Freund’s Probability and Statistics for Engineers”, Pearson Education, Asia, 7<sup>th</sup> edition, 2007.

**OBJECTIVE:**

- To educate the students about the chemistry of water, air and soil and to give an exposure in the laboratory determination of pollutants.

**UNIT I INTRODUCTION 9**

Stoichiometry and mass balance-Chemical equilibria, acid base, solubility product(Ksp), heavy metal precipitation, amphoteric hydroxides, CO<sub>2</sub> solubility in water and species distribution- – Chemical kinetics, First order, Colloids, electrical properties, double layer theory, environmental significance of colloids, coagulation

**UNIT II AQUATIC CHEMISTRY 11**

Water quality parameters- environmental significance and determination; Fate of chemicals in aquatic environment, volatilization, partitioning, hydrolysis, photochemical transformation- Degradation of synthetic chemicals-Metals, complex formation, oxidation and reduction, Eh – pH diagrams, redox zones, Fe – sorption- Chemical speciation-

**UNIT III ATMOSPHERIC CHEMISTRY 7**

Atmospheric structure –chemical and photochemical reactions – photochemical smog. Ozone layer depletion – greenhouse gases and global warming, CO<sub>2</sub> capture – Acid rain- origin and composition of particulates. Air quality parameters-effects and determination

**UNIT IV SOIL CHEMISTRY 9**

Nature and composition of soil-Clays- cation exchange capacity-acid base and ion-exchange reactions in soil – Reclamation of contaminated land.

**UNIT V EMERGING AREAS 9**

Principles of green chemistry, Atom economy, mass index- Nano materials, CNT, titania, composites, environmental applications.

**TOTAL: 45 PERIODS****REFERENCES:**

- Sawyer, C.N., MacCarty, P.L. and Parkin, G.F., Chemistry for Environmental Engineering and Science, Tata McGraw – Hill, Fifth edition, New Delhi 2003.
- Colin Baird 'Environmental Chemistry', Freeman and company, New York, 1997.
- Manahan, S.E., Environmental Chemistry, Eighth Edition, CRC press, 2005.
- Ronald A. Hites, Elements of Environmental Chemistry, Wiley, 2007.

**OBJECTIVE:**

- To educate the students in microbiology and its applications in environmental engineering, and to train them in experiments related to microbiological examination of water.

**UNIT I CLASSIFICATION AND CHARACTERISTICS 5**

Classification of microorganisms – prokaryotic, eukaryotic, cell structure, characteristics, Preservation of microorganisms, DNA, RNA, replication, Recombinant DNA technology.

**UNIT II MICROBIOLOGY OF ENVIRONMENT 10**

Distribution of microorganisms – Distribution / diversity of Microorganisms – fresh and marine, terrestrial – microbes in surface soil, Air – outdoor and Indoor, aerosols, biosafety in Laboratory – Extreme Environment – archaeobacteria – Significance in water supplies – problems and control. Concentration and detection of virus, Transmissible diseases.

**UNIT III METABOLISM OF MICROORGANISMS 10**

Nutrition and metabolism in microorganisms, growth phases, carbohydrate, protein, lipid metabolism – respiration, aerobic and anaerobic-fermentation, glycolysis, Krebs's cycle, hexose monophosphate pathway, electron transport system, oxidative phosphorylation, environmental factors, enzymes, Bioenergetics.

**UNIT IV TRANSMISSION OF PATHOGENS AND WASTEWATER TREATMENT 10**

Transmission of pathogens – Bacterial, Viral, Protozoan, Indicator organisms of water – Coliforms - total coliforms, E-coli, Streptococcus, Clostridium, Control of microorganisms; Microbiology of biological treatment processes – aerobic and anaerobic,  $\alpha$ -oxidation,  $\beta$ -oxidation, nitrification and denitrification, eutrophication.

**UNIT V TOXICOLOGY 10**

Ecotoxicology – toxicants and toxicity, Factors influencing toxicity. Effects – acute, chronic, concentration response relationships. Test organisms – toxicity testing, Bioconcentration – Bioaccumulation, biomagnification, bioassay, biomonitoring, bioleaching.

**TOTAL: 45 PERIODS****REFERENCES:**

1. Maier, R.M., I.L. Pepper and C.P. Gerba, 'Environmental Microbiology', Academic Press, New York, 1999.
2. Frank C. Lu and Sam Kacew, LU's Basic Toxicology, Taylor & Francis, London (4<sup>th</sup> Ed), 2002
3. Mcdiagram, M.T , Martinko J M and Parkn J, ' Brock Biology of Microorganisms', Printice Hall Intt Inc., India, 2003.

**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- IVSUSTAINABLE 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.

**TOTAL: 45 PERIODS**



## 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 policies, legislations, institutional frame work and enforcement mechanisms for environmental management in India.

**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 – Sitting 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**

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

**TOTAL: 45 PERIODS****REFERENCES:**

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

**EN 9104 PRINCIPLES AND DESIGN OF PHYSICO-CHEMICAL TREATMENT SYSTEMS**

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

**OBJECTIVE:**

- To educate the students on the principles and design of various physical and chemical treatment systems for water and wastewater.

**UNIT I CLASSIFICATION OF POLLUTANTS 5**

Pollutants in water and wastewater – characteristics, Standards for performance Significance of physico-chemical treatment – Selection criteria-types of reactor- reactor selection-batch-continuous type-kinetics

**UNIT II PHYSICAL TREATMENT PRINCIPLES 8**

Principles of Screening – Mixing, Equalization – Sedimentation – Filtration – Modeling back washing – Evaporation – Incineration – gas transfer – mass transfer coefficient Adsorption – Isotherms – Principles, kinetics, regeneration membrane separation, Reverse Osmosis, nano filtration, ultra filtration and hyper filtration electro dialysis, distillation – stripping and crystallization – Recent Advances.

**UNIT III CHEMICAL TREATMENT PRINCIPLES 7**

Principles of Chemical treatment – Coagulation flocculation – Precipitation – flotation solidification and stabilization – Disinfection, Ion exchange, Electrolytic methods, Solvent extraction – advanced oxidation /reduction – Recent Trends

**UNIT IV DESIGN OF MUNICIPAL WATER TREATMENT PLANTS 15**

Selection of Treatment – Design of municipal water treatment plant units – Aerators – chemical feeding – Flocculation – clarifies – tube settling – filters – Rapid sand filters slow sand filter, pressure filter, Dual media inlets Displacement and gaseous type. Design of Industrial Water Treatment Units- Selection of process – Design of softeners – Demineralisers –Reverse osmosis plants –flow charts – Layouts –Hydraulic Profile PID construction and O&M aspects – case studies, Residue management – Upgradation of existing plants – Recent Trends – Software application.

**UNIT V DESIGN OF WASTEWATER TREATMENT PLANTS 10**

Design of municipal wastewater treatment units-screens-detritors-grit chamber-settling tanks-sludge thickening-sludge dewatering systems-sludge drying beds - Design of Industrial Wastewater Treatment Units-Equalization- Neutralization-Chemical Feeding Devices-mixers-floatation units-oil skimmer- flow charts – Layouts –Hydraulic Profile PID construction and O&M aspects – case studies, Residue management – Upgradation of existing plants – Recent Trends – Software application.

**TOTAL: 45 PERIODS**

## REFERENCES:

1. Metcalf and Eddy, Wastewater engineering, Treatment and Reuse Tata McGraw Hill, New Delhi, 2003.
2. Hendricks D 'Water Treatment Unit Processes – Physical and Chemical' CRC Press, New York 2006.
3. Qasim, S.R.Motley, E.M.Zhu.G. Water works Engineering – Planning, Design and Operation, Prentice hall, New Delhi 2002.
4. Lee, CC & Shun dar Lin, Handbook of Environmental Engineering Calculations, Mc Graw Hill, New York, 1999.

**EN 9121 PRINCIPLES AND DESIGN OF BIOLOGICAL TREATMENT SYSTEM**

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

**OBJECTIVE:**

- To educate the students on principles and design of various biological treatment units used for wastewater treatment.

**UNIT I PRINCIPLES 10**

Objectives of biological treatment – significance – aerobic and anaerobic treatment kinetics of biological growth – Factors affecting growth – attached and suspended growth Determination of Kinetic coefficients for organics removal – Biodegradability assessment -selection of process- reactors-batch-continuous type-kinetics

**UNIT II DESIGN OF AEROBIC TREATMENT SYSTEMS 10**

Design of sewage treatment plant units –Activated Sludge process and variations, Sequencing Batch reactors, Membrane Biological Reactors-Trickling Filters-Bio Tower-RBC-Moving Bed Reactors-fluidized bed reactors, aerated lagoons, waste stabilization ponds – nutrient removal systems – natural treatment systems, constructed wet land – Disinfectant – disposal options – reclamation and reuse – Flow charts, layout, hydraulic profile, recent trends.

**UNIT III ANAEROBIC TREATMENT OF WASTEWATER 10**

Attached and suspended growth, Design of units – UASB, up flow filters, Fluidized beds septic tank and disposal – Nutrient removal systems – Flow chart Layout and Hydraulic profile – Recent trends.

**UNIT IV SLUDGE TREATMENT AND DISPOSAL 5**

Design of sludge management facilities, sludge thickening, sludge digestion, biogas generation, sludge dewatering (mechanical and gravity) Layout PID hydraulics profile – upgrading existing plants – ultimate residue disposal – recent advances.

**UNIT V CONSTRUCTION OPERATIONS AND MAINTENANCE ASPECTS 10**

Construction and Operational Maintenance problems – Trouble shooting – Planning, Organising and Controlling of plant operations – capacity building, Case studies – sewage treatment plants – sludge management facilities.

**TOTAL: 45 PERIODS**

**REFERENCES:**

1. Metcalf and Eddy, 'Wastewater Engineering – Treatment and Reuse. Fourth Edition, Tata Mc Graw-Hill Publishing Company Limited, New Delhi, 2003.
2. Qasim, S.R. Wastewater Treatment Plant, Planning, Design & Operation: Technomic Publications, New York, 1994.
3. Arceivala, S.J., Wastewater Treatment for PollutionControl, TMH, New Delhi Second Edition 2000.
4. Manual on "Sewerage and Sewage Treatment" CPHEEO, Ministry of Urban Development, GOI, New Delhi, 1999.

**OBJECTIVE:**

- To provide knowledge related to the broad field of environmental risk assessment, important processes that control contaminant transport and tools that can be used in predicting and managing human health risks.

**UNIT I INTRODUCTION 6**

Sources of Environmental hazards – Environmental and ecological risks – Environmental risk assessment framework – Regulatory perspectives and requirements – Risk Analysis and Management and historical perspective; Social benefit Vs technological risks; Path to risk analysis; Perception of risk, risk assessment in different disciplines.

**UNIT II ELEMENTS OF ENVIRONMENTAL RISK ASSESSMENT 10**

Hazard identification and accounting – Fate and behaviour of toxics and persistent substances in the environment – Properties, processes and parameters that control fate and transport of contaminants – Receptor exposure to Environmental Contaminants – Dose Response Evaluation – Exposure Assessment – Exposure Factors, Slope Factors, Dose Response calculations and Dose Conversion Factors – Risk Characterization and consequence determination – Vulnerability assessment – Uncertainty analysis.

**UNIT III TOOLS AND METHODS FOR RISK ASSESSMENT 12**

HAZOP and FEMA methods – Cause failure analysis – Event tree and fault tree modeling and analysis – Multimedia and multipathway exposure modeling of contaminant migration for estimation of contaminant concentrations in air, water, soils, vegetation and animal products – Estimation of carcinogenic and non carcinogenic risks to human health – Methods in Ecological risk assessment – Probabilistic risk assessments – radiation risk assessment – Data sources and evaluation.

**UNIT IV RISK MANAGEMENT 8**

Risk communication and Risk Perception – comparative risks – Risk based decision making – Risk based environmental standard setting – Risk Cost Banefit optimization and tradeoffs – Emergency Preparedness Plans – Emergency planning for chemical agent release – Design of risk management programs – risk based remediation; Risk communication, adaptive management, precaution and stake holder involvement.

**UNIT V APPLICATIONS 9**

Case studies on risk assessment and management for hazardous chemical storage – Chemical industries – Tanneries – Textile industries – Mineral processing and Petrochemical plants – Hazardous waste disposal facilities – nuclear power plants – contaminated site remediation – Case histories on Bhopal, Chernobyl, Seveso, Three Mile Island.

**TOTAL: 45 PERIODS**

## REFERENCES:

1. Cutter, S.L., Environmental Risk and Hazards, Prentice-Hall of India Pvt. Ltd., New Delhi, 1999.
2. Kolluru Rao, Bartell Steven, Pitblado R and Stricoff "Risk Assessment and Management Handbook", McGraw Hill Inc., New York,1996.
3. Kofi Asante Duah "Risk Assessment in Environmental management", John Wiley and sons, Singapore, 1998.,.
4. Kasperson, J.X. and Kasperson, R.E. and Kasperson,R.E., Global Environmental Risks, V.N.University Press, New York, 2003.
5. Risks and Decisions for Conservation and environmental management, Mark Burman, Cambridge University Press.
6. Susan L |Cutter "Environmental Risks and Hazards" Prentice Hall of India, New Delhi 1999.
7. Joseph F Louvar and B Diane Louver Health and Environmental Risk Analysis fundamentals with applications, Prentice Hall, New Jersey 1997.

**OBJECTIVES:**

- To teach the basics of economics and its applications to valuing environment and to introduce market based instruments and economic policies for environmental management..

**UNIT I INTRODUCTION TO ECONOMICS 9**

Principles of Economics - Economics and ecology – Economics and Ethics – Growth and poverty - Economy and Environment– Strong and Weak Sustainability – Measuring sustainable development - Green Accounting and Economic indicators - Normative criteria for decision making: Static and dynamic efficiency - Consumer Choice theory – Efficiency and welfare – Consumer behaviour and Demand –Market equilibrium – market efficiency and failures – property rights, externalities and environmental problems – Coase Theorem- public goods and Free rider problem – Tragedy of the commons - Trade and environment – Kuznets curve

**UNIT II NATURAL RESOURCE ECONOMICS 8**

Types, scarcity and classification of Natural Resources – Depletable and non renewable resources – Recyclable resources – Replenishable but depletable resources – Storable renewable resources – Renewable common property Resources– Resource depletion models –Optimal Resource extraction - – Natural resources accounting - Economics of Forestry and fisheries exploitation – Economics of Climate Change

**UNIT III VALUATION OF ENVIRONMENTAL COSTS AND BENEFITS 10**

Types of Economic value - Principles of Cost benefit analysis – Utility, benefits and costs –discounted cash flows – Cost effectiveness analysis - Valuing the Environment – Direct and indirect methods – Surrogate markets – travel cost – Non-market valuation – Alternatives to valuation – Measuring Resource Scarcity – Costs of Sustainability – Assessment of Loss of Ecology - Valuation of Health impacts - Uncertainties – Environmental accounting

**UNIT IV ECONOMIC INSTRUMENTS FOR ENVIRONMENTAL PROTECTION 9**

Regulatory versus Economic Instruments – Charges and Subsidies – Non Compliance fees, bonds and deposit refunds – Marketable permits – Emission trading - Pigovian and Pollution Taxes – Polluter pays Principle – Evaluation of Instruments – Choice of instruments for Environmental policy.

**UNIT V ECONOMICS OF POLLUTION PREVENTION AND CONTROL 9**

Profitability of Pollution Prevention - Pay back period – Present value estimation – Internal rate of return – Opportunity costs – Economic analysis of Pollution Prevention Case studies – Efficient allocation of pollution from mobile and stationery source – pollution control policy – economically efficient pollution control programmes – Economics of Enforcement

**TOTAL: 45 PERIODS**



## REFERENCES:

1. John Asafu Adjaye, " Environmental Economics for non-Economists – techniques and policies for Sustainable Development, World Scientific,2005
2. Tom Tietenberg, "Environmental and Natural Resource Economics', 4 th Edition, Harper Collins College Publishers, 1996.
3. Nick Hanley, Jaison F. Shogren and Ben White "Environmental Economics" – In theory and practice" Macmillan India Ltd, New Delhi. 1999,
4. Roger Perman, Yue Ma, james McGilvray, " Natural resources and Environmental Economics "Second edition, Addison Wesley Longman Ltd, Singapore., 1997.

**OBJECTIVE:**

- To impart knowledge on the elements of managing solid wastes from Municipal and industrial sources including the related engineering principles, 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 – Rehabilitation of open dumps – landfill remediation

**TOTAL: 45 PERIODS****REFERENCES:**

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

**EM 9131 ENVIRONMENTAL MANAGEMENT SYSTEMS AND AUDITING**

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

**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

**TOTAL: 45 PERIODS**

## REFERENCES:

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

## **EM 9132 ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACT ASSESSMENT**

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

### **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.

**TOTAL: 45 PERIODS**

### **REFERENCES:**

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

**OBJECTIVE:**

- To provide an understanding of the basics of energy conservation method and energy auditing in industries and the associated economical benefits.

**UNIT I INTRODUCTION 7**

Energy Scenario – India and World – Energy Resources in India – Energy consumption Pattern, Energy Conservation and Energy Efficiency – Needs and Advantages, Role of Energy Manager –Energy Conservation Act 2003.

**UNIT II AUDITING AND INSTRUMENTATION IN ENERGY MANAGEMENT 10**

Energy Audit – Purpose, Types, Methodologies, Barriers with respect to Process Industries, Power Plants, Boilers and Certain Energy Intensive Industries; Energy Audit Questionnaire - Role of instrumentation in energy conservation - total energy systems - concept of total energy – advantages, limitations & Application.

**UNIT III ENERGY MANAGEMENT 12**

Thermal energy management-Variou Energy management Measures in Steam Systems – Losses in Boiler – Methodology of upgrading Boiler programme – Energy Conservation in Refrigeration and Air-conditioning Systems - Electrical Energy management- Potential Areas for Electrical Energy management in Various Industries-Energy Management Opportunities in Electrical Heating, Lighting system, Cable selection - Energy Efficient Motors - Factors involved in Determination of Motor Efficiency Adjustable AC Drives, Applications & its use variable speed Drives/Belt Drives

**UNIT IV ENERGY ECONOMICS 8**

Energy Economics – Discount Rate, Payback Period, Internal Rate of Return, Life Cycle Costing, risk and Sensitivity Analysis, Financing Options, Energy Performance Contract and Role of ETCOS.

**UNIT V APPLICATIONS 8**

Case studies on sugar Industry –Co generation, Thermal power plant; Petrochemical Industries.

**TOTAL: 45 PERIODS**

## REFERENCES:

1. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management & Case Study, Hemisphere, Washington, 1980.
2. Trivedi, P.R., and Jolka, K.R., Energy Management, Common Wealth Publication, New Delhi, 1997.
3. Handbook on Energy Efficiency, TERI, New Delhi, 2001
4. Write, Larry C, Industrial Energy Management & Utilization, Hemisphere Publishers, Washington, 1998.
5. Jefferson W. Tester, Elisabeth M. Drake, Michael J Driscoll, Michael W. Golay, William A Peters, Sustainable Energy – Choosing among options, Prentice Hall of India, 2006

**OBJECTIVE:**

- To create an understanding of the principles of industrial ecology and their application to achieve dissipative material use, embedded utility, dematerialization, linear and cyclic material flows for designing sustainable industrial activities.

**UNIT I INTRODUCTION TO ECOLOGY AND EVOLUTION OF INDUSTRIAL ECOLOGY 7**

Aim, scope and applications of ecology-principles and concepts pertaining to ecosystems-energy flow and materials cycling in ecosystems-productivity in ecosystems – origin, goal and role of industrial ecology – elements of industrial ecology, eco efficiency – ecological approaches, limitations of industrial ecology– structural and functional differences between ecological and industrial systems.

**UNIT II PRINCIPLES OF INDUSTRIAL ECOLOGY 10**

Holistic framework – Loop closing – Materialization and Dematerialization – measures and trends – Natural and Industrial Metabolism - inventory analysis – flow diagram and inventory tests. Co-production and multi-functionality. The cause-effect chain.

**UNIT III IMPLEMENTING INDUSTRIAL ECOLOGY 10**

Life cycle design – a brief account of life cycle analysis – cycle – strategies for manufacturing – eco-designing of products – raw materials – energy- manufacturing – processing – distribution – transportation – waste management – use- reuse –recycle – green accounting – software packages for industrial ecology practice – ecoprofit – economic and eco-development policies – greening of industrial ecosystems, Environmental quality standards.

**UNIT IV ECOLOGICAL ENGINEERING 9**

Principles and processes of ecological engineering - rationale of ecological engineering and eco-technology - integrating environment and technology – generic and specific design for environment – green planning – self-organizing design and processes – interface coupling in ecological systems – determination of sustainable loading ecosystems.

**UNIT V APPLICATIONS OF INDUSTRIAL ECOLOGY 9**

Corporate practices and trends in industrial ecology – environmental marketing – eco industrial parks – case studies

**TOTAL: 45 PERIODS****REFERENCES:**

1. Graedel, T.E. and Allenby, B.R., Industrial Ecology, 2<sup>nd</sup> ed., Upper Saddle River, Prentice Hall, New Jersey, 2003.
2. Ayres, R.U. and Leslie Ayres, A handbook of industrial ecology, Edward Elgar Publishing, 2002.
3. Bleischwitz, R. and Hennicke, P., Eco-efficiency, Regulation and Sustainable Business: Towards a Governance Structure for Sustainable Development, Edward Elgar Publishing, 2004.



**OBJECTIVE:**

- To understand the concept and methodology of Life cycle assessment , its potential applications to develop sustainable products and promote sustainable consumption.

**UNIT I GOAL AND SCOPE DEFINITION 9**

Introduction to Life Cycle Thinking - - analytical tools for product and service systems – History and definition of LCA - International organizations and networks - The ISO 14040 framework - Life cycle of Products and services –Industrial ecology - Impacts & value creation along the life cycle –Life cycle management (LCM) and Stakeholder Expectations – LCM drivers and issues materials flow analysis –technical characteristics – applications - limitations and how to solve them- - Life cycle goal and scope definition - function, functional unit and reference flow

**UNIT II INVENTORY AND IMPACT ANALYSIS 9**

System boundaries, data categories, inputs and outputs, data quality, critical review and other procedural aspects - Dealing with Allocation Issues - Solutions to the multifunctionality problem - Flow diagram - Format and data categories - Attributional versus consequential LCI - LCA softwares and database - Data quality - Data collection and relating data to unit processes -Data validation - Cut-off and data estimation - Characterization factors and principle of characterization - Selection of impact categories, category indicators and characterization models – Classification - Characterization - Optional elements -normalization , grouping, weighting ,data quality analysis - Characterization models – Impact assessment Case studies

**UNIT III INTERPRETATION OF LCA RESULTS 9**

Simplified/streamlined Life Cycle Assessments - procedural approaches, numerical approaches - Examples of numerical approaches - contribution analysis, perturbation analysis, uncertainty analysis, comparative analysis, key issue analysis - Treatment of uncertainties - Elements in uncertainty handling - Sensitivity of LCA results - Sustainability analysis - Extending LCA - economic dimension, social dimension - Life cycle costing - Eco-efficiency - Combining LCA and LCC – Case studies

**UNIT IV ECODESIGN OF PRODUCTS AND ECOLABELLING 9**

Sustainable consumption – Eco-efficiency - green consumerism - product stewardship and green engineering - Extended producer responsibility – ecodesign strategies – design for Environment – Design for Disassembly - Dematerialization, rematerialization, transmaterialization – Green procurement and green distribution - Analysis framework for reuse and recycling - Typical constraints on reuse and recycling - Communication of Life Cycle Information - - Indian ecomark scheme - Environmental product declarations – Environmental marketing

LCA case studies from International Journal of Life Cycle Assessment, Journal Cleaner Production and Journal of Industrial Ecology etc. on Product Design, Product Improvement, Product Comparison and Policy development.

**TOTAL: 45 PERIODS**

**REFERENCES:**

1. Marry Ann Curan, Environmental Life Cycle Assessment, Mc Graw Hill New York 1996
2. International Organization for Standardization: ISO 14040 series of Standards for Life Cycle Analysis , 1997
3. Wimmer W, Zust R, Lee K . Ecodesign Implementation: A systematic guidance to integrating environmental considerations into product development. Springer, 2004
4. International Organization for Standardization: ISO TR 14062 Environmental management - Integrating environmental aspects into product design and development, 2002.
5. David F Ciambrone , Environmental Life Cycle Analysis, CRC Press LLC, 1997
6. UNEP/SETAC UNEP/SETAC Life Cycle Initiative website, <http://www.uneptie.org/sustain/lcinitiative> , 2004.

**OBJECTIVE:**

- To educate about the health hazards and the safety measures to be followed in the industrial environment.

**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.

**TOTAL: 45 PERIODS**

**REFERENCES:**

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

**OBJECTIVE:**

- To understand the importance of natural resources and strategies for its sustainable management.

**UNIT I INTRODUCTION 9**

Importance of the Environment and Natural Resources - A brief account of natural resources and their utilization and conservation in India. Sustaining the Environment - Resource Conservation -Population Demands. International and National Policy instruments. Principles of integrated Natural Resource Management.

**UNIT II LAND AND WATER RESOURCES MANAGEMENT 9**

Locations of minerals and their importance. - Soil Resources - Erosion- Land use and management issues - Range management. Conservation Practices. Water use plans. Marine, Brackish and Freshwater habitats and their management. Integrated water resources management- Water allocation, markets, pricing, and conservation.

**UNIT III BIORESOURCES MANAGEMENT 9**

Wetlands preservation and management. Forestry-trees and their growth-products and benefits-management of pest and disease-principal of land surveys-estimating timber and wood product volume. Aquaculture -fisheries-optimal harvesting, stock recovery, and assessing extinction risk. Wildlife management - -habitat requirements of wildlife. The human impact on wildlife -Sustaining wildlife. Recent trends in wildlife management.

**UNIT IV ENERGY RESOURCES 9**

Renewable and Non renewable sources of energy and their management- Fossil fuel management - coal, oil and petroleum, oil shale, natural gas. Wind Energy- prospects and limitations. Solar energy – applications for rural and urban energy subsidy. Wave, Tidal, Geothermal energy. Bio-energy – wood , fuels from crops - ethanol production and its importance- biodiesel production and its importance.

**UNIT V ECONOMICS OF NATURAL RESOURCES 9**

Systems approach in natural capital management. Fundamentals of renewable and non-renewable resource economics. Valuation of natural resources - Environmental accounting, Ecological footprints, Bioprospecting for genetic resources - Principles of handling risk, uncertainty, and sensitivity. Decision making under uncertainty and option value. Understanding the Stakeholders approach- Subsistence groups- Governments- Academic institutions- Conflicts and competing uses

**TOTAL: 45 PERIODS**

## REFERENCES:

1. Natural Resource Management: Need for 21st Century/Sunit Gupta and Mukta Gupta. 1998, Community-Based Natural Resource Management: Issues and Cases from South Asia by Ajit Menon, Praveen Singh, Esha Shah, Sharachchandra Lélé, Suhas Paranjape and K.J.Joy, SAGE, 2007
2. Natural Resources Management Practices: A Primer. by Peter F. Ffolliott, Luis A. Bojorquez- Topia, Mariano Hernandez-Narvaez, 2001, Iowa State University Press Remote Sensing And Gis For Natural Resource Management, Bir Abhimanyu Kumar, Academic Excellence Publishers, 2007.

**OBJECTIVE:**

- To educate the students on the various instrumental methods of monitoring the quality of air , water and soil.

**UNIT I INTRODUCTION 9**

Wet Chemistry methods and their limitations-Instrumental Methods, Selection of method- Precision and Accuracy, Error in measuring signals- Quality control & assurance- Sample preservation, Sample preparation and analyte isolation.

**UNIT II SPECTROSCOPIC METHODS 12**

Principles, techniques and applications of spectrophotometry, fluorimetry, nephelometry and turbidimetry, Atomic Absorption Spectrometry (Flame, graphite furnace and hydride generation), Atomic Emission Spectrometry (AES) , flame and Inducted Coupled Plasma (ICP) – TOC Analyzer

**UNIT III CHROMATROGRAPHIC METHODS 8**

Column, Paper and thin layer chromatography (TLC)- Principles, techniques and applications of GC, GC-MS, High performance liquid chromatography (HPLC) and Ion chromatograph (IC)-Hyphenated techniques for Environmental contaminant(trace organics) analysis.

**UNIT IV ELECTRO AND RADIO ANALYTICAL METHODS 8**

Principles, techniques and applications of Conductometry, potentiometry, coulometry, AOX analyzer Amperometry, polarography, New Activation Analysis (NAA), X-ray Fluorescence (XRF) and X-ray Diffraction (XRD) methods.

**UNIT V CONTINUOUS MONITORING INSTRUMENTS 8**

Principles, techniques and applications of NDIR analyzer for CO, chemiluminescent analyzer for NO<sub>x</sub> Fluorescent analyzer for SO<sub>2</sub>- Particulates analysis- Auto analyzer for water quality using flow injection analysis.

**TOTAL: 45 PERIODS**

## REFERENCES:

1. Willard H. Merritt, L. Dean, D.A. and Settle, F.A. 'Instrumental methods of analysis Edn. Words Worth, New York, 2004.
2. Paul R. Loconto Trace Environmental Quantitative Analysis: Principles, Techniques, and Applications , Marcel Dekker; 1 edition May 2001.
3. Ewing Instrumental Methods of Chemical Analysis, 5th Edition, McGraw Hill, New York.1985.
4. Reeve, R.N., "Introduction to Environmental Analysis", Analytical Techniques in the Sciences, John Wiley & Sons, Chichester, UK, 2002.
5. Barceló, D.(editor), "Environmental analysis. Techniques, Applications and Quality Assurance", Elsevier, The Netherlands, 1996.

**EM 9156 REMOTE SENSING AND GIS APPLICATIONS IN ENVIRONMENTAL  
MANAGEMENT**

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

**OBJECTIVE:**

- To educate the students on the principles and applications of Remote sensing and GIS in environmental management.

**UNIT I OVERVIEW OF REMOTE SENSING 5**

Historical Perspective, Principles of remote sensing, components of Remote Sensing, Energy source and electromagnetic radiation, Energy interaction, Spectral response pattern of earth surface features

**UNIT II REMOTE SENSING TECHNOLOGY 11**

Classification of Remote Sensing Systems, Energy recording technology, Aerial photographs, Photographic systems – Across track and along track scanning, Multispectral remote sensing, Thermal remote sensing, Microwave remote sensing – Active and passive sensors, RADAR, LIDAR, Satellites and their sensors, Indian space programme - Research and development

**UNIT III DATA PROCESSING 11**

Characteristics of Remote Sensing data, Photogrammetry – Satellite data analysis – Visual image interpretation, Digital image processing – Image rectification, enhancement, transformation, Classification, Data merging, RS – GIS Integration, Image processing software.

**UNIT IV GEOGRAPHICAL INFORMATION SYSTEM 6**

GIS Concepts – Spatial and non spatial data, Vector and raster data structures, Data analysis, Database management – GIS software

**UNIT V REMOTE SENSING AND GIS APPLICATIONS 12**

Monitoring and management of environment, Conservation of resources, Sustainable land use, Coastal zone management – Limitations

**TOTAL: 45 PERIODS**

**REFERENCES:**

1. Lillesand, T.M. and Kiefer, R.W., Remote sensing and image interpretation, John Wiley and sons, New York, 2004.
2. Golfried Konechy, Geoinformation: Remote sensing, Photogrammetry and Geographical Information Systems, CRC press, 1st Edition, 2002.
3. Burrough, P.A. and McDonnell, R.A., Principles of Geographic Information systems Oxford University Press, New York, 2001.
4. Lintz, J. and Simonet, Remote sensing of Environment, Addison Wesley Publishing Company, New Jersey, 1998.
5. Pmapler and Applications of Imaging RADAR, Manual of Remote Sensing, Vol.2, ASPR, 2001.



**OBJECTIVE:**

- To understand the Earth's Climate System and the concept of Global Warming, the impact of climate change on society and its mitigation measures.

**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.

**TOTAL: 45 PERIODS****REFERENCES:**

- IPCC Fourth Assessment Report – The AR4 Synthesis Report,
- Dash Sushil Kumar, "Climate Change – An Indian Perspective", Cambridge University Press India Pvt. Ltd, 2007
- Jan C. van Dam, Impacts of "Climate Change and Climate Variability on Hydrological Regimes", Cambridge University Press, 2003.
- Al core 'inconvenient truth' – video form

**OBJECTIVE:**

- To understand the Coastal and Marine Systems and the sources of pollution and methods for monitoring, modeling and control.

**UNIT I COASTAL ENGINEERING 6**

Introduction to the coastal features – Beaches, Estuaries, Lagoons – Principles of Marine Geology – Sea water Classification -The oceans and climate

**UNIT II WAVE HYDRODYNAMICS 10**

Wave Theory, Waves in shallow waters – Refraction, Diffraction and Shoaling, Approximations for deep and shallow water conditions – Tidal Classification - General circulation of ocean waters - Ocean currents - Coastal sediment transport - Onshore offshore sediment transport - Beach formation and coastal processes - Tsunamis, storm surge, El Niño effect - Physical modeling in Coastal Engineering

**UNIT III MARINE POLLUTION SOURCES AND EFFECTS 8**

Sources of Marine Pollution – Point and non-point sources, Pollution caused by Oil Exploration, Dredging, Offshore Structures, Agriculture Impacts of pollution on water quality and coastal ecosystems – Marine discharges and effluent standards

**UNIT IV MONITORING AND MODELLING OF POLLUTION 12**

Basic measurements - Sounding boat, lead lines, echo sounders – current meters - tide - use of GPS – Measurement of coastal water characteristics – sea bed sampling – Modelling of Pollutant transport and dispersion - Oil Spill Models - Ocean Monitoring satellites – Applications of Remote Sensing and GIS in monitoring marine pollution - Risk Assessment

**UNIT V MARINE POLLUTION CONTROL 9**

Coastal Zone Regulation – Total Maximum Daily Load applications – Design of out falls- Pollution Control strategies – Selection of optimal Outfall locations - National and International Treaties, Protocols in Marine Pollution – ICZM and Sustainable Development

**TOTAL: 45 PERIODS**

**REFERENCES:**

- Marine Pollution (5th Edition) R.B. Clark, C. Frid and M Attrill Oxford Science Publications, 2001.
- Marine pollution Dr.P.C.Sinha , Anmol Publications Pvt. Ltd,1998.
- Problems of Marine Pollution : India and Canada, Raghavan, Sudha , Eastern Book Corporation 1687, Multani Mohalla, Rani Bagh Delhi - 110034, India
- Laws, E.A.,2000. Aquatic pollution, an introductory text. John Wiley and Sons, Inc., New York, 639 pp.

**EN 9156 MEMBRANE TECHNOLOGIES FOR WATER AND WASTEWATER TREATMENT** **L T P C**  
**3 0 0 3**

**OBJECTIVE:**

- To introduce the concept and principles of membrane separation and its applications in water and wastewater treatment .

**UNIT I INTRODUCTION** **10**

Solid Liquid separation systems-Filtration systems- Theory of Membrane separation – mass Transport Characteristics Cross Flow filtration-Membrane Filtration- Types and choice of membranes, porous, non porous, symmetric and asymmetric – Plate and Frame, spiral wound and hollow fibre membranes – Liquid Membranes

**UNIT II MEMBRANE PROCESSES AND SYSTEMS** **10**

Microfiltration – Ultrafiltration- Nano Filtration – Reverse Osmosis – Electro dialysis- Pervaporation -Membrane manufactures – Membrane Module/Element designs – Membrane System components – Design of Membrane systems - pump types and Pump selection – Plant operations – Economics of Membrane systems

**UNIT III MEMBRANE BIOREACTORS** **9**

Introduction and Historical Perspective of MBRs, Biotreatment Fundamentals, Biomass Separation MBR Principles, Fouling and Fouling Control, MBR Design Principles, Design Assignment, Alternative MBR Configurations, Commercial Technologies, Case Studies

**UNIT IV PRETREATMENT SYSTEMS** **8**

Membrane Fouling – Pretreatment methods and strategies – monitoring of Pretreatment – Langlier Index, Silt Density Index, Chemical cleaning , Biofoulant control

**UNIT V CASE STUDIES** **8**

Case studies on the design of membrane based water and wastewater treatment systems – zero Liquid effluent discharge Plants

**TOTAL: 45 PERIODS**

**REFERENCES:**

1. Water Environment Federation (WEF), Membrane Systems for Wastewater Treatment, McGraw-Hill, USA, 2005.
2. Symon Jud, MBR Book – Principles and application of MBR in water and wastewater treatment, Elsevier, 2006.
3. K. Yamamoto and Urase T, Membrane Technology in Environmental management, special issue, Water Science and technology, Vol.41, IWA Publishing, 2000.
4. Jorgen Wagner, Membrane Filtration handbook, Practical Tips and Hints, Second Edition, Revision2, Osmonics Inc., 2001.
5. Mulder, M., Basic Principle of Membrane Technology, Kluwer Academic Publishers, 1996.
6. Noble, R.D. and Stern, S.A., Membrane Separations Technology: Principles and Applications, Elsevier, 1995.

**OBJECTIVE:**

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

**UNIT I INTRODUCTION 7**

Structure and composition of Atmosphere – Definition, Scope and Scales of Air Pollution – Sources and classification of air pollutants and their effect on human health, vegetation, animals, property, aesthetic value and visibility- Ambient Air Quality and Emission standards – Air Pollution Indices – Emission Inventories – Ambient and stack sampling and Analysis of Particulate and Gaseous Pollutants.

**UNIT II METEOROLOGY 5**

Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability, Inversion, Wind profiles and stack plume patterns- Atmospheric Diffusion Theories – Dispersion models, Software application, Plume rise, Effective stack height .

**UNIT III CONTROL OF PARTICULATE CONTAMINANTS 11**

Factors affecting Selection of Control Equipment – Gas Particle Interaction, – Working principle, Design and performance equations of Gravity Separators (cyclone) , Centrifugal separators Fabric filters, Particulate Scrubbers, Electrostatic Precipitators – Operational Considerations - Process Control and Monitoring – Costing of APC equipment – Case studies for stationary and mobile sources.

**UNIT IV CONTROL OF GASEOUS CONTAMINANTS 11**

Factors affecting Selection of Control Equipment – Working principle, Design and performance equations of absorption, Adsorption, condensation, Incineration, Bio scrubbers, Bio filters – Process control and Monitoring - Operational Considerations - Costing of APC Equipment – Case studies for stationary and mobile sources.

**UNIT V INDOOR AIR QUALITY MANAGEMENT 11**

Sources types and control of indoor air pollutants, sick building syndrome types – Radon Pollution and its control – Membrane process - UV photolysis – Internal Combustion Engines - Sources and Effects of Noise Pollution – Measurement – Standards –Control and Preventive measures.

**TOTAL: 45 PERIODS****REFERENCES:**

1. Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, Air Pollution Control Engineering, Tokyo, 2004.
2. Noel de Nevers, Air Pollution Control Engg., Mc Graw Hill, New York, 1995.
3. David H.F. Liu, Bela G. Liptak 'Air Pollution', Lweis Publishers, 2000.
4. Anjaneyulu. Y, 'Air Pollution & Control Technologies' Allied Publishers (P) Ltd., India, 2002.
5. Arthur C.Stern, 'Air Pollution (Vol.I – Vol.VIII)', Academic Press, 2006.
6. Wayne T.Davis, 'Air Pollution Engineering Manual', John Wiley & Sons, Inc., 2000.

## **EN 9151 INDUSTRIAL WASTEWATER POLLUTION - PREVENTION AND CONTROL**

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

### **OBJECTIVE:**

- To impart knowledge on the concept and application of Industrial pollution prevention, cleaner technologies, industrial wastewater treatment and residue management.

### **UNIT I INTRODUCTION 8**

Industrial scenario in India– Industrial activity and Environment - Uses of Water by industry – Sources and types of industrial wastewater – Nature and Origin of Pollutants - Industrial wastewater and environmental impacts – Regulatory requirements for treatment of industrial wastewater – Industrial waste survey – Industrial wastewater monitoring and sampling -generation rates, characterization and variables –Toxicity of industrial effluents and Bioassay tests – Major issues on water quality management

### **UNIT II INDUSTRIAL POLLUTION PREVENTION 8**

Prevention vis a vis Control of Industrial Pollution – Benefits and Barriers – Waste management Hierarchy - Source reduction techniques – Pollution Prevention of Assessment - Material balance - Evaluation of Pollution prevention options –Cost benefit analysis – pay back period - Waste minimization Circles

### **UNIT III INDUSTRIAL WASTEWATER TREATMENT 10**

Equalisation - Neutralisation – Oil separation – Flotation – Precipitation – Heavy metal Removal– Aerobic and anaerobic biological treatment – Sequencing batch reactors – High Rate reactors - Chemical oxidation – Ozonation – carbon adsorption - Photocatalysis – Wet Air Oxidation – Evaporation – Ion Exchange – Membrane Technologies – Nutrient removal.- Treatability studies

### **UNIT IV WASTEWATER REUSE AND RESIDUAL MANAGEMENT 9**

Individual and Common Effluent Treatment Plants – Joint treatment of industrial and domestic wastewater - Zero effluent discharge systems - Quality requirements for Wastewater reuse – Industrial reuse , Present status and issues - Disposal on water and land – Residuals of industrial wastewater treatment – Quantification and characteristics of Sludge – Thickening, digestion, conditioning, dewatering and disposal of sludge – Management of RO rejects.

### **UNIT V CASE STUDIES 10**

Industrial manufacturing process description, wastewater characteristics, source reduction options and waste treatment flow sheet for Textiles – Tanneries – Pulp and paper – metal finishing – Oil Refining – Pharmaceuticals – Sugar and Distilleries

**TOTAL: 45 PERIODS**

## REFERENCES:

1. Eckenfelder, W.W., 'Industrial Water Pollution Control', Mc-Graw Hill, 2000.
2. Nelson Leonard Nemerow, "Industrial waste treatment – contemporary practice and vision for the future", Elsevier, Singapore, 2007.
3. Paul L. Bishop, 'Pollution Prevention: - Fundamentals and Practice', Mc-Graw Hill International, Boston, 2000.
4. Frank Woodard, 'Industrial waste treatment Handbook', Butterworth Heinemann, New Delhi, 2001.
5. World Bank Group, 'Pollution Prevention and Abatement Handbook – Towards Cleaner Production', World Bank and UNEP, Washington D.C., 1998.