VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
SCHEME OF TEACHING AND EXAMINATION FOR
M.Tech. in INTEGRATED WASTE MANAGEMENT

I Semester

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam	
15CWM11	Principles of Waste Management	4	2	3	50	100	150
15CWM12	Solid & Liquid Waste Management	4	2	3	50	100	150
15CWM13	Renewable & Alternative Fuels	4	2	3	50	100	150
15CWM14	Applied Environmental Chemistry and Microbiology	4	2	3	50	100	150
15CWM15X	Elective - 1	4	2	3	50	100	150
15CWM16	Basics Laboratory on Waste Management	--	3	3	25	50	75
15CWM17	Seminar	--	3	--	25	--	25
	Total	**20**	**16**	**18**	**300**	**550**	**850**

Elective – I	
15CWM151	Municipal Solid Waste management
15CWM152	Statics & Optimization Techniques in waste management
15CWM153	Toxicology & Environmental risk assessment
15CWM154	Global warming and Climate change

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II Semester

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam	
15CWM21	Advanced Solid Waste Management	4	2	3	50	100	150
15CWM22	Soil Pollution Hazards & Remedies	4	2	3	50	100	150
15CWM23	Air and Noise Pollution it's Control measures	4	2	3	50	100	150
15CWM24	Legal Aspects and Policy Guidelines	4	2	3	50	100	150
15CWM25X	Elective-2	4	2	3	50	100	150
15CWM26	Advanced Laboratory on Waste Management		3	3	25	50	75
15CWM27	Seminar	--	3	--	25	--	25
	Total	**20**	**16**	**18**	**300**	**550**	**850**

Elective – II	
15CWM251	Construction and Demolition of waste management
15CWM252	Advanced Water & Waste Water Treatment
15CWM253	Advanced Atmospheric Environmental Engineering & Modeling
15CWM254	Nonpoint Sources of Pollution & Mitigation

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III Semester: INTERNSHIP

Course	Subject	No. of Hrs./Week	Duration of the	Marks for	Total

Code		Lecture	Practical / Field Work	Exam in Hours	I.A.	Exam	Marks
14CWM31	Seminar / Presentation on Internship (After 8 weeks from the date of commencement of the semester).	-	-	-	25	-	25
	Project Phase: I – Problem formulation and submission of synopsis within 8 weeks from the commencement of 3rd semester.	-	-	-	-	-	-
14CWM32	**Evaluation of Internship** - To be carried out by the Internal Guide of the college and the respective Head of the Department.	-	-	-	50	-	50
14CWM33	**Viva-Voce on Internship Report-** To be conducted *internally* by the Internship Guide (from the college) and the External Guide under whose supervision the student has carried out the internship.	-	-	-	-	75	75
	Project Phase: II – Preliminary work on Project Implementation.	-	-	-	-	-	-
	Total	**-**	**-**	**-**	**75**	**75**	**150**

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IV Semester

Subject Code	Subject	No. of Hrs./Week		Duration of Exam in Hours	Marks for		Total Marks
		Lecture	Field Work /		I.A.	Exam	

			Assignment / Tutorials				
15CWM41	Occupational health Hazards & Industrial Safety Management	4	2	3	50	100	150
15CWM42X	ELECTIVE-III	4	2	3	50	100	150
15CWM43	Interim Evaluation of Project work (after 10 weeks from the commencement of 4th Semester).	-	-	-	50	-	50
15CWM44	Final Evaluation of Project Work and Viva-voce.	–	-	3	-	100+100	200
	Total	**08**	**04**	**09**	**150**	**400**	**550**

ELECTIVE-III

14CWM421	Hazardous Waste Management	14CWM423	Environmental Planning And Management
14CWM422	Remote Sensing and GIS In Environmental Engineering	14CWM424	Ecology and Environmental Impact Assessment

NOTE:

III Semester:

- **Internship:** The student shall undergo Internship for 16 weeks.
- **Seminar / Presentation on Internship**: The student shall make a midterm presentation of the activities undertaken during the first eight weeks of internship to a panel comprising Internship Guide, a senior faculty from the department and Head of the Department of the college.
- **Project Phase: I -** Problem formulation and submission of synopsis of Project to the Head of the Department of the college with the approval of the Guide **within eight weeks** from the commencement of III Semester.
- **Report on Internship**: The College shall facilitate and monitor the student internship program. The internship report of each student shall be submitted to the Head of the Department of the college with the approval of the Guide.

- **Evaluation of Internship -** To be carried out by the Internal Guide of the college and the respective Head of the Department.
- **Viva-Voce on Internship Report-** To be conducted *internally* by the Internship Guide (from the college) and the External Guide under whose supervision the student has carried out the internship.
- **Project Phase : II** - Preliminary work on Project Implementation.

IV Semester:

- **Interim Evaluation of Project** : Comprising Evaluation of Project Phase –I and Project Phase – II – **By Internal Guide after Ten weeks from the commencement of Fourth Semester.**
- **Project Phase-III** : Finalization of Project work, dissertation report writing and submission of dissertation report.
- **Evaluation of Dissertation / Final Project:**
  - Final evaluation of project to be carried out after 24 weeks from the date of commencement of 4^{th} semester.
  - The Internal Examiner (the project guide with a teaching experience of at least three years) and External Examiner shall be appointed by the University for the final evaluation of Project.
  - Internal Examiner shall carry out the evaluation for 100 Marks, and
  - External Examiner, shall carry out the evaluation for 100 Marks.
- The average of the marks allotted by the Internal Examiner and the External examiner shall be the final marks of the Project Evaluation.
- **Viva – Voce** : The Viva-Voce shall be conducted jointly by Internal Examiner and External Examiner for 100 Marks.

PRINCIPLES OF WASTE MANAGEMENT

Subject Code	**: 15CWM11**	IA Marks	:50
No. of Lecture Hrs/Week	:04	Exam Hrs	:03
Total No.of Lecture Hrs	:50	Exam marks	:100

Objectives:

- Aims to provide knowledge and skills in the management, treatment, disposal and recycling options for solid wastes.
- Play a role in resource efficiency and conserving resources and contributing to a low carbon economy, while focusing on key engineering and technical aspects involved.
- Understanding of the basic principles of waste and resource management will be supplemented, where appropriate, by practical problem-solving exercises in the context of civil engineering.

Course Outcomes: On completion of this course, students will be able to:

- Understand and apply the basic scientific and sustainability principles behind waste management, for solving practical waste management challenges.
- Understand the role legislation and policy drivers play in stakeholders' response to the waste and resource management challenge within a circular economy.
- Understand the fundamental principles of existing and emerging technologies for the treatment of waste and recovery of value from waste.

MODULE 1: Waste management: Definition of waste and its classification in the context of Indian legislation, policy and other drivers for change including the planning and permitting regime for the delivery of waste management solutions.

MODULE 2: Waste treatment technologies including waste incineration and energy from waste, advanced conversion technologies of pyrolysis and gasification, anaerobic digestion, composting and mechanical biological treatment of wastes.

MODULE 3: Health considerations in the context of operation of facilities, handling of materials and impact of outputs on the environment. Advances in waste recycling and recovery technologies to deliver added-value products. Landfill engineering and the management of landfill leachate and the mining of old landfills.

MODULE 4: Specific waste streams including healthcare wastes, food wastes, mineral and mining wastes, hazardous wastes and producer responsibility wastes.

Sustainability and resource efficiency with consideration for materials flow through the economy, steps towards designing out waste and maximising the value of outputs from waste treatment processes.

MODULE 5: Interface of waste and resource management and civil engineering in the context of sustainable waste management in global cities and developing countries.

Use of decision support tools including multi-criteria analysis, carbon foot-printing and life-cycle analysis.

BOOKS AND REFERENCES

1. Waste Treatment and Disposal 2nd edition Paul T Williams, Wiley, 2005
2. Integrated Solid Waste Management - Engineering Principles and Management Issues, Tchobanoglous/Theisen/Vigil, McGraw Hill (1993)
3. Hazardous Waste Management, M.D. LaGrega, P.L. Buckingham and J.C. Evans, published by McGraw Hill (1994)
4. Hazardous Waste Management, C.A. Wentz, published by McGraw Hill (1995)

SOLID AND LIQUID WASTE MANAGEMENT

Subject Code: **15CWM12** IA Marks: **50**
No of lecture Hrs/Week**: 04** Exam hrs: **03**
Total No Of Lecture Hrs: **50** Exam Marks: **100**

Objectives:

- Students learn about the basic concepts and principles of waste management.
- Discussion of the concepts, principles and classification of wastes will help the students to understand the subject of waste management.
- Students will also learn about the public health importance of solid waste and liquid waste management and be introduced to the basic principles and process of waste decomposition.

Course Outcome: On completion of this course, students will be able to

- Describe public health importance of Solid Waste, the major sources and types of Solid Waste.
- Demonstrate common Solid and Liquid Waste disposal methods.
- Describe public health importance of liquid waste, the major sources and types of liquid waste.
- Demonstrate the purpose of contaminated waste, methods of collection and disposal of contaminated waste.

MODULE 1: Solid Waste Management

Introduction, Public health importance of solid waste management, Classification of solid waste, Functional elements of solid waste management, Main sources of solid waste generation, Waste handling and separation, storage and processing at the sources.

MODULE 2:

Solid waste collection, Recycling and reuse, Common solid waste disposal methods, Composting, Controlled tipping/Burying, Incineration, Ploughing in fields. Other disposal methods.

MODULE 3: Liquid Waste Management

Introduction, Public health importance of waste water/sewage, Classification of liquid waste/sewage, Waste water/sewage composition, Points to be considered before selecting one particular sewage disposal techniques.

MODULE 4:

Liquid waste disposal methods at the communities/house hold level, Sewage/wastewater treatment.

MODULE 5: Contaminated Waste Management

Introduction, Purpose of contaminated waste management, Collection and disposal of Solid contaminated waste, Collection and disposal of Liquid contaminated waste.

BOOKS AND REFERENCES

1. Handbook of Solid Waste Management by Frank Kreith, George Tchobanoglous, McGraw Hill Publication
2. Bagchi, A., Design, Construction, and Monitoring of Landfills, (2nd Ed). Wiley Interscience, 1994. ISBN: 0-471-30681-9.
3. Sharma, H.D., and Lewis, S.P., Waste Containment Systems, Waste Stabilization, and Landfills: Design and Evaluation. Wiley Interscience, 1994. ISBN: 0471575364.
4. George Techobanoglous et al, "Integrated Solid Waste Management", McGraw- Hill Publication, 1993.
5. Charles A. Wentz; "Hazardous Waste Management ", McGraw-Hill Publication, 1995.
6. Metcalf & Eddy Inc, (2003), “Wastewater Engineering, Treatment and reuse”- 4th Edition, Tata McGraw Hill Publishers Co. Ltd, New Delhi
7. S.K.Garg water supply engineering
8. Peavy, H.S., Rowe, D.R., and Tchobanoglous, G., (1986), “Environmental Engineering”, Mc Graw Hill Book Co.

RENEWABLE AND ALTERNATIVE FUELS

Subject Code	: **15CWM13**	IA Marks	: **50**
No of lecture Hrs/Week	**: 04**	Exam hrs	: **03**
Total No Of Lecture Hrs	: **50**	Exam Marks	: **100**

Objectives:

- To create awareness in students about problems related to fossil fuels and familiarity about alternative fuels.
- To teach combustion and emission characteristics of various gaseous and liquid alternative flues.
- To teach adaptability of engines to alternative fuels.

Course Outcome: **On completion of this course, students will be able to**

- Learn need for alternative fuels
- Learn sources of various alternative flues
- An understanding limitation of fossil fuels and combustion characteristics fuels

MODULE 1: Introduction to energy and resources – Renewable energy sources - Availability of solar energy – Sun-earth relationships - - Solar radiation measurement – Flat plate collectors – Solar water heating systems – Evacuated Tubular Concentrators - Solar air heating systems and applications – Concepts on solar drying, cooking, desalination, solar ponds and solar cooling - Passive heating and cooling of buildings – Basics of solar concentrators and types Solar thermal power generation

MODULE 2: Biomass to energy conversion processes – Anaerobic digestion, process parameters, biogas composition, digester types, high rate anaerobic conversion systems – Alcohol from biomass – Biodiesel: preparation, characteristics and application - Biomass combustion and power generation – Briquetting – Gasification: Process, types of gasifiers, applications – Waste to energy technologies.

MODULE 3: Power in the wind - Types of wind mills – WEG components, Power curves and energy estimation– Indian wind potential. Small Hydro Power: Types, site identification, head and flow measurement, discharge curve, estimation of power potential and system components.

Technologies for harnessing renewable energy sources like geothermal, wave, tidal and ocean thermal energy.

MODULE 4: Fossil fuels and their availability - Potential alternative liquid and gaseous fuels - Merits and demerits of various alternative fuels - Engine requirements

Methods of production - Properties - Blends of gasoline and alcohol - Performance in SI engines – Adaptability - Combustion and emission characteristics - Performance in CI engines - Emission characteristics - Properties of alcohol esters

Production and properties of CNG, LPG, hydrogen gas, biogas and producer gas - Performance and Storage, distribution and safety aspects

MODULE 5: Various vegetables oils - Properties - Esterification - Performance and emission characteristics - Bio-diesel: Feed stock, characteristics, preparation (lab and commercial), storage, applications, environmental impacts, economics, policy.

BOOKS AND REFERENCES

1. Frank Kreith and D.Yogi Goswami (2007), Handbook of Energy Efficiency and Renewable Energy, CRC Press.
2. John Twidell and Tony Weir (2006), Renewable Energy Resources, 2nd Edition, Taylor & Francis, USA.
3. John A. Duffie and William A. Beckman (2006),
4. Solar Engineering of Thermal Process, 3rd Edition, John Wiley & Sons.
5. Gilbert M. Masters (2004), Renewable and Efficient Electric Power Systems, Wiley Interscience.
6. Osamu Hirao and Richard Pefley (1988), Present and Future Automotive Fuels, Wiley Interscience Publication, New York
7. Alcohols and Motor Fuels: Progress in Technology - Series No. 19 - SAE Publication USA C

ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY

Subject Code	: **15CWM14**	IA Marks	: **50**
No of lecture Hrs/Week	**: 04**	Exam hrs	: **03**
Total No Of Lecture Hrs	: **50**	Exam Marks	: **100**

Objectives:

- The student will be exposed to Importance of Environmental Chemistry and its application.
- Students will get the knowledge of contaminants and its effect with analysis.
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Course Outcome: On completion of this course, students will be able to

- Importance of common chemical compounds and their role in environmental management.
- Understand the importance of microorganisms to the environment.
- Effect of contaminants on environmental parameters such as water, air, soil etc.

MODULE 1: Organic compounds of interest to environmental engineers (details of preparation and chemical reaction involved), general properties of the functional groups of organic compounds.

MODULE 2: Colloids – Redox potentials – partition co-efficient – Beer – Lambert's Law – Limitations – UV visible spectroscopy – basic principles – application – Atomic absorption spectroscopy – Principles – applications Gas chromatograph – Principles and applications – Principles of green chemistry – Error Analysis of Environmental Data

MODULE 3: Transport and transformation of chemicals – DO, BOD and COD – Photo catalysis - Degradation of food stuffs, detergents, pesticides and hydrocarbons. Soil chemistry- acid-base and ion-exchange reactions in soil - salt affected soil and its remediation.

MODULE 4: Classification of microorganisms- prokaryotic, eukaryotic, structure, characteristics, nucleic acids-DNA, RNA, replication. Culturing of microorganisms-Environmental factors influencing microbial growth Distribution of microorganisms—Water, Air and Soil, Indicator organisms, coliforms—fecal coliforms, E. coli, Streptococcus, Clostridium, Significance in water. Algae in water supplies—problems and control.MPN and MFT.

MODULE 5: Ecotoxicology—toxicants and toxicity, factors influencing toxicity, effects—acute, chronic, concentration response relationships, test organisms, toxicity testing, bio concentration, bioaccumulation, bio magnification, bioassay, bio monitoring.

BOOKS AND REFERENCES

1. C.N. Sawyer, P.L. MacCarty and G.F. Parkin, Chemistry for Environmental Engineering and Science, Tata McGraw-Hill, Fifth edition, New Delhi, 2003.
2. G.W. Vanloon and S.J. Duffy 'Environmental chemistry – a global perspective, Oxford University press, New York., 2000.
3. Tortora. G.J, B.R. Furke, and C.L. Case, "Microbiology-An Introduction" (4th Ed.), Benjamin/Cummings Publ. Co., Inc., California, 1992.
4. Pelczar,M.J.,Chan E.C.S. and Krieg,N.R.Microbiology,Tata Mcgraw Hill,New Delhi,1993

MUNICIPAL SOLID WASTE MANAGEMENT

Course Code	**: 15CWM151**	IA Marks	:50
No. of Lecture Hrs/Week	:04	Exam Hrs	:03
Total No.of Lecture Hrs	:50	Exam marks	:100

Objectives:

- To make the students understand the key functional elements in municipal solid waste management including waste minimization concepts.
- To illustrate design of engineered land fill sites for the disposal of wastes.
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Course Outcomes

- Student will be able to identify improper practices of solid waste disposal and their environmental implications.
- Know the basic engineering principles of solid waste management .
- Describe the need for economics in collection and transportation of solid waste and clearly discuss various types of collection systems and analyse system dynamics

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MODULE 1:Introduction: Definition, Sources – household, street, demolition, construction. Composition and Properties of Municipal Solid Wastes.

Engineering Principles - Generation, Collection rates, waste handling and separation, storage and processing at the source.

MODULE 2:Collection, Transfer and Transportation: Types, equipment, personnel requirements, analysis & collection system, collection routes, types of transfer stations, transport means and methods, location and transfer stations.

Disposal: Dumping, Landfill - classifications, Siting Considerations, Generation, movement and control of gases and leachates, layout and preliminary design of landfills.

MODULE 3:Separation, Transformation and Recycling: Unit operations for separation and processing, size reduction, separation, density separation, fundamentals of thermal processing – combustion, pyrolysis, gasification, energy
recovery system.

Biological and Chemical Conversion Technologies: Principles, Aerobic, Composting anaerobic composting and energy recovery.

MODULE 4:Incineration: Process, Types, Heat Recovery, Incineration Products, Design of Incinerators, Air Pollution Control.

MODULE 5: Planning, Siting and Wastes Management Facilities: Screening, Planning and developing a site for solidwaste management. Separation of wastes – benefits, reuse and recycle, material recovery.

BOOKS AND REFERENCES

1. Peavy, H.S., Rowe, D.R., and Tchobanoglous, G., (1986), “Environmental Engineering”, Mc Graw Hill Book Co.
2. WHO Manual on “Solid Waste Management”.
3. Versiland, A, “Solid Waste Engineering”, Thompson Books.
4. Bhide and Sundaresan (2000), “Solid Waste Management in Developing Countries”, Indian NationalScientific Documentation Centre. New Delhi.
5. George Tchobanaglous, Hilary Theisen and Samuel A. Vigil, (1993), “Integrated Solid Waste Management- Engineering Principles and Management Issues”, Mc Grawhill Inc.
6. Sincero, A.P., and Sincero, G.A., (1999), “Environmental Engineering – A Design Approach”, Prentice Hall of India Pvt. Ltd., New Delhi.

STATISTICS & OPTIMISATION TECHNIQUES IN WASTE MANGEMENT

Subject Code	: **15CWM152**	IA Marks	: **50**
No of lecture Hrs/Week	**: 04**	Exam hrs	: **03**
Total No Of Lecture Hrs	: **50**	Exam Marks	: **100**

Objectives:

- This course focuses on the use of modern computational and mathematical techniques in waste Management such as linear systems, nonlinear algebraic equations, ordinary differential equations, and differential-algebraic (DAE) systems.
- The course also focuses on probability theory and its use in physical modeling and its use in the statistical analysis of data and parameter estimation: Finite difference and finite element techniques for converting the partial differential equations obtained from transport phenomena to DAE systems.
- The use of these techniques to be demonstrated throughout the course in the MATLAB computing environment.

Course Outcomes:

- Explain the consequences of finite precision and the inherent limits of the numerical methods considered.
- Select appropriate numerical methods to apply to various types of problems in engineering and science inconsideration of the mathematical operations involved, accuracy requirements, and available computational resources.

MODULE 1: Basic decision theory (statistical games, decision criteria, the theory in practice). Statistical inference: Intervals estimation, Confidence interval for mean, variances and regression coefficients. Sampling Distribution, Test of significance of (i) Means (ii) Mean of two samples (iii) Proportions (iv) Variance (v) Two variances (vi) Two observed correlation coefficients (Fishers' z-transformation), (vii) Paired T-test (viii) Regression coefficients (ix) Chi-square test of goodness of fit, Skewness and Kurtosis tests.

MODULE 2: Probability, Sampling, descriptive statistics, discrete and continuous probability, distributions (binomial, Poisson, uniform, normal, exponential), linear combination of variables, central limit theorem, confidence intervals for mean hypothesis testing and goodness of fit, regression, introduction to Minitab.

MODULE 3: Complex method of box-Zoutendijk's method-Rosen's gradient projection method-Optimizing of evaporator design-Optimum pipe dia for transportation of fluids- Optimizing recovery of waste heat-Optimization of liquid-liquid extraction processes

MODULE 4: Numerical methods for large systems of linear equations; decomposition and iterative techniques. Numerical determination of eigen-solutions for large systems; Power Method and related algorithms.

Numerical methods for first-order ordinary differential equations: Single and multi-step schemes. Error and stability analysis using Taylor series. Numerical treatment of higher-order differential equations and first-order systems.

MODULE 5: Numerical Integration: Romberg integration, Gaussian quadrature, error analysis. Introduction to MATLAB.

Engineering applications of numerical techniques; structural vibrations, flow dynamics and control, evaluation of decision criteria in optimization, reliability analysis and risk assessment.

BOOKS AND REFERENCES

1. Rao. S. S, "Optimisation Theory & Applications", Wiley Eastern
2. Beveridge G S G & Schechter R S, "Optimisation Theory & Practice", McGraw Hill

3. Schilling “Numerical methods for Engineers Using Matlab and C” – IBH Publications
4. Stevan C Chapra and Raymond P Canale, “ Numerical methods for Engineers”, McGraw hill
5. Pallab Ghosh “ Numerical methods in Computer Programming”
6. Beightler C S, Phillips D. T and Wild D. J, “Foundations of Optimnisations”, Prentis Hall of India
7 Grewal B S, “ Higher Engineering Mathematics” Khanna Publishers.

TOXICOLOGY AND ENVIRONMENTAL RISK ASSESMENT

Subject Code: **15CWM153** IA Marks: **50**
No of lecture Hrs/Week**: 04** Exam hrs: **03**
Total No Of Lecture Hrs: **50** Exam Marks: **100**

Objectives:

- To provide knowledge related to the broad field of environmental risk assessment.
- Steps involved in the risk assessment process, including statistical characterization of observed data.
- Knowledge about tools that can be used in defining environmental risks, particularly as related to human health.

Course outcomes: On successful completion of course student will be able to

- To develop practical skills for students in disaster mitigation, planning, response.
- Students can understand post disaster rehabilitation, particularly related to health and public health**.**
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MODULE 1: Toxicology—toxicants and toxicity, factors influencing toxicity, effects—acute, chronic, concentration response relationships, test organisms, toxicity testing, bio concentration, bioaccumulation, bio magnification, bioassay, bio monitoring.

MODULE 2: Introduction 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.

MODULE 3: Elements of Environmental Risk Assessment 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.

MODULE4: Tools and Methods for Risk Assessment HAZOP and FEMA methods – Cause failure analysis – Event tree and fault tree modeling and analysis – Multimedia and multipath way 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.

MODULE 5: Risk Management Risk communication and Risk Perception – comparative risks – Risk based decision making – Risk based environmental standard setting – Risk Cost Benefit 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.

5. Applications 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.

BOOKS AND 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 Satake M ‘Environmental Toxicology “Discovery Publishing House , Delhi, 2003

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.

GLOBAL WARMING AND CLIMATE CHANGE

Subject Code	**: 15CWM154**	IA Marks	:50
No. of Lecture Hrs/Week	:04	Exam Hrs	:03
Total No.of Lecture Hrs	:50	Exam marks	:100

Objectives:

- This course explores the science of climate change, climate system working; factors causing climate change across different time scales and their interactions:
- use of models to study past and future climatic conditions; consequences of climate change on our planet. The course explores evidence for changes in ocean temperature, sea level and acidity due to global warming..
- Finally, the course looks at the connection between human activity and the current warming trend and considers some of the potential social, economic and environmental consequences of climate change.

Course Outcomes: On completion of this course, students will be able to:

- Demonstrate a solid understanding of the climate system.
- Evaluate the various factors that shape climate.
- Explain the consequences, risks, and uncertainties of climate change

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MODULE 1: Earth Systems: Atmosphere, Hydrosphere, Lithosphere, Biosphere and their linkage. Earth's geological history and development and evolution of the atmosphere; Gaia Hypothesis.
MODULE 2: Atmosphere and climate. Basic atmospheric properties, climatic controls. Climatic classifications and variability. Movement in the atmosphere: global scale, regional scale, local scale.
MODULE 3: Oceans: General circulation patterns. Air- Sea interaction.
Global Energy balance: Source, transfer, distribution. Energy balance of the atmosphere.
MODULE 4: Wind, stability and turbulence; Monsoons; El Nino, Southern Oscillations, cyclones. Natural climate changes: Records of climate change (glacial cycles, ocean sediments, corals, tree rings).
Human Impacts on climate:
(i) Causes and consequences of Global warming: Greenhouse effect; Global and regional trends in greenhouse gas emissions; Sea level rise; role of oceans and forests as carbon sinks (ii) Ozone depletion stratospheric ozone shield; Ozone hole.
MODULE 5: Impacts of Climate change: Effects on organisms including humans; effects on ecosystems and productivity; species distribution ranges; spread of diseases; Extinction risk for temperature-sensitive species; UV effects
Climate change and Policy: Montreal Protocol; Kyoto Protocol; Carbon trading; clean development mechanisms.

BOOKS AND REFERENCES

1. Barry, R. G., 2003. Atmosphere, weather and climate. Routledge Press, UK
2. Critchfield, Howard J., 1998, General climatology, Prentice Hall India Pvt. Ltd., New Delhi.
3. Firor, J., and J. E. Jacobsen, 2002. The crowded greenhouse: population, climate change and creating a sustainable world. Yale University Press.
4. Glantz, M. H., 2003. Climate Affairs: a primer. Island Press.
5. Harvey D., 2000, Climate and Global Climate Change, Prentice Hall.
6. Kump, L. R., Kasting, J.F., and Carne, R. G., 2004. The Earth System. 3 rd Ed. Prentice-Hall

BASIC LABORATORY ON WASTE MANAGEMENT

Subject Code	**: 15CWM16**	IA Marks	:25
No. of Lecture Hrs/Week	:03	Exam Hrs	:03
Total No.of Lecture Hrs	:48	Exam marks	:50

Objectives:

- To develop a basic knowledge about the concept of unit operation and unit process and impart knowledge in application in the different fields of environmental related problems.
- To conduct laboratory studies on water and wastewater treatment units.

Course Outcomes: Student will be able to

- Utilize the knowledge in developing different methods in treating water and wastewater for various usage of the community.

Environmental analysis: Water sampling: Sampling stations-Collection of water samples-Handling and Preservation.

Water analysis:

Physical parameters: Colour-Temperature-Transparency-Turbidity

Chemical parameters: pH-Electrical conductivity-Total solids-Total suspended solids- Dissolved oxygen- Carbonates-bicarbonates-Hardness-Calcium-Magnesium-Total alkalinity-Fluoride- Iron-Nitrate-nitrite –Phosphate Biochemical Oxygen Demand(BOD) - Chemical Oxygen Demand(COD). Standard Plate count method-MPN(Most Probable number)

Soil /Sediment Analysis:

Physical parameters: Density-Specific gravity-Texture

Chemical Parameters: pH-Electrical conductivity-Total Alkalinity-Chloride-Nitrates-Phosphate-Iron.

BOOKS AND REFERENCES

1. Metcalf & Eddy, Inc. 'Wastewater Engineering, Treatment, Disposal and Reuse, Third Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi 2003
2. Lee, CC & Shun dar Lin, Hand book of Environmental Engineering Calculations, Mc Graw Hill, New York, 1999
3. Casey T.J. Unit treatment processes in water and wastewater engineering, John Wileys Sons, London, 1993
4. Standard Methods for the Examination of Water and Wastewater, AWWA, APHA, WEF.

ADVANCED SOLID WASTE MANAGEMENT

Subject Code	**: 15CWM21**	IA Marks	:50
No. of Lecture Hrs/Week	:04	Exam Hrs	:03
Total No.of Lecture Hrs	:50	Exam marks	:100

Objectives:

- To make students understand description of solid waste; different types: waste flows in society: amounts and composition of waste.
- Problems due to waste generation and strategies to minimise these problems; Consumption and waste, waste hierarchy (waste prevention, recirculation etc), product development, problem solving with a system analysis approach.
- Legal and economical means of control for waste management (Sweden and EU suggestions). Waste treatment and handling: thermal and biological methods, landfill, handling of hazardous waste.

Course Outcomes: On completion of this course, students will be able to:

- Define and explain important concepts in the field of solid waste management, such as waste hierarchy, waste prevention, recirculation, municipal solid waste etc.
- Suggest and describe suitable technical solutions for biological and thermal treatment. The student should also be able to discuss the drawbacks and prerequisites for a chosen solution.
- Describe the construction and operation of a modern landfill according to the demands.

MODULE 1: Municipal Solid Waste Management:
Legal and Organizational foundation: Definition of solid waste – waste generation– major legislation, monitoring responsibilities, sources and types of solid waste – sampling and characterization – Determination of composition of MSW – storage and handling of solid waste
– Future changes in waste composition.

MODULE 2: Collection and Transport of Solid Waste:
Waste collection systems, analysis of collection system – alternative techniques for collection system. Need for transfer operation, transport means and methods, transfer station types and design requirements.

MODULE 3: Process of Solid Waste and Energy recovery:
Unit operations for separation and processing, Materials Recovery facilities, Waste transformation through combustion and aerobic composting, anaerobic methods for materials recovery and treatment – Energy recovery – Incinerators

MODULE 4: Disposal of Solid wastes Land farming, deep well injections. Landfills**:** Design and operation including: site selection, Geo-environmental investigations , engineered sites, liners and covers, leachate control and treatment, gas recovery and control, including utilization of recovered gas (energy), and landfill monitoring and reclamation, , Requirements and technical solution, designated waste landfill remediation – Integrated waste management facilities. TCLP tests and leachate studies. Economics of the on-site v/s off site waste management options. Natural attenuation process and its mechanisms.

MODULE 5: Household Hazardous Waste Management:
Design practices of solid wastes. Definition and identification of hazardous wastes-sources and characteristics – hazardous wastes in Municipal Waste – Hazardous waste regulations – minimization of Hazardous Waste-compatibility, handling and storage of hazardous waste collection and transport. Regulatory requirements for identification, characterization and disposal
of hazardous, nonhazardous and domestic wastes.

BOOKS AND REFERENCES

1. Handbook of Solid Waste Management by Frank Kreith, George Tchobanoglous, McGraw Hill Publication
2. Bagchi, A., Design, Construction, and Monitoring of Landfills, (2nd Ed). Wiley Interscience, 1994. ISBN: 0-471-30681-9.
3. Sharma, H.D., and Lewis, S.P., Waste Containment Systems, Waste Stabilization, and Landfills: Design and Evaluation. Wiley Interscience, 1994. ISBN: 0471575364.
4. George Techobanoglous et al, "Integrated Solid Waste Management", McGraw- Hill Publication, 1993.
5. Charles A. Wentz; "Hazardous Waste Management ", McGraw-Hill Publication, 1995.

SOIL POLLUTION HAZARDS AND REMEDIES

Subject Code	: **15CWM22**	IA Marks	: **50**
No of lecture Hrs/Week	**: 04**	Exam hrs	: **03**
Total No Of Lecture Hrs	: **50**	Exam Marks	: **100**

Objectives:

- This course will be introduced to the theory and application of the soil and groundwater remediation technique to student.
- The students are introduced to the nature of soil, groundwater and pollutants, then introduce the mechanism of chemical fate and transport in the underground.
- Second part introduces the principles, application and design for remediation techniques.

Course Outcomes: On completion of this course, students will be able to:

- How best the waste can be disposed
- Know the existing laws in the country
- learn about safe waste disposal methods.

MODULE 1: Earth science: Internal structure of Earth, Geological evolution, Rocks and their classification, minerals and their classification. Weathering and soil formation, soil profile, soil classification and its property (formation of peat, index properties, Permeability and seepage, Consolidation), soils of India.

Geological Hazards and its mitigation measures: Earthquake and Tsunamis, Volcanoes, Landslides and prediction of the soil properties and its usability

MODULE 2: Environmental Geochemistry: Concepts of major, trace and REE. Classification of trace elements, mobility of trace elements, Geochemical cycles. Biochemical factors in environmental health. Human use, trace elements and health. Possible effects of imbalance of some trace elements. Diseases induced by human use of land.

LAND/SOIL POLLUTION: Effects of urbanization on land degradation, Impact of Modern Agriculture on Soil, Effect on Environment and Life sustenance, Abatement measures.

MODULE 3: Basic concepts related to soil pollution: The soil and its constitution. Functions and land uses. Main causes and the processes that contribute to the degradation of soil quality (erosion, chemical degradation and physical degradation).

Sources of pollution (e.g. urban areas, industrial areas, agriculture and livestock, landfills, sewage sludge, municipal solid waste dumps, mining and hazardous waste) and types of contaminants expected. Soil quality. Agriculture and livestock as a source of soil contamination

Irrigation water as a source of soil contamination: Irrigation water as a source of soil contamination. The risk of salinity and sodicity. Quality of water for irrigation (conductivity, SAR, etc.). The use of effluent as irrigation water: Origins. Characterization. Brief description of procedures for wastewater treatment. Risks of application of effluent to the ground, fertigation, salinity and sodification. Specific ion and toxicity, Applying fertilizer to the soil: The case of phosphorus, nitrogen and nitrates. Significance of N/P ratio, Typical dose-response curve for the macro, meso and micro-nutrients and toxic trace elements. Risks of soil contamination. Risk of groundwater contamination. Eutrophication. Good Agricultural Practices.

MODULE 4: Organic residues as soils fertilizers. Application of sewage sludge to soil: Origins and treatment. Characterization. Legislation. Assessing the risks associated with its application to soil. Determination of heavy metals in sludge. Adsorption / desorption of metals. Sequential extraction. Characterization of sludge from Portuguese wastewater treatment plants.

Application of MSW compost to soil: Origin. Characterization. Recovery. Risks associated with their application to the soil. Potential Guidelines.

Heavy metals in soils: Main sources of contamination. Behavior of heavy metals in soil and soil-plant system. Determination of heavy metals in soils. Sequential extraction. Bioavailability. Transfer coefficients in soil-plant systems for the different forms of metal in soil. Symptoms of toxicity.

Application of pesticides aspects of pollution related to their use. Degradation in soil. Toxicity and toxicological classes. Analysis of toxicological effects. Determination of pesticides in soils. Industrial activity as a source of contamination of soil: Main types of industrial waste. The soil and water as the main final destinations. The particular case of mining activity.

MODULE 5: Soil Decontamination. Contaminated site characterization: A survey history.

Standards for soil quality (according to the concept of multi functionality of the soil or in accordance with usage). Reference levels. Sampling of contaminated soil (particular care in sampling methods depending on the type of contaminant, storage and analysis). Risk analysis. Diagnosis. Prognosis. Selection of remediation methodology. Decontamination procedures for inorganic and organic pollutants: On site (in situ) chemical, physical, solidification/stabilization, thermical and biological methods. Off site (ex-situ, on-site and offsite): chemical methods, physical solidification/stabilization/immobilization, thermal, and biological (bioremediation and phytoremediation). Isolation / containment of the affected area.

Biological Environment: Basic Information on Biological Systems, Conceptual Approach for Addressing Biological Impacts, Identification of Biological Impacts, Description of Existing Biological Environment Conditions, Procurement of Relevant Legislation and Regulations, Impact Prediction, Assessment of Impact Significance

BOOKS AND REFERENCES

1. Alam Singh “Soil Engineering in theory and practice Vol 1, 2, and 3, Asia Publishing House
2.Helmut Meuser ”Soil Remediation and Rehabitation” springer
3. Pinto, P.S.S. (Editor) (1998). Environmental Geotechnics. Volume II – Remediation of Polluted Land and Abandoned Landfills. A.A. Balkema/Rotterdam/Brookfield.
4. Kearney, P.C., Roberts, T. (Editors) (1998). Pesticide Remediation in Soils and Water. John Wiley and Sons. International Edition.
5. Alloway, B.J. (Editor) (1995). Heavy Metals in Soils. 2nd Edition. Blackie Academic and Professional. London
6. Ibrahim A Misral “Soil Pollution**:** Origin, Monitoring and Remediation, Springer
7. Mohammed Naseem” Environmental Law in India”, Wolters Kulveer

AIR AND NOISE POLLUTION, IT'S CONTROL MEASURES

Subject Code	**: 15CWM23**	IA Marks	: 50
No. of Lecture Hrs/Week	: 04	Exam Hrs	: 03
Total No. of Lecture Hrs	: 50	Exam Marks	:100

Objectives:

- With increasing noise and air pollution nationally and globally, it is necessary to be familiar with basic information regarding air and noise pollution to allow proper assessment of impacts arising from the various projects or activities and devising appropriate mitigation or control measures.
- To give the students an overview of air and noise pollution including methods for prevention, control, measures and management of the pollution.

Course Outcomes: On completion of this course, students will be able to:

- Identify the sources of air pollution, effects of air pollution on humans, vegetation, materials etc.
- Solve problems on stack height, concentration of pollutants.
- Identify the sampling methods and suggest the necessary control devices and take actions based on legislations and regulations.

MODULE 1: Sources of Air Pollution, Sampling and Analysis:
Concept of unpolluted air, Scales of concentration of air pollution, Ambient Air Quality(AAQ), Primary & secondary pollutants, Stationary and mobile, fugitive emissions, secondary pollutants; Effects of air pollution in regional and global scale, Air pollution episodes; Emission factors, inventory and predictive equations. Sampling and Analysis – Basic Principles of Sampling – Source and ambient sampling – Analysis of pollutants – Principles.

MODULE 2: Atmospheric Meteorology
Elements of atmosphere – Meteorological factors – Wind roses, Lapse rate, turbulent diffusion, topographic effects and separated flows, temperature profiles in atmosphere, stability, inversions, and plume behavior.

MODULE 3: Air Quality Monitoring
Objectives, time and space variability in air quality; air sampling design, analysis and interpretation of air pollution data, guidelines of network design in urban and rural areas. Stack monitoring. Air pollution standards and indices. Dispersion of air pollutants and modeling, Basic concepts, inversion layer and mixing height, atmospheric stability classes, theory and application of acoustic sounding (SODAR) technique. Boxmodel, The Gaussian dispersion model point, area and line sources. Prediction of effective stack height physics of plume rise, Holland‟s equation, Briggs equation, etc. modifications of Gaussian dispersion models; indoor air quality models. Air pollution control devices.

MODULE 4: Effects of Air Pollution and Air Monitoring Instruments, Air Pollution Control
Human health, plants, animals and microbes, archeological monuments and aesthetics, Orsat apparatus, Respirable dust sampler and source monitors. Concepts of control – Principles and design of control measures – Particulates control by gravitational, centrifugal, filtration, scrubbing, electrostatic precipitation – Selection criteria for equipment - gaseous pollutant control by adsorption, absorption, condensation, combustion – Pollution control for specific major industries.

MODULE 5: Noise Pollution- Basics of acoustics and specification of sound; sound power, sound intensity and sound pressure levels; plane, point and line sources, multiple sources; outdoor and indoor noise propagation; psycho-acoustics and noise criteria, effects of noise on health, annoyance rating schemes; special noise environments: Infra-sound, ultrasound, impulsive sound and sonic boom; noise standards and limit values; noise instrumentation and monitoring procedure; Noise indices.

BOOKS AND REFERENCES

1. Environmental Engineering – Arcadio P. Sincero and Gregoria A. Sincero, Prentice Hall of India, 1999.
2. Environmental Pollution Control Engineering- CS Rao, Wiley Eastern Ltd., New Delhi, 1996.
3. Environmental Noise Pollution – PE Cunniff, McGraw Hill, New York, 1987.
4. Handbook of Noise Measurement – APG Peterson & EE Gross PH, Englewood cliffs New Jersey, latest edition.
5. Air Pollution Control Equipment – H. Brauer and Y. B. G. Verma, Berlin Heidelberg, New York, latest edition.
6. Air Pollution Control Engineering – Noel de Nevers, Waveland Press, Inc, 2nd ed, 2010.

LEGAL ASPECTS AND POLICY GUIDELINES

Subject Code	**: 15CWM24**	IA Marks	:50
No. of Lecture Hrs/Week	:04	Exam Hrs	:03
Total No.of Lecture Hrs	:50	Exam marks	:100

Objectives:

- This course takes a hybrid approach to teaching environmental law. This course aims to: provide an overview of some of the major environmental statutes in India
- Address the variety of regulatory tools and concepts that can be used to prevent environmental harm, focusing on the proper match between regulatory tool and environmental harm; and
- Discuss the role of other disciplines (e.g., science) and alternative means (e.g., public awareness) to facilitate changes in environmental policy.

Course Outcomes: On completion of this course, students will be able to:

- Analyze contrasting environmental regulatory methods and conceptual approaches including the common law, health and technology based statutes, and informational and economic approaches.
- Evaluate the economic and ethical assumptions and justifications when choosing any regulatory approach such as cost-benefit analysis, environmental justice, and the tradeoff between environmental protection and public welfare.
- Assess the lawfulness of administrative agency and private action towards the environment by application of the relevant environmental statute or agency regulation.

MODULE 1: Environment Definitions and Acts

Environment definition in Indian law- Different environmental protection legislations- History of Environmental protection in India - Provisions in Indian Penal Code for Environmental protection-The constitutions of India – Union list- State list – Concurrent list - Panchayats and Municipalities role

MODULE 2: Water (prevention & control of Pollution) Act & Air (prevention & control of Pollution) Act

Water pollution – definition – Water (Conservation and protection) Act 1974 – Objectives of Water Act – Legislation to control water pollution – Functions of CPCB and SPCB - Local bodies role – Water (prevention & control of pollution) Act 1974 as amended by Amendment Act 1988. Water (prevention and control of pollution) Rules 1975 - Water (prevention & control of Pollution) Cess Act 1977 as amended by Amendment Act 1987 and relevant notifications - Tolerance limits for effluents discharge and drinking water - Constitution and Resources management and pollution control – Air (prevention & control of Pollution) Act 1981-Sections of Air (prevention & control of Pollution) Act 19, 20, 21, 22-Penalties -Ambient air quality standards-Noise and the Laws

MODULE 3: Environmental (Protection) Act 1986

Environment and pollution - definition as per Environmental law-General powers of Central and state Government under EPA-Important Notification in EPA 1986- The Indian Forest Act 1927- Forest Conservation Act 1980 - Wild Life (Protection) Act - Constitution of Pollution Control Boards - Powers, functions, Accounts, Audit etc. – Equitable remedies for pollution control

MODULE 4: Municipal Solid Waste Management Rules

Solid waste management – Hazardous Wastes (Handling and Management) Rules 1998-Bio-medical Wastes (Handling and Management) Rules 1998-Recyclled plastics (Manufacture and Usage) Rules, 1999-Municipal Solid Waste Management Act 2003- Rules - E.I.A and Public Hearing- Eco-labeling-Eco Mark

MODULE 5: Coastal Regulation Zone Notification and Green Benches

Coastal Regulation Zone - definition-Importance of coral reef-Regulation activities in CRZ - The Biological Diversity Act 2002-Bio diversity Rules 2004-The Intellectual Property Rights (IPR)-National Environment Appellate Authority –Environmental Tribunal and Green Benches - Some

Important cases on Environment - International Conventions - Protocols for protection of the Environment

BOOKS AND REFERENCES

1. Constitutional Law of India – J.N. Pandey 1997 (31st Edn.) Central Law Agency Allahabad.
2. Administrative Law U.P.D. Kesari 1998. Universal Book Trade Delhi.
3. Environmental Law H.N. Tiwari, Allahabad Law. Agency 1997.
4. Environmental, A., Divan and Noble M. Environmental Law and Policy in India (cases, Materials and Statutes) 1991 Tripathi Bombay.
5. Environmental Policy. Forest Policy. Bare Acts – Government Gazette Notifiaciton.
6. Environmental Laws of India-C.P.R. Environmental Education Centre.

CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT

Subject Code	**: 15CWM251**	IA Marks	:50
No. of Lecture Hrs/Week	:04	Exam Hrs	:03
Total No.of Lecture Hrs	:50	Exam marks	:100

Objectives:

- Identify environmental impacts of construction and debris, potential danger to human health or environment, and define construction and debris, Understand how construction and demolition debris is defined by state and central regulations.
- Distinguish the factors affecting C &D Debris composition, methods for estimating the composition of C&D debris. Explain the importance of landfills, landfill regulations, permitting, and design and layout.
- Illustrate characteristics of C&D landfill leachate, groundwater impacts and monitoring

Course Outcomes: On completion of this course, students will be able to:

- Analyse and apply the legal requirements of the construction industry in regard to the management of C&D waste.
- Formulate, design, evaluate and review pre–construction and construction phase efficient waste management plans.
- Evaluate, assess and recommend potential reuse/recycling/disposal options considering existing and potential future markets/uses.
- Demonstrate a comprehensive knowledge and understanding of waste prevention strategies including design for reuse and recovery; design for materials optimisation; design for off–site manufacture; design for deconstruction and design for waste efficient procurement.

MODULE 1: Environmental Impact of Building Materials

Embodied energy of materials; Impact on the local environment; Toxicity of the material; Life cycle assessment.

Nature and Source

Direct and indirect waste; site types and origins; composition; quantity; current recycling/reuse potential of building materials.

MODULE 2: Construction and Demolition Waste Management Plans

International good practice; planning requirements; guidance document; company policy; demolition plans; site implementation; supplier agreements; contractor management; role of waste management contractor; training; auditing; skip management; current markets; current disposal options; health and safety; reporting to local authorities.' Construction and Demolition and Desilting Waste (Management and Handling) Rules, 2006.

MODULE 3: Treatment of Construction and Demolition Waste

Waste permits; waste licenses; waste transfer facilities; landfills; treatment technologies; hazardous waste facilities; reporting to authorities.

MODULE 4: Designing for Waste Prevention and Minimisation

Waste prevention and minimization; client, contractor and designer attitudes; proper maintenance of existing buildings; reuse of existing building structure; design flexibility; design for reuse and recycling; dimensional coordination and standardization; modular design; material selection and control.

MODULE 5: Waste Forecasting Tools

Application of WRAP's designing out waste tool for buildings and civil engineering; WRAP net waste tool; BRE SMARTWaste;

WRAP Site Waste Management Plan Tracker.

Future developments

Potential future markets; smart materials; use of eco−materials.

BOOKS AND REFERENCES

1. Department of the Environment, Heritage and Local Government (2005) Guidelines for the Preparation of Construction and Demolition Waste Management Plans
2. CIF/FAS (2002) Construction and Demolition Waste Management Handbook for Contractors and Site Managers.
3. Coventry, S *et al.* (2001) Demonstrating waste minimisation benefits in construction.
4. Environmental Protection Agency (1996a, 2000, 2003, 2005a) National Waste Database Reports.
5. Skoyles, E.R. and Skoyles, J.R. (1987) Waste Prevention on Site.

ADVANCED WATER AND WASTEWATER TREATMENT

Subject Code	**: 15CWM252**	IA Marks	:50
No. of Lecture Hrs/Week	:04	Exam Hrs	:03
Total No.of Lecture Hrs	:50	Exam marks	:100

Objectives:

- The course covers in depth the advanced and hybrid water and wastewater treatment systems for the removal of nutrients, toxic organics, inorganic and trace contaminants, as well as sludge handling and disposal practices.
- It allows the student to understand design criteria
- Design of various advanced water and wastewater treatment processes will be illustrated.

Course Outcomes: On successful completion of course student will be able to

- Acquire knowledge of residual pollutants in the effluent of conventionally treated water and wastewater and their removal by various advanced processes.
- Describe different combinations of hybrid reactor systems and to design them for a given situation
- Suggest economical methods for treating water and waste water suiting local conditions.

MODULE 1: Advanced Wastewater Treatment Systems

Residuals in treated wastewater and their removal, Gas Stripping, DAF, Advanced Oxidation, Electro dialysis, Ion Exchange & Adsorption, Micro and Ultra Filtration

MODULE 2: Hybrid Wastewater Treatment Systems

Need for upgrading treatment plants, Possible Combinations of Physico- chemical and Biological Processes.

Electrochemical coagulation, UASB and Anaerobic filters, multistage anaerobic filters

MODULE 3: Nutrients' Removal from Wastewaters

Nitrification and denitrification, physic-chemical and biological phosphorus removal, SBR.

MODULE 4: Sludge

Chemical Sludge – Sources and generation, types, characterization, recovery of metals, and alternate uses

Biological sludge – Sources and generation, characterization, utilization possibilities – compost

MODULE 5: Recent Trends

Environmental Biotechnology - genetically engineered microorganisms for wastewater treatment, bio remediation, bio sensors, membrane bio reactors (MBR), power generation from wastewater.

BOOKS AND REFERENCES

1. Metcalf & Eddy Inc, (2003), "Wastewater Engineering, Treatment and reuse"- 4th Edition, Tata McGraw Hill Publishers Co. Ltd, New Delhi
2. S.K.Garg water supply engineering
3. . Peavy, H.S., Rowe, D.R., and Tchobanoglous, G., (1986), "Environmental Engineering", Mc Graw Hill Book Co.
4. Syed R. Qasim, (1999), " Wastewater treatment plants: planning, design, and operation" - 2nd edition, CRC Press LLC
5. Moo-Young M., Anderson W.A., Chakrabarty A.M., (2007), "Environmental Biotechnology – Principles and Applications," Kluwer Academic Publishers.

ADVANCED ATMOSPHERIC ENVIRONMENTAL ENGINEERING AND MODELING

Subject Code	**: 15CWM253**	IA Marks	:50
No. of Lecture Hrs/Week	:04	Exam Hrs	:03
Total No.of Lecture Hrs	:50	Exam marks	:100

Objectives:

- The course covers the air pollution sources, classification, effects, and measurement of air pollutants, standards, importance of meteorology in air pollutant dispersion, fate and
- It also covers transport of air pollutants using various mathematical tools, as well as air and noise pollution control technologies and regulations.

Course Outcomes: On successful completion of course student will be able to

- Understand the importance of composition and structure of atmosphere, sources, classification, effects of air pollutants, and measurement of air pollutants, air pollution standards and control regulations.
- Gain Knowledge about the monitoring of particulate matter and carryout experiments on different monitoring tests for ambient air quality parameters and modeling
- Predict problems associated with air pollutants and suggest mitigation measures.

MODULE 1:Introduction

Composition and structure of the atmosphere; sources, characterization and classification of atmospheric pollutants, air pollution episodes. Effects of air pollutants on human health, vegetation, animals and materials and monuments. Visibility and other related atmospheric characteristics. Units and conversions.

MODULE 2:Meteorology

Wind circulation, solar radiation, lapse rates, atmospheric stability conditions, wind velocity profile, Maximum Mixing Depth, Ventilation coefficient, Temperature Inversions, plume behaviour, Wind rose diagram, general characteristics of stack emissions, heat island effect.

MODULE 3:Monitoring of particulate matter

Respirable, non-respirable and nano - particulate matter. Monitoring of gaseous pollutants – CO, CO_2, Hydrocarbons, SO_X and NO_X, photochemical oxidants. Monitoring equipment and sampling devices – stack sampling (Isokinetic sampling), air samplers, gas exhaust analyzer. Air Pollution Index.

MODULE 4:Pollutants' dispersion models

Point, line and areal sources models. Box model, Gaussian plume dispersion model – for point source (with and without reflection), Gaussian dispersion coefficient, Pasquill and Gifford atmospheric stability classification. ISCST3/ISCLT3 model, Determination of ground level concentrations. Infinite line source Gaussian model. plume rise and effective stack height calculations.

MODULE 5:Air Pollution Control Equipment

Mechanisms, Control equipment for particulate matter – gravity settling chambers, centrifugal collectors, wet collectors, scrubbers, fabric filters, electrostatic precipitator (ESP) - Design principles and criteria with design Control Equipment for gaseous pollutants – adsorption, absorption, condensation and combustion. Design principles. **Indoor Air Pollution** Sources, indoor air contaminants, effects and control. air changes per hour (ACH), IAQ Standards.Review of major case studies.

BOOKS AND REFERENCES

1. Wark, K., Warner, C.F., and Davis, W.T., (1998), "Air Pollution"- Its Origin and Control"- Harper & Row Publishers, New York.
2. Perkins, H.C ., (1980), "Air Pollution", McGraw Hill.

3. Sincero, A.P. andSincero, G.A. (1999), “Environmental Engineering - A Design Approach”,Prentice Hall of India, New Delhi.
4. Crawford, M., (1980),“ Air Pollution Control Theory”- TATA McGraw Hill.
5. Stern, A.C., Air Pollution, Vol I, II, III.
6. Stern, A. C., (1977), “Air Pollution : The Effects of Air Pollution” – 3rd- Edition, Academic Press

NON-POINT SOURCES' OF POLLUTION AND MITIGATION

Subject Code	**: 15CWM 254**	IA Marks	:50
No. of Lecture Hrs/Week	: 04	Exam Hrs	:03
Total No.of Lecture Hrs	: 50	Exam marks	:100

Objectives:

- The course deals with importance, significance and types of non-point sources of pollution.
- It also covers mathematical simulation models for qualitative and quantitative assessment of non point source pollution and exposes to best management practices

Course Outcomes: Student will be able to

- Describe the problem and magnitude of non point source pollution, relate with waste assimilative capacity of natural aquatic bodies and quantify the total load giving due consideration to components of hydrologic and atmospheric conditions.
- Explain source tracking and transport and fate of ground water pollution and
- Students will be able assess influence of urbanization on pollution quantification and its movement

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MODULE 1:Introduction Problem and magnitude, Surface Water Problems, Waste Assimilative Capacity and In-stream and Effluent Discharge standards.

MODULE 2:Hydrologic Considerations: Introduction, Precipitation – Runoff Relationship. Overland Routing of the Precipitation excess, Interflow, Groundwater flow. Pollution from the Atmosphere – Atmospheric Input.

MODULE 3:Groundwater Pollution: Sources of Groundwater Contamination, and Groundwater Movement.**Pollution from impervious urban areas :** Urban storm water quantification, Deposition and accumulation of pollutants on impervious surfaces. Removal of Solids from street surfaces and porous pavement.

MODULE 4:Pollution from agricultural and mining areas: Quantification and qualitative analysis.

MODULE 5:Non-point Pollution Simulation Models Basic Concepts, Brief Description of Non-point Pollution Simulation Models, Comparative Assessment of Pollution Impact from land uses, Land-use and non-point sources of pollution.Best Management Practices of Non-point sources of pollution control.

BOOKS AND REFERENCES

1. Pavoni, J.L., "Water Quality Management Planning Edited by Pavoni. J.L " , (1997), Van Nostrand Reinhold Environmental Engg., Series
2. Novotny, V ., and Chesters , G., (1981), "Hand Book of Non-point Pollution", "Sources and Management" - Van Nostrand Reinhold Company.
3. Holland M.M., Jolankai G., Rast W., Sven-Olof Ryding and Thornton J.A., (1999), "Assessment and Control of Nonpoint Source Pollution of Aquatic Ecosystems: A Practical Approach", 1st Edition, CRC Press
4. Novotney &Chesters ,Hand Book on Nonpoint Sources & Management

ADVANCED LABORATORY ON WASTE MANAGEMENT

Subject Code	**: 15CWM26**	IA Marks	:25
No. of Lecture Hrs/Week	:03	Exam Hrs	:03
Total No.of Lecture Hrs	:48	Exam marks	:50

Objectives:

- To develop a basic knowledge about the concept of unit operation and unit process and impart knowledge in application in the different fields of environmental related problems.
- To conduct laboratory studies on water and wastewater treatment units.

Course Outcomes: Student will be able to

- Utilize the knowledge in developing different methods in treating water and wastewater for various usage of the community.

LIST OF EXPERIMENTS

- Coagulation and Flocculation
- Batch studies for sedimentation
- Characteristics of Filter media
- Water softening
- Silt Density Index
- Anaerobic Reactor systems
- Advanced Oxidation Processes
- Chlorine Demand Estimation
- Air Analysis:

Physical parameters: Wind velocity-Atmospheric pressure- Temperature-Humidity
Chemical Parameters: Carbon dioxide- Carbon monoxide-Sulphur dioxide-Nitrogen oxide

Reference Books

1. Metcalf & Eddy, Inc. 'Wastewater Engineering, Treatment, Disposal and Reuse, Third Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi 2003
2. Lee, CC & Shun dar Lin, Hand book of Environmental Engineering Calculations, Mc Graw Hill, New York, 1999
3. Casey T.J. Unit treatment processes in water and wastewater engineering, John Wileys Sons, London, 1993
4. Standard Methods for the Examination of Water and Wastewater, AWWA, APHA, WEF.

OCCUPATIONAL HEALTH HAZARD AND INDUSTRIAL SAFETY MANAGEMENT

Subject Code	**: 15CWM41**	IA Marks	:50
No. of Lecture Hrs/Week	:04	Exam Hrs	:03
Total No.of Lecture Hrs	:50	Exam marks	:100

Objectives:

- This course enables student to learn the basic principles of safety, OSH act and the national policy.
- It instills knowledge on cause - effect relationships of accidents at work places, need for economics & ergonomics, hazard identification and control aspects, fire prevention and control.
- Work place health related issues are also covered.

Course Outcomes

- Gain knowledge on safety principles, right-to-know laws and manages situation applying theories of accident at workplace.
- Perform accident investigation and report preparation.
- Develop skill of understanding the ergonomics and address specific problems with appropriate strategies.

MODULE 1:Occupational Hazard and control Principles of Safety, National Safety Policy.Occupational safety and Health Act (OSHA), Occupational Health and Safety administration - Laws governing OSHA and right to know. **Accident –** causation, investigation, investigation plan, Methods of acquiring accident facts, Supervisory role in accident investigation, industrial safety – Man Vs. Machine, Facts and fact finding – safety psychology and education.

MODULE 2:Ergonomics at work place, Ergonomics Task analysis, Preventing Ergonomic Hazards, Work space Envelops, Visual Ergonomics, Ergonomic Standards, Ergonomic Programs. Noise pollution and its control.**Hazard cognition and Analysis,** Human Error Analysis – Fault Tree Analysis – Emergency Response - Decision for action – purpose and considerations, Engineering versus management control, Hazard control measures,

MODULE 3:Fire prevention and protection - Fire Triangle, Fire Development and its severity, Effect of Enclosures, early detection of Fire, Classification of fire and Fire Extinguishers.**Electrical Safety, Product safety** – Technical Requirements of Product safety. Safe handling of chemicals, safety procedures at Nuclear installations.

MODULE 4:Health considerations at work place – types of diseases and their spread, Health Emergency.**Personal Protective Equipment (PPE)** – types and advantages, effects of exposure and treatment for metal working trades, municipal solid wastes, epoxy resins, foundries. Environment mangement plans(EMP) for safety and sustainability

MODULE 5:Occupational Health and Safety considerations in water and wastewater treatment plants. Handling of chemical and safety measures in water and wastewater treatment plants and labs.

BOOKS AND REFERENCES

1. Goetsch D.L., (1999), “Occupational Safety and Health for Technologists, Engineers and Managers”, Prentice Hall.
2. Heinrich H.W., (2007), “Industrial Accident Prevention - A Scientific Approach”, McGraw Book Co.
3. National Safety Council and Associate (Data) Publishers Pvt. Ltd., (1991), “Industrial Safety and Pollution Control Handbook
4. Colling D.A., (1990), “Industrial Safety Management and Technology”, Prentice Hall, New Delhi.
5. Della D.E., and Giustina, (1996), “Safety and Environmental Management”, Van Nostrand Reinhold International Thomson Publishing Inc.

6. Trevethick, R.A., ((1973), “Environmental and Industrial Health Hazards”- William Heinemann Medical Books Ltd., London

HAZARDOUS WASTE MANAGEMENT

Subject Code	**: 15CWM421**	IA Marks	:50
No. of Lecture Hrs/Week	:04	Exam Hrs	:03
Total No.of Lecture Hrs	:50	Exam marks	:100

Objectives:

- The course deals with sufficient knowledge on need and principles of risk assessment methodologies and tools.
- Provides detailed design aspects of the treatment, disposal and analytical methods of hazardous wastes.

Course Outcomes: Student will be able to

- Review of case studies with respect to risk identification, assessment and emergency preparedness.
- Identify the sources and describe characteristics of hazardous wastes. Enumerate on waste minimization and resource recovery techniques.
- Prepare the transportation protocol for safe transport of hazardous wastes. Propose and design the treatment methods includingengineered land fill and containment.

MODULE 1: Background -Sources, Classification, Impacts of Mismanagement, Problems in Developing Counties and Regulations for Hazardous Waste Management
MODULE 2: Hazardous Waste Characterization, Designated Hazardous Wastes, Waste Minimization and Resource Recovery – Approaches, Development of a Waste Tracking System, Selection of waste Minimization Process, Case Studies-on by-product recovery – plating and solvent
Transportation of Hazardous Waste – requirements, regulations, containers and Labelling, bulk and non-bulk transport, Emergency Response, personal protective equipment.

MODULE 3: Treatment & Disposal: Physico-chemical, Chemical and Biological Treatment of hazardous waste, Thermal treatment - Incineration and pyrolysis, Co-processing
MODULE 4: Toxicology and Risk Assessment: Toxic effects, dose-response relationships, carcinogens, ecotoxicology, risk,exposure and toxicity assessment, risk characterization, ecological risk assessment.

MODULE 5: Land Disposal: Landfill operations, site selection, liner and leachate collection systems, cover systems,contaminant transport through landfill barriers, landfill stability, closure and post-closure care, other types of land disposal facilities. Site Remediation: Site assessment and inspection, remedial action, monitoring of disposal sites.

BOOKS AND REFERENCES

1. Lagrega M.D., Buckingham P.L., and Evans J.C., (1994), “Hazardous waste Management”, McGraw Hill International Edition
2. Wentz C.A.,(1995),“Hazardous Waste Management”, McGraw Hill International Edition
3. SinceroA.P., and Sincero G.A., (1996),”Environmental Engineering- A Design
4. Approach”, Eastern Economy Edition, Prentice Hall of India Pvt., Ltd.
5. Lehman, (1983), “Hazardous Waste Disposal”, Plenum Press.
6. Fawcett, (1984), “Hazardous and Toxic Materials: Safe Handling and Disposal”, John Wiley.
7. CPCB guidelines for Hazardous Wastes

REMOTE SENSING AND GIS IN ENVIRONMENTAL ENGINEERING

Subject code	**: 15CWM422**	IA Marks	:50
No. of Lecture Hrs/Week	: 04	Exam Hrs	:03
Total No.of Lecture Hrs	: 50	Exam marks	:100

Objectives:

- The course lays the foundation for basics of remote sensing, remote sensing systems, image processing, and related aspects.
- It also covers the various facets of GIS and data management as well as the applications of RS & GIS in Environmental Management

Course Outcomes: On successful completion of course student will be able to

- Describe the concepts and principles of remote sensing and remote sensing systems including EM spectrum, RS satellites and resolutions.
- Interpret satellite images by applying the concepts of elements of visual image interpretation.
- Explain the methodologies of image preprocessing, enhancement, filtering, transformation and classification.

MODULE 1:Basics of remote sensing: EMR spectrum; Energy sources and radiation laws, Energy interactions with atmosphere and Earth's surface features; Spectral reflectance curves, basic concepts of remote sensing, airborne and space borne sensors, passive and active remote sensing

MODULE 2: Remote Sensing Systems: Ideal RS system, Platforms and orbits; Satellite system parameters, spectral bands of sensors;spectral, radiometric, spatial, and temporal resolutions of satellites; multi-spectral, thermal and hyper-spectral sensing; remote sensing satellites and their features

MODULE 3: Image interpretation and processing: Visual image interpretation; concept of colour, colour composites, Preprocessing, image registration, image enhancement, spatial filtering, image transformation, image classification

Geographical Information System (GIS)

MODULE 3: Introduction Origin and importance of GIS; scale; coordinate and projection systems, Linkage of Remote Sensing toGIS **Data Models and Structures**

Spatial data models – Raster, vector; spatial and attribute data.

MODULE 4: Spatial Data Input and Editing: Encoding methods of data input: keyboard, manual digitizing, scanning and automatic digitizing methods. Electronic data transfer, GPS, Data Editing: spatial and attribute data accuracy, concept of topology.**Spatial Analysis**Raster and Vector overlay analysis; Terrain modeling; Spatial interpolation; Buffering and Neighborhood function, Networks;

MODULE 5: Applications of RS and GIS: Pattern detection and characterization, pattern comparison, space-time emphasizing application, predictive modeling applications (Watershed management; Rainfall-runoff modeling; Flood mapping; Environmental monitoring; Groundwater vulnerability modeling; Optional routing of solid wastes collection system of an urban area; Environmental siting and zoning atlas development)Microwave remote sensing

BOOKS AND REFERENCES

1. Lillesand, T. M., Kiefer, R. W., Chipman, J. W. (2004) " Remote sensing and Image Interpretation", 5th Edition, John Wiley & Sons
2. Michael N. DeMers (2008) " Fundamentals of GIS" John Wiley and Sons. Inc

3. Anji Reddy (2008) " Text Book of Remote sensing and Geographical Information systems", 3rd Edition, B. S. Publications, Hyderabad
4. Longley, P. A., Goodchild, M. F., Maguire, D. J., and Rhind, D. W., (2005) Geographical Information Systems: Principles, Techniques, Management and Applications, 2nd Edition, John Wiley & Sons, 2005.

ENVIRONMENTAL PLANNING AND MANAGEMENT

Course Code	**: 15CWM423**	IA Marks	:50
No. of Lecture Hrs/Week	:04	Exam Hrs	:03
Total No.of Lecture Hrs	:50	Exam marks	:100

Objectives:

- The course deals in detail the nature and characteristics of Management,
- It also covers Scope and functional areas of Management & Administration: roles of Management, Levels of Management.
- Nature, importance and purpose of planning process: Decision making – Importance of planning

Course Outcomes: On successful completion of course student will be able to

- Effectively handle Project Identification, Project Selection, Project Report,
- Understand the need and significance of Project, Contents, formulation, Guidelines by Planning Commission for Project Report.
- Understand the Role of Entrepreneurs in Economic Development

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MODULE 1:Management

Introduction – Meaning – nature and characteristics of Management, Scope and functional areas of management– Management as a science, art or profession – Management & Administration – Roles of Management, Levels of Management, Development of Management Thought – early management approaches – Modern management approaches **Planning** Nature, importance and purpose of planning process – objectives – Types of plans (Meaning only) – Decision making – Importance of planning – steps in planning & planning premises – Hierarchy of plans. **MODULE 2:Organizing and Staffing**

Nature and purpose of organization – principles of organization – Types of organization – Departmentation – Committees – Centralisation Vs Decentralisation of authority and responsibility – Span of control – MBO and MBE (Meaning only) Nature and importance of Staffing – Process of Selection & Recruitment (in brief).

Directing & Controlling -Meaning and nature of directing – Leadership styles, Motivation Theories, Communication – Meaning and importance – Coordination, meaning and importance and Techniques of Coordination. Meaning and steps in controlling – Essentials of a sound control system – Methods of establishing control (in brief).

MODULE 3: Entrepreneurship

Meaning of Entrepreneur, Evolution of Concept, Functions of Entrepreneur, Types of Entrepreneur, Entrepreneur – an emerging class. Concept of Entrepreneurship – Evolution of Entrepreneurship, Development

of Entrepreneurship, Stages in entrepreneurial process, Role of Entrepreneurs in Economic Development; Entrepreneurship in India; Entrepreneurship – its Barriers. **MODULE 4:Small Scale Industry**

Definition; Characteristics; Need and rationale : Objectives, Scope, role of SSI in Economic Development.Advantages of SSI. Steps to start an SSI – Government policy towards SSI, Different Policies of SSI., Government Support on SSI., during 5 year plans. Impact of Liberalization, Privatisation, Globalization on SSI.

Effect of WTO / GATT Supporting Agencies of Government for SSI Meaning. Nature of support; Objectives; Functions; Types of Help; Ancillary Industry and Tiny Industry (Definition only).

MODULE 5: Preparation of Project

Meaning of Project, Project Identification, Project Selection, Project Report, Need and significance of Project, Contents, formulation, Guidelines by Planning Commission for Project Report, Network

Analysis, Errors ofProject Report, Project Appraisal.Identification of Business Opportunities.Market Feasibility Study : Technical Feasibility Study, Financial Feasibility Study & Social Feasibility Study.

BOOKS AND REFERENCES

1. Principles of Management – P.C. Tripathi, P.N. Reddy, Tata McGraw Hill,
2. Dynamics of Entrepreneurial Development & Management – Vasant Desai – Himalaya Publishing House
3. Entrepreneurship Development – Small Business Enterprises – Poornima M. Charantimath – Pearson Education – 2006 (2&4).
4. Management Fundamentals – Concepts, Application, Skill Development – Robert Lusier – Thomson .
5. Entrepreneurship Development – SS Khanka – S Chand & Co.
6. Management – Stephen Robbins – Pearson Education / PHI – 17th Edition, 2003.

ECOLOGY AND ENVIRONMENTAL IMPACT ASSESSMENT

Subject Code	: **15CWM424**	IA Marks	:50
No. of Lecture Hrs/Week	:04	Exam Hrs	:03
Total No.of Lecture Hrs	:50	Exam marks	:100

Objectives:

- The course introduces both ecology environmental impact assessment for environmental engineers.
- It explains different ecosystems and their interactions through symbiotic and synergic relationships, reviews ecological indices and modes.
- It describes trophic levels of lakes, influence of nutrient loading and control measures for eutrophication.

Course Outcomes:

- Student will be able to Classify and discuss the structure and function of ecosystems.
- Describe symbiotic and synergic relationships.
- Illustrate the need for bio- geo- cycles. Apply ecosystem models.

MODULE 1: Ecology: Classification of Ecosystems, Structure and Function of Ecosystems, Energy flow in Ecosystems, Ecological Niche and succession, Biogeochemical cycles, Ecological Pyramids. System ecology and Ecosystem Modeling

MODULE 2: Aquatic and Terrestrial Ecosystems: Diversity and dominance Indices, Ecosystem Models. Lake Ecosystem, Trophic levels, nutrient loading, nutrient enrichment, Leibig's Law, control of eutrophication.

MODULE 3: Environmental Impact Assessment

Carrying capacity concept and Environmental Impact Assessment – Objectives, Types - Rapid and Comprehensive EIA, EIS, FONSI. Environmental Economics, Ethics, Step-by-step procedure for conducting EIA and Limitations of EIA, Prevention of Significant Deterioration Programme, Frame work of Impact assessment, scope and contents of EIA, methodologies and techniques of EIA, Public participation in EIA, Attributes, Standards and Value functions.Impact prediction models for various attributes.

MODULE 4: Environmental Audit, Environmental Management Plan (EMP) and Disaster Management Plan (DMP)

MODULE 5 : EIA Case Studies – Pharmaceutical, Thermal Power Plant, Mining, Construction Projects, infrastructural / development Projects ,Water and Wastewater Treatment Plants.

BOOKS AND REFERENCES

1. Canter L., (1995), "Environmental Impact Assessment", McGraw Hill.
2. Jain R.K., Urban L.V., Stacey G.S., (1977), "Environmental Impact Analysis – A New Dimension in Decision Making", Van Nostrand Reinhold Co. 12
3. Clark B.C. Bisett and Tomlinsan P , (1985), "Perspective on Environmental Impact Assessment", Allied Publishers.
4. Odum E.P. & Barret G.W., (2005), "Fundamentals of Ecology", 5th Edition , Cengage Learning
5. George E. P. Box, William G. Hunter, and J. Stuart Hunter, "Statistics for Experiments An Introduction to Design, Data Analysis, and Model Building", John Wiley & Sons.
6. APHA, (2002), "Standard Methods for Examination of Water and Wastewater"; 21st Edition.
7. Adam M. Neville and John B. Kennedy, "Basic Statistical Methods for Engineers and Scientists", International Text Book Company