DEPARTMENT OF CIVIL ENGINEERING

ANNA UNIVERSITY, CHENNAI

OUR VISION:

Department of Civil Engineering, Anna University, shall strive hard to develop and impart technical knowledge and professional skills required for Civil Engineering practice through excellence in teaching, research and consultancy to address sustainable infrastructure development needs at local, national and International levels.

OUR MISSION:

Department of Civil Engineering, Anna University shall contribute to technological and social development by

1. Providing a firm scientific and technological base in Civil Engineering to achieve self-reliance.
2. Providing quality education through innovation in teaching practices at par with global standards.
3. Nurturing leadership and entrepreneurship qualities with ethical values.
4. Developing and disseminating latest knowledge and technologies in emerging areas of Civil Engineering.
5. Sharing intellectual resources and infrastructure facilities through collaborative partnership.
6. Ensuring supporting conditions for enhancing the employability skills.

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS 2023

CHOICE BASED CREDIT SYSTEM

M.E. ENVIRONMENTAL MANAGEMENT (FULL-TIME)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

Graduates of the M.E. Environmental Management Programme will

PEO1	Gain knowledge and skills in environmental management which will enable them to have a career and professional accomplishment in the public or private sector organizations
PEO2	Become consultants and entrepreneurs on sustainable development issues relatedto clean water and sanitation, solid waste management, climate change, environmental policies, environmental impact assessment, environmental Management systems and pollution prevention.
PEO3	Become and develop processes and technologies to meet desired environmental protection needs of society and formulate solutions that are technically sound, economically feasible, and socially acceptable
PEO4	Enter into research and development studies of Environmental Management and Environmental Policies leading to research degrees and innovative solutions
PEO5	Lead the implementation of environmental policies and practices and raiseawareness at all levels of an organization, about emerging environmental issues with due consideration of health, safety, and socio cultural factors and advocate policies, systems, processes and equipment for sustainable development.

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
1.	An ability to independently carry out research/investigation and development work to solve practical problems
2.	An ability to write and present a substantial technical report/document
3.	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the programme. The mastery should be at a level higher than the requirements in the appropriate bachelor programme.
4.	Demonstrate in-depth knowledge of environmental management, with an ability to develop, implement, monitor and maintain environmental strategies, policies, programmes and systems that promote sustainable development.
5.	Evaluate environmental performance including compliance with environmental legislation across the organization, and coordinate all aspects of pollution control, waste management, environmental health and conservation.
6.	Identify, formulate, analyze, and develop management systems and formulate solutions that are technically sound, economically feasible, and socially acceptable

Attested

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PEO/PO Mapping:

PEO	PO					
	PO1	PO2	PO3	PO4	PO5	PO6
I	1	2	3	4	5	6
II	3	3	3	3	3	3
III		3	3	3		3
IV			3			
V	3	3	3	3	3	3

- 1-low, 2-medium, 3-high

MAPPING OF COURSE OUTCOME AND PROGRAMME OUTCOME

		Course Name	PO1	PO2	PO3	PO4	PO5	PO6
YEAR 1	SEMESTER I	Environmental Statistics	3	2	2	2	2	2
		Research Methodology and IPR	2	2	2	2	2	2
		Design of Water and Wastewater Treatment Systems	3	2	2	2	2	2
		Environmental Chemistryand Microbiology	2	2	2	2	2	2
		Principles of Sustainable Development	2	2	2	2	2	2
		Environmental Policy and Legislations	1	1	1	1	2	2
	SEMESTER II	Environmental Economics	2	2	2	2	2	2
		Environmental Impact and Risk Assessment	1	1	1	1	2	2
		Solid and Hazardous Waste Management	2	2	3	2	2	2
		Seminar	3	3	3	3	2	3
YEAR 2	SEMESTER III	Practical Training (4 Weeks)	3	2	2	3	2	2
		Project Work I	3	3	2	3	3	3
	SEMESTER IV	Project Work II	3	2	3	3	3	3

• 1-low, 2-medium, 3-high

MAPPING FOR PROFESSIONAL ELECTIVE COURSES [PEC]

S. NO.	COURSE TITLE	PO1	PO2	PO3	PO4	PO5	PO6
1.	Air and Noise Pollution Control	2	2	2	2	2	2
2.	Soil Pollution and RemediationTechnologies	2	2	2	2	2	2
3.	Environmental Quality Monitoring	1	1	1	1	1	1
4.	Industrial Wastewater Pollution-Prevention and	3	2	3	3	3	2
5.	Life Cycle Assessment and Design for Environment	3	3	2	3	3	2
6.	Environmental Social Governance	2	2	3	2	2	3
7.	Climate Change Modelling, Mitigation and Adaptation	3	3	2	2	3	2
8.	Sustainable Agriculture for Environmental	2	2	2	2	2	-
9.	Waste to Energy	3	2	2	-	3	3
10.	Environmental System Modelling	3	2	3	2	3	2
11.	Environmental Toxicology andMonitoring	2	2	2	2	2	2
12.	Environmental Biotechnology	2	2	2	2	2	2
13.	Environmental Management	3	1	3	3	2	2
14.	Membrane Separation for Water andWastewater Treatment	2	1	3	3	2	2
15.	Environment, Health and Safety inIndustries	2	2	2	2	2	2
16.	Industrial Ecology	2	1	3	3	3	2
17.	Energy Management in Industries	2	2	2	2	2	2
18.	Marine Pollution and Control	2	3	3	3	3	3
19.	Remote Sensing and GIS Applications in Environmental Management	3	2	2	3	3	3
20.	Operation and Maintenance of Waterand Wastewater Treatment Systems	2	2	2	2	2	2
21.	Sludge and Septage Management	2	2	2	2	2	2
22.	Rural Water Supply and Onsite Sanitation	2	2	2	2	2	2

• 1-low, 2-medium, 3-high

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ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. ENVIRONMENTAL MANAGEMENT (FULL-TIME)
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM
CURRICULA AND SYLLABI FOR I TO IV SEMESTERS

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	EN3151	Environmental Statistics	FC	4	0	0	4	4
2.	EM3101	Design of Water and Wastewater Treatment Systems	PCC	4	0	0	4	4
3.	EM3102	Environmental Chemistry and Microbiology	PCC	3	0	4	7	5
4.	EM3103	Principles of Sustainable Development	PCC	3	0	0	3	3
5.	EM3104	Environmental Policy and Legislations	PCC	3	0	0	3	3
6.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
			TOTAL	**19**	**1**	**4**	**24**	**22**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	EM3201	Environmental Economics	PCC	3	0	0	3	3
2.	EM3251	Environmental Impact and Risk Assessment	PCC	3	0	0	3	3
3.	EM3252	Solid and Hazardous Waste Management	PCC	3	0	0	3	3
4.		Professional Elective I	PEC	3	0	0	3	3
5.		Professional Elective II	PEC	3	0	0	3	3
6.		Professional Elective III	PEC	3	0	0	3	3
PRACTICALS								
7.	EM3211	Seminar	EEC	0	0	2	2	1
			TOTAL	**18**	**0**	**2**	**20**	**19**

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SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective IV	PEC	3	0	0	3	3
2.		Professional Elective V	PEC	3	0	0	3	3
3.		Professional Elective VI	PEC	3	0	0	3	3
PRACTICALS								
4.	EM3311	Practical Training (Four weeks / fourteen days) during summer vacation of II semester	EEC	0	0	0	0	2
5.	EM3312	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**17**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	EM3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR AWARD OF THE DEGREE: 70

FOUNDATION COURSES (FC)

S. NO.	COURSE CODE.	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	EN3151	Environmental Statistics	4	0	0	4	1

PROFESSIONALCORE COURSES (PCC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	EM3101	Design of Water and Wastewater Treatment Systems	4	0	0	4	1
2.	EM3102	Environmental Chemistry and Microbiology	3	0	4	5	1
3.	EM3104	Environmental Policy and Legislations	3	0	0	3	1
4.	EM3103	Principles of Sustainable Development	3	0	0	3	1
5.	EM3201	Environmental Economics	3	0	0	3	2
6.	EM3251	Environmental Impact and Risk Assessment	3	0	0	3	2
7.	EM3252	Solid and hazardous Waste Management	3	0	0	3	2
					TOTAL CREDITS	**23**	

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	RM3151	Research Methodology and IPR	2	1	0	3	1

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	EM3211	Seminar	0	0	2	1	2
2.	EM3311	Practical Training	0	0	0	2	3
3.	EM3312	Project Work I	0	0	12	6	3
4.	EM3411	Project Work II	0	0	24	12	4
					Total Credits	**21**	

PROFESSIONAL ELECTIVE COURSES [PEC]

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	EN3251	Air and Noise Pollution Control	3	0	0	3
2.	EM3001	Soil Pollution and Remediation Technologies	3	0	0	3
3.	EM3002	Environmental Quality Monitoring	3	0	0	3
4.	EN3252	Industrial Wastewater Pollution-Prevention and Control	3	0	0	3
5.	EM3003	Life Cycle Assessment and Design for Environment	3	0	0	3
6.	EM3004	Environmental Social Governance	3	0	0	3
7.	EM3053	Climate Change Modelling, Mitigation and Adaptation	3	0	0	3
8.	EM3005	Sustainable Agriculture for Environmental Management	3	0	0	3
9.	EM3006	Waste to Energy	3	0	0	3
10.	EM3007	Environmental System Modelling	3	0	0	3
11.	EM3008	Environmental Toxicology and Monitoring	3	0	0	3
12.	EM3009	Environmental Biotechnology	3	0	0	3
13.	EM3051	Environmental Management Systems and Auditing	3	0	0	3
14.	EN3052	Membrane Separation for Water and Wastewater Treatment	3	0	0	3
15.	EM3010	Environment, Health and Safety in Industries	3	0	0	3
16.	EM3011	Industrial Ecology	3	0	0	3
17.	EM3012	Energy Management in Industries	3	0	0	3
18.	EN3051	Marine Pollution and Control	3	0	0	3

19	EM3013	Remote Sensing and GIS Applications in Environmental Management	3	0	0	3
20	EM3052	Operation and Maintenance of Water and Wastewater Treatment Systems	3	0	0	3
21.	EM3014	Sludge and Septage Management	3	0	0	3
22.	EM3015	Rural Water Supply and Onsite Sanitation	3	0	0	3

Summary

NAME OF THE PROGRAMME: M.E ENVIRONMENTAL MANAGEMENT						
S. No	**Subject Area**	**Credits per Semester**				**Credits Total**
		I	**II**	**III**	**IV**	
1	**FC**	4	--			**4**
2	**PCC**	15	09			**24**
3	**PEC**	---	9	9		**18**
4	**RMC**	3				**3**
5	**EEC**	---	1	8	12	**21**
	Total	**22**	**19**	**17**	**12**	**70**

EN3151 ENVIRONMENTAL STATISTICS L T P C
4 0 0 4

UNIT I ENVIRONMENTAL DATA 12

Environmental data; types and objectives **-** Air, Water, Noise, Climate and Meteorological Data- generation -measurement scales; interpreting environmental standards and data- Environmental Problems and Statistics

UNIT II ENVIRONMENTAL STATISTICS 12

Statistical descriptors of environmental data – numerical and graphical; uncertainty – accuracy, precision and bias estimation of environmental data; variability and errors in environmental data. concept of random variable and its relevance.

Probability concepts; probability distribution functions and their applications-discrete and continuous distributions. Probability distribution applications-.

UNIT III ENVIRONMENTAL DATA SAMPLING AND ANALYSIS 12

Need and purpose of sampling; types of sampling designs-probability and non-probability sampling designs for environmental monitoring- Sampling theory, sampling distributions; environmental parameter estimation-point and interval estimates; confidence interval estimation; sample size determination Hypothesis testing-parametric and non-parametric tests: assessment of violation of environmental standards, comparing environmental parameters

UNIT IV ENVIRONMENTAL DATA ANALYTICAL TOOLS 12

Correlation analyses: graphical analysis, covariance, correlation coefficient, distribution of correlation coefficient and its statistical significance. Empirical model Building-Regression analysis: assumptions and definitions, principle of least squares, regression parameters their distribution.

Analysis of Variance(ANOVA); Mid-term Exercises- Multivariate exploratory technique Ordination, principle component analysis- Cluster analysis- Diversity measure- Machine leaning- Monte-Carlo method and risk assessment

UNIT V APPLICATIONS AND CASE STUDIES 12

Case studies: Climate change and volume-discharge curve Applications: Stage-discharge curve and volume-discharge curves, water quality parameters and agriculture. Analysis of trend in the environmental data Introduction to time-series analysis; characteristics of hydrological, water and air quality time series; Trend and seasonality; detecting and estimating trends-applications to hydrological, meteorological, water and air quality data.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

By the end of this course, students will be able to:

CO1 Statistically analyse and present the environmental data

CO2 demonstrate the applications of statistical techniques to problems drawn from industry, management and other engineering fields

CO3 Explain major statistical analysis and modeling techniques for scientific understanding of environmental problems

CO4 Select appropriate statistical analysis methods depending on particular environmental problem and type of data

CO5 Apply major statistical analysis and modeling techniques to particular dataset, and interpret the results from such applications.

REFERENCES:

1. Environmental and Ecological Statistics with R, 2010, S. S. Quin, CRC Press
2. Environmental Statistics: Methods and Applications, 2003, Vic Barnett, wiley
3. Statistics for Environmental Science and Management, 2008, Bryan F.J. Manly, CRC Press
4. Statistics for Environmental Engineers, Linfield C. Brown, Paul Mac Berthouex, 2002, CRC Press
5. Statistical Tools for Environmental Quality Measurement, 2003, Douglas E. Splitstone, Michael E. Ginevan, Chapman & Hall

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CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	2
CO2	3	3	2	2	3	3
CO3	3	2	2	2	2	2
CO4	2	3	2	2	2	3
CO5	3	2	3	3	2	2
Avg	**3**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

EM3101 DESIGN OF WATER AND WASTEWATER TREATMENT SYSTEMS LT P C
4 0 0 4

UNIT I PRINCIPLES OF TREATMENT 12

Pollutants in water and wastewater – characteristics - standards for performance, treatment processes – Selection criteria-types of reactors - kinetics – Unit operations and unit processes-physico-chemical treatment principles - screening, skimming, floatation – mixing, equalization, sedimentation, filtration – gas transfer – adsorption Isotherms –membrane separation, electro dialysis – stripping neutralization - coagulation flocculation – precipitation – stabilization – disinfection, Ion exchange – advanced oxidation process – principles of biological treatment – aerobic and anaerobic treatment - kinetics of biological growth – attached and suspended growth process.

UNIT II DESIGN OF WATER TREATMENT PLANTS 12

Design of treatment plant units – selection of process - upgrading existing plants – aerators – chemical feeding – Flash mixer- Clari-flocculator – lamella and plate settlers- – filters – rapid sand filters, pressure filter, dual media filters-Multimedia filters disinfectors- design of softeners – demineralization plant –reverse osmosis plants Hydraulic profiles for treatment plants.

UNIT III DESIGN OF CONVENTIONAL WASTEWATER TREATMENT PLANTS 12

Design of treatment units - screens- grit chamber - settling tanks - design of aerobic treatment systems - activated sludge process and variations, trickling filters-bio tower- RBC- aerated lagoons – natural treatment systems- waste stabilization ponds, constructed wetland – Disinfection – Design of anaerobic treatment system - septic tanks – Nutrient removal systems

UNIT IV DESIGN OF ADVANCED WASTEWATER TREATMENT PLANTS 12

Design of sequencing batch reactors- moving bed biofilm reactors- membrane bioreactor-reclamation and reuse of wastewater-design of tertiary treatment units- application of membrane separation technologies in reuse of sewage -nutrient removal systems- UASB – post treatment systems for UASB reactor- anaerobic filters – expanded bed and fluidized bed anaerobic systems - design of nutrient removal systems - anaerobic ammonium oxidation process -recent trends.

UNIT V RESIDUAL MANAGEMENT OPERATION AND MAINTENANCE ASPECTS 12

Characteristics of sludge from WTP and STP-Design of sludge management facilities for WTP and STP-sludge thickening-sludge digestion- design of anaerobic digester- biogas generation-sludge dewatering –filter press-vacuum filtration- centrifugation-- sludge drying beds - construction, operation and Maintenance aspects of WTP and STP trouble shooting – Planning, Organizing and controlling of plant operations – capacitybuilding, case studies of Retrofitting.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

On completion of the course, the student is expected to be able to

CO1 Understand the principle of water and wastewater treatment

CO2 Design and sizing the different components of water treatment plant.

CO3 Design of conventional wastewater treatment units
CO4 understand in detail about the design of advanced wastewater treatment units
CO5 design the different elements of sludge treatment systems and understand theimportance O&M issues pertaining to WTP and STP

REFERENCES:

1. Arceivala S.J., and Asolekar S.R "Wastewater Treatment for Pollution Control and reuse "McGraw Hill, third Edition, New Delhi, 2007.
2. Manual on “Sewerage and Sewage Treatment Systems Part A, Part B &Part C”CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
3. Metcalf & Eddy, INC, Wastewater Engineering – Treatment and Reuse, FourthEdition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2017.
4. Qasim, S. R. and Guang Zhu "Wastewater Treatment and Reuse. Theory and DesignExamples", CRC Press, New York, 2018.
5. F.R. Spellman, "Hand Book of Water and Wastewater Treatment Plant operations",CRC Press, New York 2009.
6. David Hendricks, "Fundamentals of Water Treatment Process", CRC Press, New York2016.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	3	2	3
CO2	2	2	2	2	3	2
CO3	3	2	2	2	2	2
CO4	2	3	3	3	2	3
CO5	2	2	3	2	3	2
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

EM3102 ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY L T P C
3 0 4 5

UNIT I ENVIRONMENTAL AQUATIC CHEMISTRY 9

Stoichiometry and mass balance-chemical equilibria, acid base, solubility product(Ksp), chemical kinetics, fate of chemicals and typical pollutants in aquatic environment, - characteristics of water pollution, volatilization, coagulation, partitioning, hydrolysis, photochemical transformation– Degradation of pesticides and surfactants - Metals, complex formation, oxidation and reduction.

UNIT II ATMOSPHERIC AND ENVIRONMENTAL SOIL CHEMISTRY 9

Atmospheric structure – major air pollutants – oxides of carbon, nitrogen, sulphur – Hydrocarbons - chemical and photochemical reactions – photochemical smog. Ozone layer depletion – greenhouse gases and global warming, Acid rain- origin and composition of particulates, evolution of soil chemistry- contaminants in soil – soil decontamination – inorganic soil components- primary soil minerals, secondary soil minerals, nature and composition of soil-clays- ion-exchange reactions in soil – agricultural chemicals in soil, Heavy metals-Chemical speciation and their toxicity- humic substances- retention of pesticides and other organic substances by humic substances - Nano materials, CNT, titania, composites , applications.

UNIT III CLASSIFICATION AND CHARACTERISTICS OF MICROORGANISMS 9

Classification and distribution of microorganisms – aerobic and anaerobic cultures, synchronous and asynchronous culture, batch, fed batch and continuous culture. measurement of growth, factors affecting growth. extremophiles: Microbial interactions - chemolithotrophic organisms and biogeochemical cycles – Nutrition and metabolism in microorganisms, growth phases, carbohydrate,

protein, lipid metabolism – respiration, aerobicand anaerobic-fermentation, glycolysis, Kreb's cycle, hexose monophosphate pathway, electron transport system, oxidative phosphorylation, environmental factors, enzymes, bioenergetics - importance (NO_3 respiration, SO_4 respiration, Halorespiration).

UNIT IV MICROORGANISMS AS INDICATORS OF POLLUTANTS 9

Water borne pathogens and their effects, transmission of pathogens, - total coliforms, E-coli, streptococcus, clostridium, concentration and detection of virus, factors influencing toxicity. effects – acute, chronic, test organisms – toxicity testing, microbial toxicology and degradationof xenobiotics - bioconcentration – bioaccumulation, biomagnification, bioassay, biomonitoring, bioleaching. - emerging Contaminants biodrgradation – factors affecting biodegradation.

UNIT V APPLICATIONS OF MICROORGANISMS FOR CLEAN ENVIRONMENT 9

Microbial assessment of water quality, microbes as bio-indicators, potability of water, treatment of municipal water. solid and liquid based treatment, biological (aerobic, anaerobic,primary, secondary & tertiary) treatment. Nutrients removal – BOD, nitrogen, phosphate, nitrification and denitrification, eutrophication – causes and effects, removal of pathogens fromwater and wastewater – bacteria, protozoa, virus – methods – physical, chemical andbiological.

LIST OF EXPERIMENTS 60

A: Environmental Chemistry

1. Estimation of hardness in Water sample by volumetric titration
2. Estimation of Na/K in soil by Flame Photometer
3. Determination of sulphate
4. Determination of phosphate
5. Determination of Total Solids, Total suspended solids, Total dissolved solids
6. Determination of COD in the wastewater sample
7. Determination of BOD in the wastewater sample

B: Environmental Microbiology

1. Preparation of culture media
2. Isolation and enumeration of bacteria in soil
3. Isolation and enumeration of bacteria in water
4. Detection of algae in water
5. Identification of bacteria using Gram Staining technique
6. Bacteriological analysis of wastewater (Coliforms & Streptococcus) – MPN Technique
7. Bacteriological analysis of wastewater (Coliforms & Streptococcus) MF technique

TOTAL : 105 PERIODS

COURSE OUTCOMES:

On completion of the course, the student is expected to be able to

CO1: Explain the various chemical pollutants present in aquatic environment, their sources, characteristics, and the chemical reactions involved

CO2: Demonstrate knowledge and understanding of various soil and atmospheric chemical environment arise in nature, apply the knowledge to explain the real-world environmental chemistry. Capable of using theoretical knowledge to solve real-world type problems.

CO3: Gain knowledge on the distribution of various microorganisms in different ecosystems,the factors affecting the growth of the organisms, the significance of the organisms in organic matter decomposition and environmental clean up

CO4: Select appropriate techniques to enumerate the pathogens in wastewater, exploitation of microorganisms to indicate the various pollutants in water and design experiments to remove the pollutants from wastewater using microorganisms

CO5: Apply the knowledge to design appropriate methods or experiments to treat the wastewater to remove the nutrients by utilizing the suitable microorganisms, their nutrient requirement and the metabolic pathway

REFERENCES

1. Chemistry for Environmental Engineering and Science, Sawyer,C.N., MacCarty, P.L. and Parkin, G.F Tata McGraw – Hill, Fifth edition, New Delhi (2003).
2. Environmental Chemistry', Freeman and company, New York, (2012).
3. Environmental Chemistry, Eighth Edition, Colin Baird and Michael Cann Manahan,S.E., CRC press (2005)
4. P.K. Goel, Water Pollution: Causes, Effects and Control, New Age International,NewDelhi, 2006
5. Hand Book of Environmental Microbiology, S.C.Bhatia, Vol 1, 2 and 3, Atlantic Publisher,2008.
6. Text Book of Environmental Microbiology, Pradipa K. Mohapatra, I.K. InternationalPublishing House pvt. Ltd., 2008
7. A Text Book of Microbiology, R.C. Dubey and D. K. Maheswari S. Chand & CompanyLtd - New Delhi, 2013
8. Environmental Microbiology: Fundamentals and Applications Bertrand, J.-C., Caumette, P., Lebaron, P., Matheron, R., Normand, P., Sime-Ngando, T. (Eds.) Springer, 2015
9. APHA, "Standard Methods for the Examination of Water and Wastewater", 23 rd Ed Washington, 2017.
10. "Laboratory Manual for the Examination of water, wastewater soil Rump", H.H. and Krist, H. – VCH, Germany, 3rd Edition, 1999.
11. ."Methods of air sampling & analysis", James P.Lodge Jr(Editor) 3rd Edition, Routledge; 2020

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	3	2	3
CO2	2	2	2	2	3	2
CO3	3	2	2	2	2	2
CO4	2	3	3	3	2	3
CO5	2	2	3	2	3	2
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

EM3103 PRINCIPLES OF SUSTAINABLE DEVELOPMENT L T P C
3 0 0 3

UNIT I SUSTAINABILITY CONCEPT AND PRINCIPLES 9

Core problems and cross cutting Issues of the 21 Century - History and emergence ofsustainable development - Environmental, Economic and Social Pillars of sustainability - strong and weak sustainability – mindsets for sustainability: earthly, analytical, precautionary, action and collaborative– syndromes of global change: utilisation syndromes, development syndromes, and sink syndromes –- Sustainable development models – Rio Principles of sustainable development - Natural Step- Peoples Earth Charter – Ten Principles of the UN Global Compact.

UNIT II SUSTAINABLE DEVELOPMENT GOALS AND SOCIETY 9

Social short fall and ecological overshoot of nations - United Nations' 2030 Agenda forsustainable development – 17 sustainable development goals and targets, indicatorsand intervention areas -The Unjust World and inequities - Quality of Life - Poverty, Population and Pollution - Combating Poverty - - Demographic dynamics of sustainability -Actions to reach the 2030 Agenda for sustainable development - Strategies to end Rural and Urban Poverty and Hunger – Sustainable Livelihood Framework- Health, Education and Empowerment of Women, Children, Youth,Indigenous People, Non-Governmental Organizations and Local Authorities .

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UNIT III ECOSYSTEM CONSERVATION AND RESTORATION 9

Conservation vs restoration - Prevention, Precaution, Preservation and Public Participation - Selection and implementation of restoration interventions - SustainableConsumption and Production – Investing in Natural Capital- Agriculture, Forests, Fisheries - Food security and nutrition and sustainable agriculture- Water and sanitation - Biodiversity conservation and Ecosystem integrity – Ecotourism -– ClimateChange –Paris agreement -Mitigation and Adaptation - Safeguarding Marine Resources

UNIT IV SCIENCE, TECHNOLOGY AND INNOVATION FOR SUSTAINABILITY 9

Science and Technology for sustainable development – Applying science, technologyand innovation for Water, Energy, mobility, Circularity, housing, Equity and empowerment - Nature of sustainable development strategies and current practice – Resource efficiency-Decoupling- Sustainable Cities – Green Buildings - Sustainable Transportation –- Sustainable Mining - Sustainable Energy – Inclusive Green Growthand Green Economy –Financial frameworks and resources to advance the Agenda 2030

UNIT V MONITORING AND ASSESSING PROGRESS 9

Sustainability in global, regional and national context – Actions to localizing SDGs - Performance indicators of sustainability and Assessment mechanism - Approaches tomeasuring and analyzing sustainability–- limitations of GDP- Data Driven Assessmentof Sustainability – carbon foot print- Ecological Footprint- Human Development Index-business charter for sustainable development - SDGs, ESG, CSR and Sustainability- ESG Reporting and Corporate Sustainability- National Sustainable DevelopmentStrategy Planning and National Status of Sustainable Development Goals

TOTAL: 45 PERIODS

'**COURSE OUTCOMES:**

- On completion of the course, the student is expected to be able to

CO1 Explain and evaluate current challenges to sustainability, including social, environmental, and economic issues.

CO2 Identify and critically analyze the social environmental, and economic dimensions of sustainability in terms of UN Sustainable development goals

CO3 Develop a fair understanding of the social, economic and ecological linkage of Humanwell being, production and consumption

CO4 Evaluate sustainability issues and solutions using a holistic approach that focuses on connections between complex human and natural systems.

CO5 Integrate knowledge from multiple sources and perspectives to understandenvironmental limits governing human societies and economies and social justice dimensions of sustainability.

REFERENCES:

1. A guide to SDG interactions:from science to implementation, InternationalCouncil for Science, Paris,2017
2. Ajay Ahlawat (2019), Sustainable Development Goals: Directive Principles forSustainable India by 2030, MyARSu.
3. Karel Mulder (2017), Sustainable Development for Engineers - A Handbookand Resource Guide, Rouledge Taylor and Francis, 2017.
4. Klaus Bosselmann (2017), The Principle of Sustainability - Transforming Law and Governance, Routledge.
5. NITI Aayog (2022), The Indian Model of SDG Localisation, and other Reports of NITI Aayog, Government of India
6. Julia Walker, Alma Pekmezovic, Gordon Walker (2019), Sustainable Development Goals: Harnessing Business to Achieve the SDGs through Finance, Technology, and Law Reform, John Wiley & Sons Ltd

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	3	2	2
CO2	2	2	2	2	3	2
CO3	3	2	2	2	2	2
CO4	2	3	3	3	2	3
CO5	2	2	3	2	3	2
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

EM3104 EMENVIRONMENTAL POLICY AND LEGISLATIONS L T P C
3 0 0 3

UNIT I INTRODUCTION TO ENVIRONMENTAL LEGISLATIONS AND INTERNATIONAL SCENARIO 9

International law; sources of international law; law of treaties; signature, ratification. Evolution of international environmental law: Customary principles; Common but differentiated responsibility. Stockholm conference; Rio conference, Basel Convention on the Control of Trans boundary Movement of Hazardous Wastes and their disposal**-** Convention of Biological Diversity**-**U. N Frame Work Convention on Climate Change**-** Montreal Protocol on Substances that deplete Ozone Layer**-** Kyoto Protocol**.**

UNIT II INDIAN CONSTITUTIONS -ENVIRONMENTAL PROTECTION 9

Introduction to environmental laws in India; Indian Constitution and Environmental Protection ,Bhopal gas tragedy -Constitutional provisions concerning Environment Articles 14,15,(2) (b) 19 (e),21,31,32,38,39,42,47, 48-A,49,51,51-A: Indian Environmental Policy 2006 Administrative machinery for pollution control. Common Law & Criminal Law Nuisance, Negligence, Strict liability and Absolute liability, Provisions of IPC relating to environmental problems (public nuisance u/s 268 and others (Sections 269,270,277,284,285,286,425 to 440) Section 133 of Cr.P.C.

UNIT III REMEDIES FOR ENVIRONMENTAL POLLUTION 9

Common Law Remedies/Remedies under Law of Tort – Penal Remedies – Indian Penal Code and Code of Criminal Procedure – Remedies under Constitutional Law – Writs – Public Interest Litigation - Public Liability Insurance Act, 1991 – The National Green Tribunal Act 2010. Polluter Pay Principle, Precautionary Principle, Public Trust Doctrine

UNIT IV MAJOR INDIAN ENVIRONMENTAL LEGISLATIONS 9

Water Act (1974), Air Act (1981) ,Environmental Protection Act (1986) Major Notifications - Solid Waste Management Rules, 2016 - Biomedical Waste Management Rules, 2016 Hazardous and other Wastes (Management & Transboundary Movement) Rules, 2016amendment Rules, 2022 - E- Waste (Management) Rules, 2022- Battery Waste Management Rules, 2022- Plastic Waste Management Rules, 2016, as amended, 2022-Guidelines on Extended Producer Responsibility for Plastic Packaging.Guidelines for Environmentally Sound Facilities for Handling, Processing and Recycling of End-of- Life Vehicles (ELV). Extended Producer Responsibility (EPR) : Waste Tyre ,Plastic waste management and E waste management. Coastal Regulation Zone Notification

UNIT V ENVIRONMENT AND DEVELOPMENT CASE LAWS 9

Meaning and concept of development - Its impact on environment; conflict between environment and development, Concept of Sustainable Development, Environment Impact Assessment Notifications- - Public Hearing Notifications.

Landmark Judgments **-** Olium gas leakage case, Rural Litigation and Entitlement Kendra, Dehradun, (1985) Supp SCC 487) Vellore Citizen Welfare Forum v. Union of India, (1996) 5SCC 647) Ganga Pollution case (1988) I SCC) S. Jagannath v. UOI (1997).**)** Sachidanand Pandey v. State of West Bengal (1987) Indian Council for Enviro-Legal Action vs. Union of India (1996)

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 be familiar with the laws, policies and institutions in the field of environment in national as well in international level

CO2 acquire the skills needed for interpreting laws, policies and judicial decisions in a holistic perspective

CO3 acquire the ability to evaluate the role of law and policy in conservation and management of natural resources and prevention of pollution

CO4 Critically analyze environmental laws within various contexts and to evaluate laws against procedural and substantive criteria

CO5 Understand and the Legal system operating in India and will be in a position to prepare compliance reports for getting environmental clearance

REFERENCES:

1. Leelakrishnan P., Environmental Law in India, Butterworths,1998
2. Divan S. and Rosencranz A. (2005) Environmental Law and Policy in India, 2 nd ed., Oxford, New Delhi
3. Leelakrishnan P. (2008) Environmental Law in India, 3rd ed., Lexis Nexis, India.
4. Birnie P. (2009) et al., International Law and the Environment, 3rd ed., Oxford.
5. Desai A. (2002) Environmental Jurisprudence, 2nd ed., Modern Law House, Allahabad.
6. Shanthakumar S. , Environmental Law – An Introduction, Butterworths,2004
7. Shyam Diwan and Armin Rosencranz, Enviromental Law and Policy in India, Oxford, 2001
8. Statutory Materials Bare Act/s
9. Hand Book of International Environmental Law UNEP Publication
10. Philippe Sands, Principles of International Environmental Law, Cambridge,1998
11. Elli Louka, International Environmental Law, Cambridge,1999'

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	-	3	-	3
CO2	-	1	2	1	-	-
CO3	-	2	2	1	-	1
CO4	1	1	3	2	3	2
CO5	-	1	2	3	-	1
Avg	1	1	3	2	3	2

• 1-low, 2-medium, 3-high

RM3151 RESEARCH METHODOLOGY AND IPR L T P C
2 1 0 3

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

EM3201 ENVIRONMENTAL ECONOMICS L T P C
3 0 0 3

UNIT I PRINCIPLES OF ECONOMICS 9

Environment as an Asset - Interaction between economy and environment – Economic concepts of Wealth, Welfare, Scarcity, Growth, Sustainability, Costs, Benefits, Opportunity costs ,Social Costs- Trade off and marginal thinking- Marginal Costs and Marginal Benefits –Positive and Normative criteria for decision making - Equi marginal principle- Abatement costand Efficient level of pollution - Marginal Damage Functions –Consumer Choice theory – Economic Efficiency and Markets– Supply and Demand– Consumers’surplus - Producers’ surplus and net social benefit -Static and dynamic efficiency - market failures –Property Rights, Externalities, and Environmental Problem - Coase Theorem - Public Goods and Externalities - Free rider problem – Tragedy of the commons

UNITII ECONOMIC VALUATION OF ENVIRONMENTAL RESOURCES 9

Types of Economic value - Environmental Benefits and Environmental Costs – Classifying economic valuation methods– Direct and indirect methods – Surrogate markets – Stated Preference and

Revealed Preference methods- hedonic prices, travel cost models, contingent valuation, benefit transfer –economic valuation of ecosystem services- Assessment of Loss ofEcology - Valuation of Health impacts - Environmental accounting

UNITIII ECONOMICS OF POLLUTION PREVENTION AND CONTROL 9

Economics of Environmental Quality- - Cost benefit analysis and Cost effectiveness analysis– welfare foundation of cost-benefit analysis - Principles, methodology and Limitations – Discounting and intergenerational equity - Profitability of Pollution Prevention - Pay back period – Present value estimation – Internal rate of return –Economic analysis of Pollution Prevention Case studies– economically efficient pollution control programmes – Economics of Enforcement - Efficient allocation of pollution from mobile and stationery source – Total Cost Assessment- Life cycle costing-Green Accounting and Economic indicators

UNIT IV ECONOMIC INSTRUMENTS FOR ENVIIRONMENTAL PROTECTION 9

Economic analysis of Environmental Policy -Regulatory versus Economic Instruments – Decentralized Policies: Liability Laws, Property Rights, and Moral Suasion - Command-and- Control Strategies - Pigovian and Pollution Taxes – Internalizing externality using the Pigouvian tax approach - Emission Charges and Subsidies– Marketable permits – Emission trading -– Non Compliance fees, bonds and deposit refunds –Evaluation of Instruments – Choice of instruments for Environmental policy - macroeconomic effects of environmental regulations - - Economics of Climate Change – Climate Finance – Carbon credits.

UNIT V NATURAL RESOURCE ECONOMICS 9

Natural Resources and Environmental resources – Concept and Classification , Scarcity and its economic implications - Economics of depletable and non renewable resources – Recyclable resources – Replenishable but depletable resources – Storable renewable resources – Renewable common property Resources–Optimal Use of Exhaustible Resources-

Natural resources accounting - Economics of Forestry and fisheries exploitation –Trade and environment – Income Effects and Environmental Kuznets Curves – Race to the Bottom and Pollution Haven Hypothesis - Porter Hypothesis

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1 explain the various terms and basic principles of environmental economics

CO2 apply the knowledge of science and engineering fundamentals to analyse costs, benefits and value of environmental and natural resources accounting

CO3 design of economic instruments and policies for optimal pollution, economics of exhaustible resources and renewable resources

CO4 select appropriate economic instruments and policies for environmental management taking into account the impact of the solutions in a sustainability context

CO5 conduct research pertinent to environmental economics and communicate effectively to different stakeholders as well as engage in independent life-long learning

REFERENCES:

1. Tom Tietenberg, Lynne Lewis ,Environmental Economics: The Essentials, Taylor &Francis, 2019
2. Tom Tietenberg, Lynne Lewis , Natural Resource Economics: The Essentials, Taylor& Francis, 2019
3. Barry Field and Martha Field, Environmental Economics: An Introduction, McGraw-Hill,2021.
4. Nancy Olewiler; Barry Field, Environmental Economics , McGraw-Hill Ryerson, 2015
5. Kate Raworth, Doughnut Economics - Seven ways to think like a 21st century Economist, Random House Business Books, UK, 2017
6. Kolstad, Charles, Environmental Economics", Oxford University Press, New York,2011
7. John Asafu Adjaye, " Environmental Economics for non-Economists – techniques and policies for Sustainable Development, World Scientific,2005

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CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	3	2	2
CO2	2	2	2	2	3	2
CO3	3	2	2	2	2	2
CO4	2	3	3	3	2	3
CO5	2	2	3	2	3	2
Avg	2	2	2	2	2	2

• 1-low, 2-medium, 3-high

EM3251 ENVIRONMENTAL IMPACT AND RISK ASSESSMENT L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Historical development of Environmental Impact Assessment (EIA). Environmental Clearance-EIA in project cycle. legal and regulatory aspects in India – types and limitations of EIA –EIA process-screening – scoping - terms of reference in EIA- setting – analysis – mitigation. Crosssectoral issues –public hearing in EIA- EIA consultant accreditation.

UNIT II IMPACT INDENTIFICATION AND PREDICTION 9

Matrices – networks – checklists – cost benefit analysis – analysis of alternatives – expert systems in EIA. prediction tools for EIA – mathematical modeling for impact prediction – assessment of impacts – air – water – soil – noise – biological — cumulative impact assessment

UNIT III SOCIO-ECONOMIC IMPACT ASSESSMENT 9

Socio-economic impact assessment - relationship between social impacts and change in community and institutional arrangements. factors and methodologies- individual and family level impacts. communities in transition-rehabilitation

UNIT IV EIA DOCUMENTATION AND ENVIRONMENTAL MANAGEMENT PLAN 9

Environmental management plan - preparation, implementation and review – mitigation and rehabilitation plans – policy and guidelines for planning and monitoring programmes – post project audit – documentation of EIA findings – ethical and quality aspects of environmental impact assessment and Case Studies

UNIT V ENVIRONMENTAL RISK ASSESSMENT AND MANAGEMENT 9

Environmental risk assessment framework-Hazard identification -Dose Response Evaluation
- Exposure Assessment – Exposure Factors, Tools for Environmental Risk Assessment– HAZOP and FEMA methods – Event tree and fault tree analysis – Multimedia and multipathway exposure modeling of contaminant- Risk Characterization Risk communication
- Emergency Preparedness Plans –Design of risk management programs.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1 Understand need for environmental clearance, its legal procedure, need of EIA, its types, stakeholders and their roles

CO2 Understand various impact identification methodologies, prediction techniques and model of impacts on various environments

CO3 Understand relationship between social impacts and change in community due to development activities and rehabilitation methods

CO4 Document the EIA findings and prepare environmental management and monitoring plan

CO5 Identify, predict and assess impacts of similar projects based on case studies

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REFERENCES

1. EIA Notification 2006 including recent amendments, by Ministry of Environment, Forest and Climate Change, Government of India
2. Sectoral Guidelines under EIA Notification by Ministry of Environment, Forest andClimate Change, Government of India
3. Canter, L.W., Environmental Impact Assessment, McGraw Hill, New York. 1996
4. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrentproblems, Wiley-Interscience, New Jersey. 2003
5. Lee N. and George C. 2000. Environmental Assessment in Developing andTransitional Countries. Chichester: Willey
6. World Bank –Source book on EIA ,1999
7. Sam Mannan, Lees' Loss Prevention in the Process Industries, Hazard Identification Assessment and Control, 4th Edition, Butterworth Heineman, 2012.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	-
CO2	1	1	1	2	2	3
CO3	1	1	1	1	1	1
CO4	-	2	2	1	3	1
CO5	1	2	3	2	3	3
Avg	**1**	**1**	**2**	**1**	**2**	**2**

• 1-low, 2-medium, 3-high

EM3252 SOLID AND HAZARDOUS WASTE MANAGEMENT L T P C
3 0 0 3

UNIT I WASTE CLASSIFICATION AND REGULATORY REQUIREMENTS 9

Sources and types of solid and hazardous wastes - need for solid and hazardous waste management – salient features of latest Indian legislations on management and handling of solid wastes, hazardous wastes,Plastic wastes, biomedical wastes, electronic wastes, construction and demolition wastes, plastics and discarded lead acid batteries – elements of integrated waste management and roles of stakeholders - seven elements and seven step approach to integrated solid waste management planning.

UNITII WASTE CHARACTERIZATION, SOURCE REDUCTION AND RECYCLING 9

Waste sampling and characterization plan - waste generation rates and variation – physical composition, chemical and biological properties – hazardous characteristics – ignitability, corrosivity and TCLP tests –source reduction, segregation and onsite storage of wastes – waste exchange - extended producer responsibility - recycling of plastics, Micro plastics,C&D wastes and E wastes.

UNITIII WASTE COLLECTION, TRANSPORT AND MATERIAL RECOVERY 9

Door to door collection of segregated solid wastes -analysis of hauled container and stationery container collection systems - compatibility, storage, labeling and handling of hazardous wastes –- principles and design of transfer and transport facilities - hazardous waste transport and manifests - mechanical processing and material separation technologies – Size reduction – size separation - density separation - magnetic separation – compaction – principles and design of material recovery facilities – physico chemical treatment of hazardous wastes - solidification and stabilization – E-waste kiosks - case studies on waste collection and material recovery

UNITIV BIOLOGICAL AND THERMAL PROCESSING OF WASTES 9

Biological and thermo chemical conversion technologies – composting – biomethanation – incineration – pyrolysis- plasma arc gasification –principles and design of biological and thermal

treatment facilities - MSW processes to energy with high-value products and specialty BY-Products - operation of facilities and environmental controls - treatment of biomedical wastes – case studies and emerging waste processing technologies.

UNIT V WASTE DISPOSAL 9

Sanitary and secure landfills - components and configuration– site selection - liner and cover systems - geo synthetic clay liners and geo membranes - design of sanitary landfills and secure landfills- leachate collection, treatment and landfill gas management – landfill construction and operational controls - landfill closure and environmental monitoring – landfill bioreactors – rehabilitation of open dumps and biomining of dumpsites-remediation of contaminated sites- Case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1 Explain the various functional elements of solid and hazardous waste management including the associated legal, health, safety, and culturalissues as well as responsibilities of different stakeholders

CO2 Apply the knowledge of science and engineering fundamentals to characterize different types of solid and hazardous wastes, assess thefactors affecting variation and assess performance of waste treatmentand disposal systems

CO3 Design of systems and processes to meet specified needs of waste minimization, storage, collection, transport, recycling, processing anddisposal.

CO4 Select appropriate methods for processing and disposal of solid and hazardous wastes, taking into account the impact of the solutions in asustainability context

CO5 Conduct research pertinent to solid and hazardous waste managementand communicate effectively to different stakeholders as well as engage in independent life-long learning

REFERENCES:

1. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, “Integrated Solid Waste Management, Mc-Graw Hill India, First edition, 2015.
2. CPHEEO, “Manual on Municipal Solid waste management,Vol I, II and III, Central Public Health and Environmental Engineering Organisation , Governmentof India, New Delhi, 2016.
3. William A. Worrell, P. Aarne Vesilind, Christian Ludwig, Solid Waste Engineering - A Global Perspective, 3rd Edition, Cengage Learning, 2017.
4. Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans and "Environmental Resources Management, Hazardous waste Management", Mc-Graw Hill International edition, New York,2010.
5. John Pitchtel, Waste Management Practices, CRC Press,Taylor and Francis Group,2014.
6. Gary C. Young, Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons, Wiley, 2010
7. Cherry P M, Solid and Hazardous Waste Management, CBS publishers and distributors Pvt Ltd, 2018
8. Rao M.N, Razia Sultana, Sri Harsha Kota, solid and hazardous waste management –Science and Engineering , Butterworth-Heinemann, 2016

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	2	2
CO2	2	1	3	3	2	2
CO3	2	1	3	3	2	2
CO4	2	1	3	3	2	2
CO5	2	1	3	3	2	2
Avg	3	1	3	3	2	2

• 1-low, 2-medium, 3-high

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EM3211 **SEMINAR** **L T P C**
0 0 2 1

SYLLABUS CONTENT

The students have to select any advanced topic of their choice related to Environmental Management, generally a topic, which is not a part of syllabus of a regular course. The students will have work for two hours per week. Students shall submit a brief report on their seminar topic and present the seminar. It will be an open seminar. The valuation will be based on the content of the report, technical presentation and the interaction during the seminar. A three-member committee constituted by HoD will evaluate the report and presentation.

TOTAL: 30 PERIODS

COURSE OUTCOME:

CO1 Identify various innovative and latest advancements in the Environmental field through research studies.

CO2 Improve their communication skills and Understand the art of writing research work through analysis of a specific topic in the related field.

CO3 Learn to make good presentation and explain a concept.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	1	1
CO2	2	3	2	2	1	1
CO3	2	3	2	2	1	1
Avg	**2**	**3**	**2**	**2**	**1**	**1**

• 1-low, 2-medium, 3-high

EM3311 **PRACTICAL TRAINING (4 WEEKS)** **L T P C**
0 0 0 2

Syllabus Content:

- Students shall undertake training either individually or group (not exceeding four members in a group) in reputed Companies identified by Centre for Environmental Studies, dealing with Water treatment, sewage treatment, effluent treatment, Solid waste Processing Facility, Industrial Waste management cells, Environmental consultancies, Air pollution control, Environmental Impact Assessment and any other environmental management related works during the summer vacation of II semester for a specified period of four weeks.
- Students allowed to get field exposure and effectively interact with Environmental engineers and managers in the field
- At the end of training, a detailed report on the work done should be submitted to the course coordinator
- Students will be evaluated through a viva-voce examination by a team of internal staff members constituted by HoD.

COURSE OUTCOME:

CO1 Understand the various organizations and to have an exposure on projects carried out and understand the real field problem and compare the theoretical knowledge with field

CO2 Develop knowledge in analysing and uunderstand the professional ethics

CO3 Solve Environmental related problems in the field either individually or in team

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CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	2
CO2	2	2	2	2	2	2
CO3	2	3	2	2	2	2
Avg	2	2	2	2	2	2

• 1-low, 2-medium, 3-high

EM3312 **PROJECT WORK I** **L T P C**
0 0 12 6

SYLLABUS:
The student individually works on a specific topic supervised by faculty member who is familiar in this area of interest. The student can select any topic which is relevant to his/her specialization of the programme. The topic may be experimental or analytical or filed related studies. The progress if the work will be evaluated internally through reviews by a committee constituted by HoD. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work, methodology for carrying out the work and results of preliminary works. The students will be evaluated through a viva-voce examination by a panel of examiners including one external examiner, Supervisor and an Internal Examiner.

TOTAL: 180 PERIODS

COURSE OUTCOME:

- students will be able to

CO1 Identify Environmental management problems and critically evaluate literature in a chosen area of research and establish the scope of work
CO2 Develop study methodology, and identify appropriate techniques to analyze complex Environmental management problems
CO3 Apply engineering and management principles through efficient handling of the project and demonstrate a sound technical knowledge of their selected project topic

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	2
CO2	2	2	3	3	3	3
CO3	2	2	3	3	3	3
Avg	2	2	3	3	3	3

• 1-low, 2-medium, 3-high

EM3411 **PROJECT WORK II** **L T P C**
0 0 24 12

SYLLABUS:
The student may continue the Project work I on the selected topic as per the formulated methodology or they can do different project in an industry. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated based on the report and the viva-voce examination by a panel of examiners including one external examiner, Supervisor and an Internal Examiner.

TOTAL: 360 PERIODS

COURSE OUTCOME:

- students will be able to

CO1 Identify Environmental management problems and critically evaluate literature in a chosen area of research and establish the scope of work

CO2 Develop study methodology, and identify appropriate techniques to analyze complex Environmental Management problems

CO3 Apply engineering and management principles through efficient handling of the project and demonstrate a sound technical knowledge of their selected project topic

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	2
CO2	2	2	3	3	3	3
CO3	2	2	3	3	3	3
Avg	2	2	3	3	3	3

• 1-low, 2-medium, 3-high

PROFESSIONAL ELECTIVE COURSES

EN3251 AIR AND NOISE POLLUTION CONTROL L T P C

3 0 0 3

UNIT I INTRODUCTION 9

Structure and composition of Atmosphere – Sources and classification of air pollutants – Effects of air pollutants on human health, vegetation & animals, Materials & Structures – Effects of air Pollutants on the atmosphere, Soil & Water bodies – Long- term effects– Ambient Air Quality and Emission Standards – Air Pollution Indices – Emission Inventories-Indoor Air Pollution

UNIT II AIR POLLUTION MONITORING AND MODELLING 9

Ambient and Stack Sampling and Analysis of Particulate and Gaseous Pollutants -Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability, Inversion, Wind profiles and stack plume patterns- Transport & Dispersion of Air Pollutants – Modelling Techniques – Air Pollution Climatology.

UNIT III CONTROL OF PARTICULATE POLLUTANTS 9

Factors affecting Selection of Control Equipment; Gas Particle Interaction, – Working principle, Design and performance equations of Gravity Separators, cyclones, Fabric filters, Particulate Scrubbers, Electrostatic Precipitators – Operational Considerations - Costing of APC equipment –. Recent Advances

UNIT IV CONTROL OF GASEOUS POLLUTANTS 9

Factors affecting Selection of Control Equipment -Working principle, Design and performance equations of Absorption, Adsorption, Condensation, Incineration, Bio-scrubbers, Bio-filters –Control Technologies-SO_2,NO_x CO, H_2S; VOC, Process control and Monitoring - Operational Considerations - Costing of APC Equipment –Emerging Trends,

UNIT V NOISE POLLUTION 9

Noise Pollution: Sources and Effects of Noise Pollution – Measurement –Equivalent Noise Level-Ambient and Source Noise Standards-Occupational Noise-Sampling of ambient and industrial Noise-Statistical Analysis of Noise Control and Preventive measures.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion of this course, the student is expected to be able to understand:

CO1 Various types and sources of Air Pollution and its effects
CO2 Methods of source and ambient monitoring and dispersion of pollutants and theirmodeling
CO3 The principles and design of control of particulate pollutants
CO4 The principles and design of control of Gaseous pollutant
CO5 Sources, effects and control of vehicular, indoor air and noise pollution

REFERENCES:

1. Noel de Nevers, "Air Pollution Control Engg", Mc Graw Hill, New York, 2016.
2. Daniel Vallero “Fundamentals of Air Pollution”, Fourth Edition, 2008.
3. Arthur C.Stern, “Air Pollution (Vol.I – Vol.VIII)”, Academic Press, 2006.
4. Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004.
5. David H.F. Liu, Bela G. Liptak, “Air Pollution”, Lweis Publishers, 2000.
6. Wayne T.Davis, “Air Pollution Engineering Manual”, John Wiley & Sons, Inc., 2000.
7. P.K.Behera ,S.K.Sahu,Environmental Monitoring and Analysis, Dominant publishers and Distributors, New Delhi, 2009
8. Central Pollution Control Board Guidelines for real time sampling and analysis 2013.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	3	2	3
CO2	2	2	2	2	3	2
CO3	3	2	2	2	2	2
CO4	2	3	3	3	2	3
CO5	2	2	3	2	3	2
Avg	2	2	2	2	2	2

• 1-low, 2-medium, 3-high

EM3001 SOIL POLLUTION AND REMEDIATION TECHNOLOGIES L T P C
3 0 0 3

UNIT I GENERATION OF WASTES AND CONSQUENCES OF SOIL POLLUTION 9

Introduction to Geo environmental engineering – Environmental cycle – Sources, production and classification of waste – Causes of soil pollution – Factors governing soil pollution interaction clay minerals - Failures of foundation due to waste movement.

UNIT II SITE SELECTION AND SAFE DISPOSAL OF WASTE 9

Safe disposal of waste – Site selection for landfills – Characterization of land fill sites andwaste – Risk assessment – Stability of landfills – Current practice of waste disposal – Monitoring facilities – Passive containment system – Application of geosynthetics in solidwaste management – Rigid or flexible liners.

UNIT III TRANSPORT OF CONTAMINANTS 9

Contaminant transport in sub surface – Advection, Diffusion, Dispersion – Governing equations – Contaminant transformation – Sorption – Biodegradation – Ion exchange – Precipitation – Hydrological consideration in land fill design – Ground water pollution.

UNIT IV WASTE STABILIZATION 9

Stabilization - Solidification of wastes – Micro and macro encapsulation – Absorption, Adsorption, Precipitation – Detoxification – Mechanism of stabilization – Organic and inorganic stabilization – Utilization of solid waste for soil improvement – case studies.

UNIT V REMEDIATION OF CONTAMINATED SOILS 9

Exsitu and Insitu remediation-Solidification, bio-remediation, incineration, soil washing, phyto remediation, soil heating, vetrification, bio-venting.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

After completion of this course, the student is expected to be able to understand:

CO1 The generation of wastes and consequences of soil pollution
CO2 Site selection and safe disposal of waste
CO3 Transport of contaminants
CO4 Waste stabilization Techniques
CO5 Remediation of contaminated soils

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	3	2	3
CO2	2	2	2	2	3	2
CO3	3	2	2	2	2	2
CO4	2	3	3	3	2	3
CO5	2	2	3	2	3	2
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

EM3002 ENVIRONMENTAL QUALITY MONITORING L T P C
3 0 0 3

UNIT I MONITORING AND CHARACRATERIZATION OF ENVIRONMENT 9

General approach to environmental analysis, Choice of Lab.Vs. Field analysis, Environmental monitoring-current and future status-sensors and remote, Lab. Standards, Data quality objectives, statistics in environmental monitoring, Accuracy and precision, detection limit, types of errors, Automated Data acquisition and processing-sensors and transducers , Monitoring Network and real time monitoring

UNIT II ENVIRONMENTAL SAMPLING 9

Location, planning, Types of sampling ,sampling equipment's for water, solids and air, sample storage for physical and chemical contaminants ,types of sampling, representative samples, sample preparation techniques-Solvent Extraction, SPE, Head space, Purge and trap and SPME

UNIT III WATER ANALYSIS 9

Techniques for analysis of major ions-UV-visible Spectrophotometer, Flame photometer, AAS, ICP (AES and MS), Trace organic pollutants(PCB, dioxins, pesticides) GC and HPLC (Columns Detectors and Application)

UNIT IV ATMOSPHEREIC ANALYSIS 9

Ambient air and flue gas, Gaseous pollutants-Determination of time weighted average concentration(Absorption trains, solid adsorbents and differential tubes), Direct reading instruments(fluorescence ,chemiluminescent,IR and Electrochemical sensors, GC-MS for trace organics, Particulate sampling methods- High volume sampler, personal sampler, PM 10 and 2.5, Blackcarbon, Metals Direct(XRF) and dissolution methods(AAS/AES)

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UNIT V ANALYSIS OF SOIL AND WASTE 9

Problem in analysis of soil and Waste -sampling, pretreatment -extraction and clean up, New extraction techniques, Automated soxhlet and solvent extraction, microwave digestion and sonication,SCF(CO2), Analysis for trace pollutants, Analysis of leachate.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1: Understand the basics of environmental monitoring
CO2: Able to select appropriate sampling protocol for chemical analysis
CO3: Understand various methods of analysis of pollutants in water
CO4: Select correct method for toxic pollutants estimation in air
CO5: Familiar with analysis of land and wastes

REFERENCES:

1. Reeve, R.N., "Introduction to Environmental Analysis", Analytical Techniques in the Sciences, John Wiley & Sons, Chichester, UK, 2002.
2. Barcelo, D.(editor), "Environmental analysis. Techniques, Applications and Quality Assurance", Elsevier, The Netherlands, 1996
3. Paul R. Loconto Trace Environmental Quantitative Analysis: Principles, Techniques, and Applications, Marcel Dekker; 2nd Edition , 2005,
4. Janick Artiola, Ian Pepper and Mark Brusseau, ENVIRONMENTAL MONITORING AND CHARACTERIZATION , Academic Press,2004.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	3
CO2	1	1	2	2	1	2
CO3	1	1	2	2	1	2
CO4	1	1	2	2	1	2
CO5	1	1	2	2	1	2
Avg	**1**	**1**	**1**	**1**	**1**	**1**

• 1-low, 2-medium, 3-high

EN3252 INDUSTRIAL WASTEWATER POLLUTION - PREVENTION AND CONTROL

L T P C
3 0 0 3

UNIT I INTRODUCTION 8

Industrial scenario in India – Industrial activity and Environment - Uses of Water by industry – Sources and types of industrial wastewater - Characteristics of Industrial effluents – 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 and Bioassay tests – Major issues on water quality management.

UNIT II INDUSTRIAL POLLUTION PREVENTION & WASTE MINIMISATION 8

Sources of Pollution – Effects of industrial effluents on sewers and Natural water Bodies – Impact Assessment – Environmental Audit - Prevention vs Control of Industrial Pollution - Source Reduction Techniques - Evaluation of Pollution Prevention Options - Waste Minimization – Cost benefit analysis – Payback period – Implementing Pollution prevention programmes in industries.

UNIT III INDUSTRIAL WASTEWATER TREATMENT 10

Equalization and Neutralization – Oil Separation - Flotation - Precipitation - Aerobic and Anaerobic Biological Treatment - Treatability studies - Air Stripping – Refractory organics removal by Absorption - Nitrification and Denitrification - Phosphorous removal - Heavy metal removal - Sequencing Batch

Reactors - High Rate Reactors - Chemical Oxidation – Advanced Oxidation - Evaporation - Ion Exchange - Membrane Technologies - Advanced Treatment Methods.

UNIT IV WASTEWATER REUSE AND RESIDUAL MANAGEMENT 9

Individual and Common Effluent Treatment Plants - Joint treatment of industrial and domestic wastewaters - Integrated Wastewater Management for Zero Effluent Discharge Systems –Disposal of Effluent on Land – Wastewater irrigation system - Recycle and reuse of wastewater - Residual Management - Thickening, Dewatering and Disposal of Sludge

UNIT V CASE STUDIES 10

Industrial Manufacturing process description, Wastewater Characteristics, Source reduction, Treatment and disposal of highly polluting industries viz., Textile - Pulp and Paper – Tannery - Sugar - Distillery - Dairy - Petroleum refinery - Electro plating.

TOTAL: 45 PERIODS

COURSE OUTCOME:

- On Completion of the course, the student is expected to be able to

CO1 Explain the source and types of industrial wastewater and their environmental impacts and choose the regulatory laws pertaining to environmental protection

CO2 Identify industrial wastewater pollution and implement pollution prevention, waste minimization in industries

CO3 Develop various technologies for removal pollutants from industrial wastewater and design wastewater treatment systems for industries

CO4 Audit and analyze environmental performance of industries to internal, external client, regulatory bodies and design water reuse management techniques

CO5 Conduct research to develop effective management systems for industrial wastewater that are technically sound, economically feasible and socially acceptable

REFERENCES:

1. Athar Hussain, Sirajuddin Ahmed, “Advanced Treatment Techniques for Industrial Wastewater”, IGI Global Publisher, 2018.
2. Shyam. R. Asolekar, Soli. J. Arceivala, “Waste water Treatment for pollution control and reuse”,Tata Mcgraw Hill, 2007.
3. Frank Woodard, “Industrial Waste Treatment Handbook”, Butterworth Heinemann, New Delhi, 2001.
4. Paul L. Bishop, “Pollution Prevention: Fundamentals and Practice', Mc-GrawHill International, Boston,2000.
5. "Industrial wastewater management, treatment & disposal, Water Environment" Federation Alexandria Virginia, Third Edition, 2008.
6. Lawrance K. Wang, Yung Tse Hung, Howard H.Lo and Constantine Yapijakis “hand book of Industrial and Hazardous waste Treatment”, Second Edition,2004.
7. Qasim S.R., Guang Zhu., “Wastewater Treatment and Reuse”, Volume 1& 2 2018.
8. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
9. Nelson Leonard Nemerow, “ Industrial waste Treatment”, Elsevier,2007.
10. Wesley Eckenfelder W., “ Industrial Water Pollution Control”, Second Edition, Mc Graw Hill, 2000.
11. Nemerow, N.I, Butterworth-Heinemann, “Theories of practice of Industrial Waste Treatment”, 2006.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	2
CO2	2	2	2	2	3	2
CO3	3	2	3	3	2	3
CO4	3	3	3	2	3	2
CO5	3	3	3	3	3	3
Avg	3	2	3	3	3	2

• 1-low, 2-medium, 3-high

EM3003 LIFE CYCLE ASSESSMENT AND DESIGN FOR ENVIRONMENT LT P C
3 0 0 3

UNITI LIFE CYCLE THINKING AND LIFECYCLE MANAGEMENT 9

Introduction to Life Cycle Thinking — Industrial ecology— Life cycle management (LCM) and Stakeholder Expectations - LCM drivers and issues - materials flow analysis -Life cycle of Products and services- International organizations and networks - History and definition of LCA - analytical tools for product and service systems -Value creation along the life cycle–technical characteristics–applications–limitations.

UNIT II LCAGOAL, SCOPE AND INVENTORY 9

ISO 14040 framework for LCA - Life cycle goal and scope definition - function, functional unit and reference flow System boundaries, data categories, inputs and outputs, data quality, critical review and other procedural aspects - Inventory Analysis: Raw Material Extraction and Processing, Manufacturing and Production, Product Use and Consumption, End-of-lifeManagement, Transportation and Distribution - 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 — Datavalidation-Cut-offanddata estimation.

UNIT III LIFE CYCLEIMPACT ANALYSIS AND INTERPRETATION 9

Characterization factors and principle of characterization - Selection of impact categories, category indicators and characterization models — Classification -Characterization - Optional elements - normalization, grouping,weighting, dataquality analysis-Characterization models— Impact assessment Case studies-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-CombiningL CA and LCC—Case studies

UNIT IV DESIGN FOR ENVIRONMENT AND ECO LABELLING 9

Sustainable consumption – Eco-efficiency - green consumerism - product stewardship and green engineering - Extended producer responsibility – Design For Environment Strategies, Practices, Guidelines, Methods, And Tools. Eco-design strategies–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

UNIT V LCA SOFTWARES AND CASE STUDIES 9

LCA Software - LCA Software Demo: Sima Pro, GREET, BEES, CMU EIO,GABI - Advances in LCA: Hybrid LCA, Thermodynamic LCA-LCA case studies on Product Design, Product Improvement, Product Comparison and Policy development.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1 Explain the various functional elements of Life Cycle Analysis and Design for Environment
CO2 apply the knowledge of science and engineering fundamentals to characterize the environmental interactions of products and services
CO3 design of engineering system staking into account the material flow and pollutant interactions between engineering decisions and the environment
CO4 select appropriate LCA tools to support product/process design and decision making, taking into account the impact of the solutions in a sustainability context
CO5 conduct research pertinent to Life Cycle Management and communicate effectively to different stakeholders in terms of eco labels as well as engage in independent life-long learning

REFERENCES:

1. ISO14040-2016- Environmental management-Lifecycle assessment-Principles and framework, International Organization for Standardization, 2016
2. T.E.Graedel, Braden R. Allenby, Industrial Ecology and Sustainable Engineering, Prentice Hall,2010
3. RalphHorne,Tim Grant, KarliVerghese, LifeCycle Assessment: Principles, Practice and Prospects,Csiropublishing,2009ISO 14040-2016-Environmental management - Life cycle assessment - Principles and framework, International Organization for Standardization, 2016
4. T. E. Graedel, Braden R. Allenby,Industrial Ecology and Sustainable Engineering, Prentice Hall, 2010
5. Ralph Horne, Tim Grant, KarliVerghese, Life Cycle Assessment: Principles, Practice and Prospects, Csiro Publishing, 2009
6. ISO/TR 14047:2003, Environmental management - Life cycle impact assessment - Examples of application of ISO 14042, International Organization for Standardization, 2007
7. International Organization for Standardization: ISO TR 14062 Environmental management - Integrating environmental aspects into product design and development, 2002.
8. European Commission - Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. Luxembourg. European Union; 2010
9. Catherine Benoît, UQAM/CIRAIG, and Bernard Mazijn, Guidelines for Social Life Cycle Assessment of Products, United Nations Environment Programme,2009

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	1	-	3	-	-
CO2	3	3	-	-	2	2
CO3	1	-	3	3	3	2
CO4	2	-	-	-	-	-
CO5	3	2	1	-	-	-
Avg	**3**	**3**	**2**	**3**	**3**	**2**

• 1-low, 2-medium, 3-high

EM3004 ENVIRONMENTAL SOCIAL GOVERNANCE LT P C
3 0 0 3

UNIT I INTRODUCTION 9

Fundamentals and strategies of Environmental Social Governance (ESG) - ESG in international context - Sustainability and ecological transition - Effects of climate change on liabilities, rating and valuation - Standards, norms and recommendations for transparency and reporting - Energy efficiency and its importance - ESCO models and financing trends - Circular Economy and the ESG's impact - Role of technology in the green transition- ESG in India.

UNIT II ENVIRONMENT, CLIMATE CHANGE, GREEN TRANSITION & SUSTAINABLE FINANCE 9

Evolving to the new green economy - Triple dimension of climate change - Green taxonomy - Opportunities, strategies and risks for the financial sector - Implementing ESG criteria in investment decisions - Systemic nature of climate - Related financial risks - Co-financing strategies and tools to foster sustainability - Decarbonisation of capital markets - ESG ratings – Carbon pricing - Policies, markets and strategies for CO_2 pricing - Fundamentals of carbon markets in an international context – Green technological innovation and ESG-related products - Blue economy.

UNIT III SOCIAL INCLUSION AND GENDER EQUALITY 9

Social pillars - Implementation of social and gender criteria - Challenges and future trends in gender equality - Best Practices: Equality in the board of directors and top management - Creating the ESG Culture within the organization -Involvement of organizations' employees in ESG policies - Importance of social inclusion at multiple levels.

UNIT IV GOVERNANCE 9

Evolution of corporate governance frameworks - development of corporate governance - Sustainability and ESG – Governance Factors - ESG regulation and impact - Sustainability and reputational risk of the company - Company governance and risk management - The future of governance: challenges and opportunities - Implementing environment, social and governance factors into companies - Getting shareholders' commitment to the corporate strategy.

UNIT V ESG ANALYSIS, VALUATION, AND INTEGRATION 9

Different approaches of integrating ESG analysis – Qualitative and quantitative approaches – Tangible and intangible material ESG-related factors – ESG issues using risk mapping methodologies – challenges of undertaking ESG analysis across different geographic regions and cultures – challenges of identifying and assessing material ESG issues – challenges of integrating ESG analysis into a firm's investment process – approaches taken across a range of ESG integration databases and software available.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

By the end of this course, students will be able to:

CO1 Explain the essential concepts, rationales, drivers and processes of Environmental, Social and Governance (ESG) in organizations

CO2 Analyze critical issues and opportunities in ESG in organizations

CO3 Enable to prepare and assess the ESG performance of an organization, the processes behind the preparation of an ESG report, and identify key material issues in relations to reporting standards

CO4 Apply the practice knowledge and skills to transform ESG from a reporting (compliance) practice into a sustainable strategy.

CO5 Create a new practice for organizations in serving the interest of the profit, public and the environment

REFERENCES:

1. Tiffany Cheng Han Leung, Wang-Kin Chiu, Cindy Shi-Xiang You, Ben Yuk Fai Fong, "Environmental, Social and Governance and Sustainable Development in Healthcare", Springer publisher, 2023.
2. Karlheinz Spitz, John Trudinger, Matthew Orr, "Environmental Social GovernanceManaging Risk and Expectations", CRC Press, 2022.
3. Eric Bouye, Daniela Klingebiel and Marco Ruiz, ""Environmental, Social and Governance", World bank group. 2021.
4. Boffo, R., and R. Patalano, "ESG Investing: Practices, Progress and Challenges", OECD, 2020.
5. Raghu Krishnamoorthy , "Environmental, Social, and Governance (ESG) Investing: Doing Good to Do Well",Academic Publisher, 2021.
6. Andy Gouldson, "Environmental Policy and Governance", John Wiley & Sons Ltd, 2022
7. Richard Morrison, "Environmental, Social, and Governance Theory Defusing a Major Threat to Shareholder Rights", Competitive Enterprise Institute, 2021.
8. "Environmental, Social, And Governance Issues In Investing A Guide For Investment Professionals", CFA Institute, 2015.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	2	2	3
CO2	2	2	2	3	3	2
CO3	3	3	3	2	2	2
CO4	2	3	3	3	2	3
CO5	3	2	2	2	3	3
Avg	2	2	3	2	2	3

• 1-low, 2-medium, 3-high

Attested

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EM3053 CLIMATE CHANGE MODELLING, MITIGATION AND ADAPTATION L T P C
3 0 0 3

UNIT I GLOBAL WARMING AND CLIMATE CHANGE 9

Climate system – Weather and climate - composition, classification - Milankovitch (Orbital) Cycles and their Role in Earth's Climate - Climate parameters - (Temperature, Rainfall, Humidity, Wind etc.,) – Green House effect and Climate change- Greenhouse gases and sources– Global warming and effects – Extreme weather events – Climate Change and Disasters - Sea level rise - Retreat of Glaciers – Thermohaline circulation –Global warming and ocean acidification –Ocean currents – Ekman Layers and the Ekman Spiral–El Nino – La Nina – causes, effects.- United Nations Framework Convention on Climate Change (UNFCCC), Conference of Parties (COPs) - International Agreements and protocols - Intergovernmental Panel on Climate Change (IPCC) -– IPCC Assessment Reports – Sixth Assessment Report

UNIT II CLIMATE CHANGE MODELLLING AND PROJECTIONS 9

Climate change projection Scenarios and storylines –Representative Concentration Pathways and Shared Socio EconomicPathways (SSPs) - Salient features. - Modeling of the climate systems - Earths' energy budget – types, hierarchy and components of a climate model, Equations governing the atmosphere - Development of Climate models - General Circulation Models (GCMs) - Coupled Climate-Economy-Ecology-Biosphere Modeling - Issues with GCMs - Introduction to Regional Climate Models (RCMs) and Limited Area Models (LAMs) - Downscaling of Global Climate Model –selection of GCMs for regional climate change studies – Ensemble theory - selection of ensembles, model domain (Spatial domain and temporal domain), Resolution and climate variables - lateral boundary conditions - methods of downscaling (Statistical and Dynamical) - Bias correction – Delta method, Quantile Mapping, Salient features and limitations, Model validation and calibration- evaluating model performance- post processing - Climate Projections for India and Tamil Nadu

UNIT III CLIMATE CHANGE IMPACTS AND ACTION FRAMEWORK 9

Climate Change Vulnerability and Risk assessment- Impact on Water Systems - Freshwater Resources - Ground water -Ocean and marine Resources - Agriculture and food security – Coastal and Terrestrial Ecosystems – Biodiversity and shift in major biomes - Forests – Health —Climate change impacts on vulnerable populations -Climate Equity and Environmental justice – Climate Action Framework – Parris agreement – NET Zero targets- Nationally determined Contributions – Climate Change Action Plan at national and State Level – National and State level Climate Change Missions and Action agenda

UNIT IV CLIMATE CHANGE MITIGATION 9

Established Technologies for Climate Change Mitigation- Energy Conservation, Efficiency, and Sustainable Energy Systems – Renewable energy systems – Solar energy systems – Wind energy systems – tidal and wave energy- Green Hydrogen –Biomass Energy- Energy Storage Challenges and Emerging options-Energy conservationin transportation and building – Alternative Energies – Carbon capture and storage – Chemical absorption – oxy –fuel combustion – Clean Coal Technology (CCT) – Carbon Sink estimation and Enhancement - Reducing Energy in Transport, Building, and Agriculture Through Social Efficiency – Co Benefits of Climate Change Mitigation – Carbon Markets –carbon Finance

UNIT V CLIMATE CHANGE ADAPTATION 9

Loss and Damages due to climate Change - Climate Change adaptation in agriculture sector - Climate resilient practices – Crop management – Drought tolerant crops, short duration crops, optimizing crop calendars, crop rotation - Water Resource management – Drip irrigation systems, programmed irrigation systems, small scale reservoirs – Site specific nutrient management – Livestock systems – Rotational grazing, Silvopastoral systems (Crop-livestock), Cut and carry fodder system, Manure Management –Forest management - Reforestation, regeneration and afforestation, Payments for ecosystem services(PES) – Nature based adaptive actions for Coastal ecosystems- Climate Resilient City Action Plan -Co Benefits of Climate Change Adaptation

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the student is expected to be able to

CO1: Understand the basics of climate parameters and their effect on climate change and Comprehend the latest IPCC climate scenarios and International Agreements and Protocols

CO2: Understand the application of climate models and downscaling approach for future climate prediction

CO3: Gain thorough knowledge on how different sectors are affected by climate change and the action plans at National and State level

CO4: Gain in-depth knowledge on climate change mitigation measures

CO5: Understand the adaptive measures to be taken on different sectors to mitigate the climate change impacts

REFERENCES:

1. Maximilian Lackner, BaharakSajjadi and Wei-Yin Chen, Handbook of Climate Change Mitigation and Adaptation, Third Edition, Springer Nature, 2022.
2. IPCC Sixth Assessment Report, 2021.http://www.ipcc.ch/.
3. Tziperman, E. Global Warming Science: A Quantitative Introduction to Climate Change and Its Consequences, Princeton University Press, USA, P. 333. 2022.
4. Kendal McGuffie, Ann Henderson, "A Climate Modelling" Primer 4th Edition, John Wiley & Sons, Ltd, Chichester, UK 2014.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	2
CO2	2	2	2	2	3	3
CO3	3	2	2	2	3	2
CO4	2	3	2	2	2	3
CO5	3	3	3	2	2	2
Avg	**3**	**3**	**2**	**2**	**3**	**2**

• 1-low, 2-medium, 3-high

EM3005 SUSTAINABLE AGRICULTURE FOR ENVIORNMENTAL MANAGEMENT

L T P C
3 0 0 3

UNIT I CONCEPTS OF SUSTAINABLE AGRICULTURE 9

Low input farming systems – Regenerative farming systems – biodynamic farming systems – organic farming systems – conservation farming systems – hydroponics –Indicators of sustainability

UNIT II SOIL MANAGEMENT IN SUSTAINABLE AGRICULTURE 9

Soil media – sustained organic soils – technologically supported soils – problems with soil – loss of soil fertility – minimizing loss of nutrients due to leaching, minimizing denitrification, Soil erosion – types, causes, effects, Water erosion – wind erosion, controlof erosion, salinity problems and control, soil sodicity, soil structure decline, soil acidification – causes and effects, building up of chemical residues, soil improvement – organic matter amendment – problems with organic matter, lime addition and gypsum addition, cultivation techniques, - conservation tillage, natural fertilizers – animal manure, poultry manure, bone meal, seaweed extract, Soil life – earthworms, mycorrhiza, nitrogen fixation, compost – mulching – benefits.

UNIT III WATER MANAGEMENT IN SUSTAINABLE AGRICULTURE 9

Water storage methods- rainwater collection and storage, bore well, farm dams- criteriafor farm dam design, livestock water requirements, problems with water – water quality,salinity – causes, effects – treating saline water – strategies, water saving measures – using farm wastewater – characteristics

– physical, chemical, biological, Recycling farm wastewater - swales and keylines, - design, irrigation system – design, maintenance and scheduling – cereals, pulses, millets, fruits and vegetables, surface/flood irrigation, springer irrigation.

UNIT III PEST AND DISEASE CONTROL IN SUSTAINABLE AGRICULTURE 9

Harmful effects of chemical pesticides – soil, water, air, Pest management and system thinking – Integrated Pest Management (IPM) – cultural control, physical control – traps,repellants, biological control, companion planting, crop rotation, cleanliness and hygiene, climate modification, organic sprays and dusts, biological control – antagonistic organisms, predators, parasites, pheromone traps – advantages and cost.

UNIT IV SUSTAINABLE WEED CONTROL 9

Types of weeds in crop lands – problems, need for controlling weeds, sustainable approach to control weed – soil improvement- amelioration of soil, minimize sources of weed seeds, cultivation, mulching, biological weed control methods – chemical weed control – problems and management, other weed control measures – mowing/slashing, flooding, solarisation, burning, hot water treatment,

UNIT V MANAGEMNT ASPECTS FOR SUSTAINABLE AGRICULTURE 9

Changing an existing farm to a sustainable property - The Rodale Institute conversion experiment, new farm products, pre-planning, considerations – farm activities, off- property effects, biologic and climatic considerations, socio-economic options, legal considerations, monitoring and reviewing the farm system – socio-economic consideration – profitability, social aspects – Production farming – economy of scale, materials, equipment, value adding – organic certification schemes - Contingencies and seasonal variations – managing plants – managing animals in sustainable way - guidelines for raising different livestock.

TOTAL:45 PERIODS

COURSE OUTCOMES:

On completion of the course, the student is expected to be able to

CO1: Understand the concepts of different farming systems for sustainable agriculture

CO2: Educate to manage the problem soils using sustainable materials to improve theproductivity

CO3: Understand how to manage pest and disease using sustainable approaches forbetter yield

CO4: Gain in-depth knowledge on methods used to control weeds in agricultural systems in sustainable manner

CO5: Understand the need for sustainable agriculture and various management aspectsrequired for sustainable agriculture

REFERENCES

1. Wealth from Waste, S. C. Bhatia, Atlantic Publishers, 2007
2. Farmers Handbook on Basic Agriculture, Chandra Sekar et al, (Eds.), 2016
3. The complete Technology Book on Vermiculture and Vermicomposting, NPCS Board of Consultants and Engineers, Asia Pacific Business Press Inc., 2004
4. Biomass Based Products, NPCS Board of Consultants and Engineers, Asia Pacific Business Press Inc., 2015
5. Agricultural Waste Management Problems, Processes and Approaches 1st Edition, Raymond Loehr(Ed.) Academic Press, 1974.
6. Science and technology of Organic farming, Allen V Barker(Ed.) CRC Press, 2010
7. Principles of Agronomy for Sustainable Agriculture, Villalobos, Francisco J., Fereres, Elias (Eds.), Springer, 2016.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	2	2	2	1	-
CO2	2	1	2	2	3	-
CO3	3	2	1	1	3	-
CO4	-	3	2	2	-	-
CO5	3	3	3	2	1	-
Avg	**2**	**2**	**2**	**2**	**2**	**-**

• 1-low, 2-medium, 3-high

Attested

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EM3006 **WASTE TO ENERGY** **L T P C**
3 0 0 3

UNIT I INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

– Waste as a Resource and Alternate Energy Source - Classification of waste as fuel – Agro based, Forest residue, Domestic waste and Industrial waste - MSW – Conversion devices –Incinerators, gasifiers, digestors –Plasma Arc Technology and other new Technologies.

UNIT II BIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT III BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration ingasifier operation.

UNIT IV BIOMASS COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, fixed bed combustors,Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNITV BIO ENERGY 9

Basic concepts of circular economy based on organics - Properties of biogas (Calorific valueand composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 Understand the various types of wastes from which energy can be generated
CO2 Gain knowledge on biomass pyrolysis process and its applications
CO3 Develop knowledge on various types of biomass gasifiers and their operations
CO4 Gain knowledge on biomass combustors and its applications on generating energy
CO5 Understand the principles of bio-energy systems and their features

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S.,Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1989.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, JohnWiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd.,1991.
4. Non-Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	2	-	-	-
CO2	3	-	2	-	-	3
CO3	3	-	2	-	-	3
CO4	3	2	2	-	3	-
CO5	3	2	2	-	3	-
Avg	**3**	**2**	**2**	**-**	**3**	**3**

• 1-low, 2-medium, 3-high

EM3007 ENVIRONMENTAL SYSTEM MODELLING L T P C
3 0 0 3

UNIT I ECOLOGICAL SYSTEM 9

Basic concepts in ecology and ecological modelling, population dynamics: birth and death processes. Single species growth, prey-predator models: Lotka-Volterra, Rosenzweig- MacArther, Kolmogorov models. multi-species modeling - structural analysis and stability of complex ecosystems.

UNIT II REACTOR MODELLING 9

CSTR, plug-flow, dispersion. A case study of a tubular reactor with axial dispersion, parameter calibration: search algorithms for nonlinear dynamical models, variance of estimated parameters. application to Monod and Haldane kinetics.

UNIT III WATER QUALITY MODELLING 9

Rivers and streams water quality modeling -dispersion and mixing- water quality modelling process-model sensitivity-assessing model performance; models for dissolved oxygen and pathogens-pollutant and nutrient dynamics -dissolved oxygen dynamics -groundwater qualitymodeling.

UNIT IV MICROBIAL DYNAMICS AND ENERGETICS 9

Requirements for carbon and nutrient removal. Activated sludge: process schemes: completely mixed, plug-flow, SBR, nutrient removal. Anaerobic digestion: process dynamics,operational control of wastewater treatment processes.

UNIT V COMPUTER BASED SOLUTION 9

Formulation of linear optimization models. linear programming. sensitivity testing and duality. Solution techniques and computer programming; Formulation of linear optimization models. Application of models- simulation, parameter estimation and experimental design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On completion of the course, the students are able to

CO1 Apply the principle of system modeling
CO2 Do reactor modeling
CO3 Develop water quality models.
CO4 Model microbial dynamics
CO5 Apply the knowledge of numerical techniques to environmental system modeling

REFERENCES:

1. Deaton, M.L and Winebrake, J.J., "Dynamic Modeling of Environmental Systems",Springer-Verlag, 2000
2. Orhon, D and Artan, N., "Modeling of Activated Sludge Systems, Technomic" Publ.Co., 1994.
3. Steven C. Chapra, “Surface Water Quality Modelling”, Tata McGraw-Hill Companies, Inc., New Delhi 2018.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	2
CO2	2	2	2	2	3	2
CO3	3	2	3	3	2	3
CO4	3	3	3	2	3	2
CO5	3	3	3	3	3	3
Avg	**3**	**2**	**3**	**2**	**3**	**2**

• 1-low, 2-medium, 3-high

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EM3008 ENVIRONMENTAL TOXICOLOGY AND MONITORING L T P C
3 0 0 3

UNIT I CLASSIFICATION OF TOXICOLOGY 9

Toxicology Definition – classification – occupational toxicology, forensic toxicology, veterinary toxicology, Environmental toxicology – Historical development – Toxicity types - Acute – Chronic – Sub chronic – Toxicides – types – basics of toxic action, biochemical, molecular, behavioral, nutritional toxicology, applications of toxicology in clinical, veterinary, forensic and environmental sciences, Regulatory issues in toxicology.

UNIT II TOXICANTS IN ENVIRONMENT 9

Sources of toxic compounds – point and non-point sources, plant, animal, and mineral based toxic compounds, exposure classes, toxicants in air, water, soil, domestic and occupational environments — Endocrine disrupting compounds – Disinfectant byproducts - Pesticides – acute pesticide poisoning, movement of toxicants in the environment - typesof air pollutants, particulate matter, Radioactive toxicity – sources, types and effects – types of mutation - Applicable standards and exposure guidelines - Techniques for evaluating potential exposures, food additives and flavors – toxins from microorganisms and their effect.

UNIT III MECHANISM OF ACTION OF TOXICANTS 9

Determination of toxicity – Dose-Response Relationship, Probit transformation – Reversibility of toxicity – the concept of receptors – Mode of entry of toxins – translocationof xenobiotics- metabolism of xenobiotics – phases of metabolism – phase 1 biotransformation – Disposition of Epoxides - Phase 2 – conjugation - common toxic mechanisms and action of lead, cadmium mercury, chromium, arsenic and pesticides andtheir mode of action, Factors affecting toxicity – selective toxicity, sub-cutaneous toxicity, enzyme activity, Food additives and flavours – Toxins from microbes and their action.

UNIT IV METABOLISM OF TOXICANTS 9

Metabolic reactions involving toxicants, physiological effects, genetic effects, environmental effects, nutritional effects of toxicants. Environmental persistence,
degradation, accumulation, Biotransformation – Sites of biotransformation – Cytochrome system P - 450 dependent oxidative reactions, Non cytochrome P-450 dependent oxidations – Reduction, hydrolysis reactions, Factors affecting biotransformation – enzyme induction, enzyme inhibitors, genetic variation, age.

UNIT V TOXICITY TESTING AND RISK ASSESSMENT 9

Toxicity testing in animals —acute toxicity, chronic toxicity testing studies, Animals used for toxicity testing studies – Exposure mode, species differences, Risk assessment – Additivity, synergy, antagonism, Risk assessment tests - bacterial mutagenesis test, Amesassay, DNA repair assay, mammalian mutagenicity assay, mammalian cell chronic cytotoxicity assay, exposure assessment, prevention of toxicity, human health risk, exposure and characterization of risk and management.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the student is expected to be able to

CO1 Explain the basic importance of toxicology and its applications in different fields

CO2 Understand and describe the type of toxicants in the environment, their effects andevaluation techniques

CO3 Select and apply appropriate methods for assessing the toxicity of a compound in the environment

CO4 Explain factors affecting biotransformation and the metabolism of toxic compounds

CO5 Conduct testing and research on risk assessment, understand the importance of testanimals in toxicity testing studies

REFERENCES:

1. Forbes V.E. and T. L. Forbes (1994). Ecotoxicology in Theory and Practice. Chapman &Hall, London.

2. Lippmann, M (2009). Environmental Toxicants Human Exposures and their Effects, 3rdEdition, Jonh Wiley & Sons Inc., USA, ISBN: 978-0-471-79335-9.
3. Jacobson – Kram, D. (2006). Toxicological Testing Handbook: Principles, Applicationsand Data Interpretation, Taylor and Francis, New York.
4. Klaassen C.D. and Watkins, J.B. (2003). Essentials of Toxicology, McGraw HillProfessional, New Delhi.
5. Levin, S. A. and M. A. Harwell, J. R. Kelley and K. D. Kemball (1989). Ecotoxicology:Problems and Approaches. Springer-Verlag, New York.
6. Pery, G. (1980). Introduction to Environmental Toxicology, Elsevier, Amsterdam.
7. Subramanian M. A. (2004). Toxicology – Principles and Methods, MJP publishers,Chennai.
8. Walker, C.H., R.M. Sibly, S.P. Hopkin and D.B. Peakall (2012). Principles ofEcotoxicology, CRC Press, New York.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	2
CO2	2	2	2	2	3	3
CO3	3	2	2	3	3	3
CO4	2	3	2	2	2	2
CO5	3	3	3	3	2	2
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

EM3009 ENVIRONMENTAL BIOTECHNOLOGY L T P C
3 0 0 3

UNIT I BASIC CONCEPTS OF ENVIRONMENTAL BIOTECHNOLOGY 9

Environmental issues – land, soil, water; Environmental Biotechnology for safer Environment – Microbial Communities of Environmental Engineering systems, Interaction of biological species in the environment – Types of interactions, factors affecting the interaction, transformation and removal of heavy metals, processing of solid waste, development of bio pesticides – Current status, scope

UNIT II BIOTECHNOLOGY FOR ENVIRONMENTAL MONITORING AND RESOURCE MANAGEMENT 9

Environmental monitoring process – sampling - land, water, air; Analysis – physical, chemical, biological methods; Use of microorganisms for environmental monitoring – Recombinant DNA technology and proteomics; Monitoring pollution – bio indicators; Biomarkers – biochemical indicators, immunochemistry, genetic indicators, Biosensors – principles, mechanism, types - Reclamation of wastelands – biomass production – Leaching of metals and minerals – Biogasand biofuel production – Monitoring and degradation of pollutants – Nature of pollutants - organic and inorganic pollutants; Biocatalysts - Microbial Fuel Cell(MFC) – Features, Environmental applications, Recent developments.

UNIT III BIOTECHNOLOGY AND BIODIVERSITY CONSERVATION 9

Basic concepts – factors affecting biodiversity, biodiversity extinction, threats to biodiversity,climate change and biodiversity, biological invasions – biodiversity indices – Biodiversity conservation strategies - Germplasm/gene bank, tissue culture, Global and indigenous approaches to conserve biodiversity, International programs for biodiversity conservation, Biodiversity improvement, sources of genetic variation, Population genetics – Hardy - Weinberg equilibrium, Molecular approaches to assess biodiversity, Molecular maps and markers – Random Amplified Polymorphic DNA (RAPD), Restriction Fragment Length Polymorphism (RFLP), Amplified Fragment Length Polymorphism (AFLP), DNA finger printing.

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UNIT IV MOLECULAR BIOLOGY AND GENETIC ENGINEERING 9

Nucleic acids – DNA, RNA – structure, function; Genetically Engineered organisms – Genetic Manipulation – Basic principles – Enzymes – Genetic libraries – Cloning Vectors – ExpressionVectors – Reporter genes – Recombinant DNA technology - Development of organisms resistance to pollutants, improved plants for phytoremediation, new products from plants, bacteria, fungi – pesticides, herbicides and other biocontrol agents; transgenic plants - resistance to herbicides, insects and pests; biosafety issues

UNIT V BIOTECHNOLOGY FOR A CLEAN ENVIRONMENT 9

Biotechnology approaches for environmental remediation – Whole organism – approach, bio substitutions – types, Phytoremediation, mycoremediation, wastewater treatment, bioleaching, Production of clean fuel, biopolymers, bioenzymes, biofertilizers, biofilters; Biotechemical pathways of hazardous waste remediation, Integrated Environmental Biotechnology – methods, Case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the student is expected to be able to

CO1 Understand the importance of biotechnology and the associated process occurring inthe environment for safer environment

CO2 Explain the significance of biotechnology and the indicators for environmentalmonitoring and resource management

CO3 Understand importance of biodiversity for the healthy environment and thebiotechnology and molecular biology techniques to protect the biodiversity

CO4 Conduct research on Recombinant DNA technology to develop organisms survive inadverse conditions and polluted environment

CO5 Understand the various biotechnology approaches and techniques to maintain clean and healthy ecosystem

REFERENCES

1. Evans, GG, Furlong, F. “Environmental Biotechnology: Theory and Application, 2nd Edition. Wiley Blackwell Publishers, 2011, ISBN: 978-0-470-97538-1.
2. Agarwal, S.K. “Advanced Environmental biotechnology” A.P.H Publishers, 2005,ISBN: 81-7648-937-9.
3. Kumar, R. Sharma, A. K, Ahluwalia, S. S.“Advances in Environmental Biotechnology”. Springer Nature, Singapore, 2017. ISBN: ISBN: 978-0-470-97538-1.
4. Inamuddin, I, Ahamed, M. I, Prasad, R. “Application of Microbes in Environmental and Microbial Biotechnology’. Springer Nature, Singapore, 2022, ISBN: 978-981-16-2224-3.
5. Singh, R. K. “Principles and Applications of Environmental Biotechnology for a Sustainable Future”, 2017, Springer Nature Singapore, ISBN: 78-981-10-1865-7.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	3
CO2	3	3	2	2	3	2
CO3	2	2	2	2	2	2
CO4	2	3	3	2	2	2
CO5	3	2	2	3	3	3
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

Attested

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EM3051 ENVIRONMENTAL MANAGEMENT SYSTEMS AND AUDITING L T P C
3 0 0 3

UNIT I ENVIRONMENTAL MANAGEMENT STANDARDS 9

Unique Characteristics of Environmental Problems - Classification of Environmental Impact Reduction Efforts - Systems approach to Corporate environmental management - BusinessCharter for Sustainable Production and Consumption – Tools and Barriers - Evolution of Environmental Stewardship –National policies on abatement of pollution and conservation ofresources - Charter on Corporate responsibility for Environmental protection - Environmental quality objectives – Rationale of Environmental standards: Concentration and Mass standards, Effluent and stream standards, Emission and ambient standards, Minimum national standards, environmental performance evaluation: Indicators, benchmarking-UGC SATAT Framework.

UNIT II PREVENTIVE ENVIRONMENTAL MANAGEMENT 9

Pollution control Vs Pollution Prevention - Opportunities and Barriers – Cleaner productionand Clean technology, closing the loops, zero discharge technologies – Four Stages and nine approaches of Pollution Prevention - Getting management commitment – Analysis of Process Steps- source reduction, raw material substitution, toxic use reduction and elimination, process modification – Material balance – Technical, economical and environmental feasibility evaluation of Pollution Prevention options in selected industries – Preventive Environmental Management over Product cycle.

UNIT III ENVIRONMENTAL MANAGEMENT SYSTEM 10

ISO 14000 family- EMS as per ISO 14001– benefits and barriers of EMS – Understanding the organisation and its context- Understanding the needs and expectations of interested parties- Determining the scope of the environmental management system- Leadership andcommitment- Environmental policy- Organizational roles, responsibilities and authorities- Actions to address risks and opportunities- Environmental objectives and planning – Resources- Competence-Awareness- Communication-Documented Information – Operational Planning and Control- Emergency preparedness and response- Monitoring, measurement, analysis and evaluation - Management review- Life cycle Assessment – Ecolabelling, ecological and carbon footprints – Greenhouse gas accounting, Energy accounting.

UNIT IV ENVIRONMENTAL AUDIT 8

Environmental management system audits as per ISO 19011-Internal Audits and Certification Audits – Principles of auditing- Roles and qualifications of auditors - Determining auditor competence- Managing an audit programme – Establishing and Implementing audit programme- Selecting audit team members and Assigning responsibility Conducting an audit- opening meeting, Audit evidence gathering - Collecting and verifying information - Managing and maintaining audit programme records- closing meeting and reporting - Non conformance – Corrective and preventive actions - Continual improvement -compliance audits – waste audits and waste minimization planning – Environmental statement (form V) - Due diligence audit – ISO 14064 & IS 50001.

UNIT V CASE STUDIES 9

Case studies on applications of EMS, Life cycle Assessment, , Waste Audits and Pollution Prevention in Textile industry , Tanning industry, Electroplating, Pulp & Paper, Dairy, Chemical industries and service organizations, automobile sector, cement industry, steel and Aluminium Manufacturing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1 Explain the various elements of Corporate Environmental Management systems andaudits complying to international environmental management system standards

CO2 Apply the knowledge of science and engineering fundamentals to pollution prevention assessment and environmental performance evaluation

CO3 Develop environmental management systems for organisations

CO4 Conduct environmental management system audits taking into account the sustainability context

CO5 Conduct research pertinent to pollution prevention and communicate effectively todifferent stakeholders as well as engage in independent life-long learning

REFERENCES:

1. ISO 14001/14004:2015 Environmental management systems – Requirements and Guidelines – International Organisation for Standardisation, 2015
2. ISO 19011: 2018, "Guidelines for auditing Management Systems, International Organisation for Standardisation, 2018
3. ISO 14031:2013, Environmental Management – Environmental Performance evaluation Guidelines, International Organization for Standardizatio, 2021.
4. ISO 14064-1:2018 – Greenhouse Gases – Part 1: Specification With Guidance At The Organization Level For Quantification And Reporting Of Greenhouse Gas Emissions And Removals,2018
5. ISO 14064-2:2019 – Greenhouse Gases – Part 2: Specification With Guidance At TheProject Level For Quantification, Monitoring And Reporting Of Greenhouse Gas Emission Reductions Or Removal Enhancements , 2019
6. ISO 14064-2:2019 – Greenhouse Gases – Part 2: Specification With Guidance At TheProject Level For Quantification, Monitoring And Reporting Of Greenhouse Gas Emission Reductions Or Removal Enhancements, 2019
7. ISO 14064-3:2019 – Greenhouse Gases – Part 3: Specification With Guidance For The Verification And Validation Of Greenhouse Gas Statements,2019
8. ISO 50001:2018 – Energy Management Systems Requirements with guidance for use.
9. Marek Bugdol and Piotr Jedynak, Integrated Management Systems, Springer International, 2015.
10. Ryan Dupont, Kumar Ganesan, Louis Theodore, Pollution Prevention: Sustainability, Industrial Ecology, and Green Engineering, Second Edition, CRC Press, 2016
11. Paul L Bishop 'Pollution Prevention: Fundamentals and Practice', McGraw- Hill International, Boston, 2004.
12. Lennart Nilsson, Per Olof Persson, Lars Rydén, Siarhei Darozhka and Audrone Zaliauskiene,Cleaner Production Technologies and Tools for Resource Efficient Production, The Baltic University Environmental Management book series, Uppsala 2007

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	2	2
CO2	2	1	3	3	2	2
CO3	2	1	3	3	2	2
CO4	2	1	3	3	2	2
CO5	2	1	3	3	2	2
Avg	**3**	**1**	**3**	**3**	**2**	**2**

• 1-low, 2-medium, 3-high

EN3052 MEMBRANE SEPARATION FOR WATER AND WASTEWATER TREATMENT **L T P C 3 0 0 3**

UNIT I MEMBRANE FILTRATION PROCESSES **10**

Membrane filtration for solid Liquid separation- crossflow filtration–History of Development and Recent advancements- Basic terms and principles- Recovery, Flux, Rejection, Fouling - membrane flux and trans membrane pressure-Theory of membrane separation– mass transport characteristics–porous and non porous filtration models – concentration polarisation types and choice of membranes –membrane structures and materials – plate and frame, spiral wound and

hollow fibre membranes –membrane performance factors and considerations – membrane manufacturing process.

UNIT II MEMBRANE SYSTEMS 10

Membrane module/element designs – membrane system components– design of membrane systems – design of modules,assembly,plant process control and applications –Basic Flow patterns-Arrays, recycle, Double Pass, multiple Trains- design and applications of low pressure membrane technology systems-microfiltration and ultrafiltration- design and applications of diffusive membrane technologies- nanofiltration and reverse osmosis–Normalised Permeate Flow and Salt Rejection– electrodialysis:Ionexchangemembranes, process design- design of membrane systems – pump types and pump selection–plant operations– economics of membrane systems

UNIT III MEMBRANE BIOREACTORS 8

Historical perspective of MBRs-biotreatment fundamentals-MBR principles and fundamentals-MBR design principles, design assignment, alternative MBR configurations – commercial technologies-Membranes, Modules, and Cassettes - Process Flow of Wastewater Treatment Plants Using MBR - fouling and fouling control- Reversible versus Irreversible and Recoverable versus Irrecoverable Fouling - MBR Operation- Aeration for Biotreatment and Membrane Aeration- trouble Shooting-Case Studies of the MBR Processes Using Popular Membranes

UNIT IV PRETREATMENT AND POST TREATMENT SYSTEMS 8

Membrane fouling–source water quality characterization- particulate membrane foulants - mineral membrane-scaling foulants - natural organic foulants- microbial foulants- parameters and measurement methods- Langlier index, silt density index -combined impacts of various types of foulants- control of fouling-pretreatment methods and strategies–source water screening and conditioning- Mechanical pretreatment-Chemical Pretreatment-monitoring of pretreatment–chemical cleaning systems- biofoulant control – post treatment systems

UNIT V CASE STUDIES 9

Casestudiesonthedesignofmembranebasedwaterandwastewatertreatmentsystems – RO Design Software–zero liquid effluent discharge plants–desalination of brackish water and seawater – project implementation and project economics – environmental issues –reject management -energy recovery systems –Issues concerning system engineering –operation and maintenance issues and good operational practices

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1 Explain the various main membrane processes, principles, separation mechanisms, and applications

CO2 Apply the knowledge of science and engineering fundamentals to analyse the mechanisms of membrane filtration

CO3 Design of membrane systems involving microfiltration, ultrafiltration, nanofiltration, reverse osmosis, electrodialysis and membrane bioreactor processes

CO4 Select appropriate membrane technologies for water and wastewater treatment taking into account the impact of the solutions in a sustainability context

CO5 Conduct research pertinent to membrane technology applications to water and wastewater treatment and communicate effectively to different stakeholders as well as engage in independent life-long learning

REFERENCES:

1. Mihir K. Purkait, Randeep Singh, Membrane Technology in Separation Science, CRC Press, 2018
2. Jane Kucera, Reverse Osmosis: Industrial Processes and Applications, wiley 2015
3. Nikolay Voutchkov, Desalination Engineering-Planning and Design, McGraw-Hill,Newyork,2013
4. SymonJud, MBR Book "Principles and application of MBR in water and wastewater treatment", Elservier,2010.

5. Hee-Deung Park In-Soung Chang Kwang-Jin Lee, Principles of Membrane Bioreactors for Wastewater Treatment, CRC Press, 2015
6. A.F. Ismail, Takeshi Matsuura, Membrane Technology for Water and Wastewater Treatment, Energy and Environment, CRC Press, 2016
7. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse fourth Edition, McGraw-Hill, 2017

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	2	2
CO2	2	1	3	3	2	2
CO3	2	1	3	3	2	2
CO4	2	1	3	3	2	2
CO5	2	1	3	3	2	2
Avg	**2**	**1**	**3**	**3**	**2**	**2**

• 1-low, 2-medium, 3-high

EM3010 ENVIRONMENT, HEALTH AND SAFETY IN INDUSTRIES L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Need for developing Environment, Health and Safety systems in work places- International initiatives, National Policy and Legislations on EHS in India - Regulations and Codes of Practice - Role of trade union safety representatives - Ergonomics.

UNIT II OCCUPATIONAL HEALTH AND HYGIENE 9

Definition of occupational health and hygiene - Categories of health hazards – Exposure pathways and human responses–Exposure Assessment-occupational exposure limits - Hierarchy of control measures - Role of personal protective equipment and the selection criteria

UNIT III WORKPLACE SAFETY AND SAFETY SYSTEMS 9

Features of Satisfactory and Safe design of work premises – good housekeeping - lighting and color, Ventilation and Heat Control, Noise, Chemical and Radiation Safety – Electrical Safety – Fire Safety – Safety at Construction sites, ETP – Machine guarding – Process Safety,Working at different levels

UNIT IV HAZARDS AND RISK MANAGEMENT 9

Safety appraisal – Job Safety Analysis-Control techniques – plant safety inspection – Accident investigation - Analysis and Reporting – Hazard and Risk Management Techniques –Onsite and Offsite emergency Plans. Employee Participation- Education and Training- Case Studies

UNIT V ENVIRONMENTAL HEALTH AND SAFETY MANAGEMENT 9

Concept of Environmental Health and Safety Management – Elements of Environmental Health and Safety Management Policy and implementation and review – ISO 45001-Strucureand Clauses - Auditing – PESTLE-Case Studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After completion of this course, the students are expected to be able to understand:

CO1 Need for EHS in industries and related Indian regulations
CO2 Various types of Health hazards, effect, assessment and control methods
CO3 Various safety systems in working environments
CO4 The methodology for preparation of Emergency Plans and Accident investigation
CO5 EHS Management System and its elements

REFERENCES:

1. The Facility Manager's Guide to Environmental Health and Safety by Brian Gallant, Government Inst Publ., 2007.

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

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	3
CO2	3	3	2	2	3	2
CO3	2	2	2	2	2	2
CO4	2	3	3	2	2	2
CO5	3	2	2	3	3	3
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

EM3011 INDUSTRIAL ECOLOGY LT P C
3 0 0 3

UNIT I INTRODUCTION TO INDUSTRIAL ECOLOGY 9

Origin of IE, its definition, Goals and concepts, the environment and the anthrosphere, industrial systems, material resources, societal factors and environmental equity. Link to sustainable development. Goals and concepts Systems analysis, industrial metabolism, biological analogies, material and energy flow and their transformations, closing the materials cycle (open vs, closed-loop systems)

UNIT II ENVIRONMENTAL MANAGEMENT AND SUSTAINABILITY FRAMEWORKS 9

Industrial vs. Ecological Economy. IPAT Equation Changes in Environmental Management Definitions and Drivers for Sustainability Indicators, Energy & Material Resources, Waste and Pollution, Sustainability Thresholds, industrial and Natural Ecosystems, Industrial Symbiosis and Circular Economy, Biomimicry, Systems Analysis (Material and Energy Flows) and Metrics: MFA, LCA, Material & Energy Auditing / Mass & Energy Balances, Waste-to-Product Ratios

UNIT III INDUSTRIAL ECOSYSTEMS AND KEY ISSUES IN ECO-INDUSTRIAL DEVELOPMENT 9

Components of an industrial ecosystem (Kalundborg example), industrial symbiosis, role of government, community, developers, management, evaluating the success of eco-industrial development-industrial symbiosis

UNIT IV LIFE CYCLE ANALYSIS 9

Life cycles of products, processes and facilities; life cycle assessment (components, methodology, applications, difficulties), Inventory Analysis, Energy and Transportation Modeling, design for environment, efficient use of material (remanufacturing, recycling, reuse, etc) Phases, Life Cycle Impact Assessment

UNIT V LIFE CYCLE DESIGN AND MANAGEMENT 9

Life Cycle Management-Life Cycle Design Process Product Life Extension, Dematerialization, Rebound Effect, Purchase, ownership, disposition, Private and social costs, Environmental

Accounting-Internal costs: conventional, hidden, liability, less tangible costs; external costs, Activity Based Accounting and Cost allocation, Revisit Sourcing Decisions, Extended Producer Responsibility, E Waste, Decision-making Frameworks, Success stories, Environmental Marketing & Labeling

TOTAL 45 PERIODS

COURSE OUTCOMES:

On completion of this course, students should be able to:

CO1: Articulate the core philosophy and principles of industrial ecology as it is practiced globally. Identify the benefits and limitations of tools like materials flow analysis, design for environment, environmentally extended input-output analysis, and process-based life-cycle assessment.

CO2: Differentiate and choose appropriately among tools for measuring environmental impacts of industrial systems.

CO3: Relate the concepts of reverse logistics, industrial symbiosis, and biomimicry to design solutions for sustainability problems in the industrial system.

CO4: Apply and operate screening-level life cycle assessment tools and software in case studies for product and packaging design.

CO5: Conduct a comparative environmental life cycle assessment (LCA) in support of a decisions with respect to design, operations, or policy making for products, products systems, or infrastructure in the industrial system

REFERENCES:

1. Graedel, T.E., and Allenby, B.R. 2010. Industrial Ecology and Sustainable Engineering. Upper Saddle River, New Jersey: Pearson Education.
2. Ashby, M.F. 2013. Materials and the Environment: Eco-Informed Material Choice. (2nd Edition) Amsterdam: Elsevier Publishers. below)
3. Edward Cohen-Rosenthal E. and Musnikow J. (edited) (2003) Eco-industrial trategies, Sheffield, UK: Greenleaf Publishing.
4. Erkman S. and Ramaswamy R. (2003) Applied Industrial Ecology – A New Platform for Planning Sustainable Societies, AICRA Publishers, Bangalore, India.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	3	2
CO2	2	1	3	3	3	2
CO3	2	1	3	3	3	2
CO4	2	1	3	3	3	2
CO5	2	1	3	3	3	2
Avg	**2**	**1**	**3**	**3**	**3**	**2**

• 1-low, 2-medium, 3-high

EM3012 ENERGY MANAGEMENT IN INDUSTRIES LT P C
3 0 0 3

UNIT I INTRODUCTION 8

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

UNIT II AUDITING AND INSTRUMENTATION IN ENERGY MANAGEMENT 9

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 9

Thermal energy management-Various 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 Areasfor Electrical Energy management in Various Industries-Energy Management Opportunities in Electrical Heating, Lighting system, Cable selection - Energy Efficient Motors - Factors involved 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; PetrochemicalIndustries.

TOTAL: 45PERIODS

COURSE OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1 Understand Energy Scenario and Energy Resources in India and Energy consumption Pattern, Energy Conservation and Energy Efficiency, Needs andAdvantages, Role of Energy Manager and Energy Conservation Act.

CO2 Understand principles of Energy Audit and Methodologies, Barriers with respect toProcess Industries, Power Plants, Boilers and Certain Energy Intensive Industries;

CO3 Understand various Energy management Measures in Steam Systems

CO4 Estimate Energy Economics, Life Cycle Costing, risk and Sensitivity Analysis, understand Financing Options and Energy Performance

CO5 Plan energy management measures for sugar Industry –Co generation, Thermal power plant; Petrochemical Industries based on similar case studies.

REFERENCES:

1. Handbook on Energy Efficiency, TERI, New Delhi, 2001
2. Jefferson W. Tester, Elisabeth M. Drake, Michael J Driscoll, Michael W. Golay, WilliamA Peters, Sustainable Energy – Choosing among options, Prentice Hall of India, 2006
3. Murphy W.R. and Mckay G., Energy Management, Elsevier, 2007.
4. Roger A. Hinrichs and Merlin H. Kleinbach, Energy: Its Use and the Environment,Cengage Learning, 2012.
5. Barney L. Capehart, Wayne C. Turner and William J. Kennedy, Guide to EnergyManagement, 7th Ed., Keinnedu Fairmant Press, 2011.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	3
CO2	3	3	2	2	3	2
CO3	2	2	2	2	2	2
CO4	2	3	3	2	2	2
CO5	3	2	2	3	3	3
Avg	**2**	**2**	**2**	**2**	**2**	**2**

1-low, 2-medium, 3-high

EN3051 MARINE POLLUTION AND CONTROL L T P C
3 0 0 3

UNIT I MARINE AND COASTAL ENVIRONMENT 9

Seas and oceans, continental area, coastal zone, properties of sea water, principles of marine geology, coastal features — beaches, estuaries, lagoons, salt marshes, mangroves and sand dunes – the oceans and climate, coastal zone regulation in india – national and international treaties.

UNIT II OCEAN HYDRODYNAMICS 9

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 Nino and La Nina effect.

UNIT III MARINE POLLUTION 9

Sources of marine pollution — point and non-point sources, pollution caused by effluent discharge, oil exploration, dredging, offshore mining, port and harbour activities, power plants, agriculture runoff, plastic waste, marine debris and marine litter - effects of marine pollution on marine water quality and coastal ecosystems.

UNIT IV MARINE POLLUTION MONITORING 9

Basic measurements – sounding boat, echo sounders – current meters – tide gauge – 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.

UNIT V MARINE POLLUTION CONTROL MEASURES 9

Marine discharges and effluent standards, pollution control strategies — marine outfall design-selection of optimal marine outfall locations - Total Maximum Daily Load (TMDL) applications — protocols in marine pollution control – Integrated Coastal Zone Management (ICZM) and sustainable development.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On completion of the course, the students are able to

CO1 Know about the different components of marine environment.
CO2 Understand physical concepts lying behind the tides, waves, and oceanic currents and natural processes of various activities happening over the marine environment
CO3 Identify and measure the marine pollution levels and effects
CO4 Apply the knowledge of remote sensing and GIS for monitoring marine environment water quality.,
CO5 Develop marine pollution control measures.

REFERENCES:

1. "Marine Pollution R.B. Clark, C. Frid and M Atttrill, Oxford Science Publications, 5th Edition, 2021.
2. Marine Pollution: New Research - TobiasN. Hofer,Nova Publishers, 2018,
3. Laws, E.A., "Aquatic pollution", an introductory text. John Wiley and Sons, Inc., New York, 2007.
4. Practical Handbook of Estuarine and Marine Pollution, Michael J. Kennish, Volume 10 of CRC Marine Science, CRC Press, 2021

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	2	3
CO2	1	3	2	3	2	3
CO3	3	3	3	2	3	2
CO4	3	3	2	3	3	3
CO5	2	2	3	3	3	3
Avg	**2**	**3**	**3**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

EM3013 REMOTE SENSING AND GIS APPLICATIONS IN ENVIRONMENTAL MANAGEMENT

L T P C
3 0 0 3

UNIT I ELEMENTS OF REMOTE SENSING 9

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

UNIT II REMOTE SENSING TECHNOLOGY 9

Classification of Remote Sensing Systems, Aerial photographs, Scanning –Acrosstrack and along track scanning, Multispectral remote sensing, Thermalremote sensing, Microwave remote sensing – Active and passive sensors, RADAR, LIDAR

UNIT III SATELLITE REMOTE SENSING 9

Satellites and their orbits, Satellite sensors, Indian space Research and development - ISRO satellites, LANDSAT, ERS, SPOT, TERRA and NOOA satellite series, Characteristics of Remote Sensing data, Satellite data Products

UNIT IV REMOTE SENSING APPLICATIONS AND CASE STUDIES 9

Visual image interpretation, Digital image processing – Image rectification, Enhancement, transformation, Classification, Data merging – Remote sensing applications in Monitoring and management of environment - Conservation of resources, Disaster management, Sustainable urban land use, Agriculture, EIA, Marine and Coastal zone management – Case studies

UNIT V GEOGRAPHICAL INFORMATION SYSTEM AND CASE STUDIES 9

GIS - Concepts and components, Spatial and non-spatial data, Vector and raster datastructures, Data analysis, Database management – RS – GIS Integration,Image processing software, GIS software GIS applications in Monitoring and management of environment - Case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the students are able to

CO1 Know about the remote sensing principle and the different stages of remote sensing
CO2 Understand the various type remote sensing technology.
CO3 Apply the knowledge of satellite sensing system for different environmental issues.
CO4 Apply the knowledge of GIS and image analysis for environmental applications.
CO5 Develop the GIS data base. And work with multi-disciplinary team.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	3	2	2
CO2	2	1	3	3	2	2
CO3	3	3	3	2	3	3
CO4	3	1	2	2	3	3
CO5	3	3	2	3	3	3
Avg	**3**	**2**	**2**	**3**	**3**	**3**

• 1-low, 2-medium, 3-high

EM3052 OPERATION AND MAINTENANCE OF WATER AND WASTEWATER TREATMENT SYSTEMS **L T P C 3 0 0 3**

UNIT I ELEMENTS OF OPERATION AND MAINTENANCE 9

Strategy for good operation and maintenance- preventive and corrective maintenance scheduling - operation and maintenance Plan - proper and adequate tools, spare units and parts - training requirements- laboratory control- records and reports- housekeeping – sampling procedure- analytical techniques- code of practice for analytical laboratories- measurement of flows, pressures and Levels -safety in O&M operations - management information system - measures for conservation of energy

UNIT II OPERATION AND MAINTENANCE OF WATER SUPPLY SYSTEMS 9

Operational problems, O&M practices and records of operation of reservoir and intakes - causes of failure of wells- rehabilitation of tube wells & bore wells- prevention of incrustationand corrosion - problems in transmission mains- maintenance of pipelines and leakage control- repair method for different types of pipes- preventive and corrective maintenance ofwater pumps - problems in the water distribution system and remedies- water quality monitoring and surveillance

UNIT III OPERATION AND MAINTENANCE OF SEWERAGE SYSTEMS 9

Components and functions of sewerage system – maintenance of collection system – operational problems– clogging of pipes – hazards – precautions against gas hazards – precautions against infections – devices for cleaning the conduits – preventive and corrective maintenance of sewage pumps –operation and maintenance of sewage pumpingstations- maintenance hazards and operator protection –SOP-case studies

UNIT IV OPERATION AND MAINTENANCE OF PHYSICO-CHEMICAL TREATMENT UNITS 9

Operation and maintenance in screen chamber, grit chamber and clarifiers- operation issues, trouble shooting guidelines and record keeping requirements for clarifier, equalization basins, neutralization unit - chemical storage and mixing equipment - chemicalmetering equipment - flash mixer –filters, thickeners and centrifuges- filter press - start-up and maintenance inspection - motors and pumps - hazards in chemical handling – jar test -chlorination equipment - membrane process systems- SDI and LSI determination- process chemistry and chemical dosage calculations- SOP-case studies

UNIT V OPERATION AND MAINTENANCE OF BIOLOGICAL TREATMENT UNITS 9

Construction, operation and maintenance aspects of activated sludge process, trickling filters, anaerobic digester, SBR, UASBR, MBRs- startup and shutdown procedures-DO, MLSS and SVI monitoring- trouble shooting guidelines –planning, organizing and controllingof plant operations – capacity building, case studies of retrofitting- SOP-case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the student is expected to be able to

CO1 Understand the O&M issues pertaining to STP and WTP
CO2 Understand operation and maintenance of water intakes and supply systems
CO3 Recognize the O&M issues relevant to sewerage system
CO4 Understand operation and maintenance of physico-chemical treatment units
CO5 Understand operation and maintenance of biological treatment units

REFERENCES:

1. CPHEEO, Manual on operation and maintenance of water supply systems, CentralPublic Health and Environmental Engineering Organisation, Ministry of Urban Development, Government of India 2013
2. Ministry of Drinking Water and Sanitation, operation and maintenance manual forrural water supplies, Government of India, 2013
3. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill,2017

4. Ananth S Kodavasal, The STP Guide-Design, Operation and maintenance, Karnataka State Pollution Control Board, Bangalore,2011
5. Frik Schutte, handbook for the operation of water Treatment Works,The Water Research Commission, The Water Institute of Southern Africa, TT265/06, 2006.
6. Michael D. Nelson, Chair, Operation of municipal waste water treatment plants, Water environment federation, vol.2 liquid process, 2007.
7. Michael D. Nelson, Chair, Operation of municipal waste water treatment plants, Water environment federation, vol.1 Management and support systems, sixth edition,2007.

CO-PO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	2	3
CO2	3	3	2	2	3	2
CO3	2	2	2	2	2	2
CO4	2	3	3	2	2	2
CO5	3	2	2	3	3	3
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

EM3014 SLUDGE AND SEPTAGE MANAGEMENT L T P C
3 0 0 3

UNIT I SOURCES AND CHARACTERISTICS OF SLUDGE 9

Objectives of sludge treatment – sources of sludge- Sludge from WTP, STP and CETP- Sludge-Quantification-generation from various treatment plants – Characteristics in eachstage of treatment –-Physico-chemical and biological- Mass balance in sludge treatment

UNIT II SLUDGE THICKENING AND DEWATERING 9

Sludge thickening- Gravity thickening - Drum thickener - Air floatation – Centrifugation-conditioning -Sludge Dewatering- Centrifuge- Vacuum Filtration-Sludge drying bed- performance of thickener and dewatering systems-operation and maintenance

UNIT III SLUDGE STABILIZATION 9

Objectives-Aerobic and Anaerobic Sludge digestion processes – Types of anaerobicdigesters – design of Low rate and High-rate digesters – Two stage digester-Aerobicdigestion- Pure oxygen and thermophilic aerobic digestion - Chemical and Thermal stabilization process

UNIT IV REUSE AND LAND APPLICATION OF SEWAGE SLUDGE 9

Introduction- beneficial use-requirements and associated risks-handling and management- storage - operation aspects of transport and application of biosolids application land- Lagoon- Landfilling-land farming-Composting-windrow composting -Vermicomposting -Lawsand regulations on sludge management

UNIT V SEPTAGE MANAGEMENT 9

Sources of Septage – characteristics- Public health and environmental hazards- Elements ofseptage management- Pumping and Desludging Septic Tanks-Transportation- Treatment- Dewatered septage sludge reuse- Operation and maintenance - Planning and implementation of septage management schemes-Case studies

TOTAL : 45 PERIODS

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

COURSE OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1 Understand sources and characteristics of various sources of sludge.
CO2 Design sludge thickening and dewatering units
CO3 Design of sludge stabilization units
CO4 Know about the requirements and associated risk while reusing sewage sludge
CO5 Plan and implement septage management scheme

REFERENCES

1. Septage management in urban India, National Urban Sanitation policy, Ministry of Urban Development Government of India,2013
2. National Policy on Fecal Sludge and Septage Management (FSSM) Ministry of Urban Development Government of India,2017
3. A.F. Ismail, Takeshi Matsuura, Membrane Technology for Water and Wastewater Treatment, Energy and Environment, CRC Press, 2016
4. Michael D. Nelson, Chair, Operation of municipal waste water treatment plants, Water environment federation, vol.2 liquid process,2007
5. Michael D. Nelson, Chair, Operation of municipal waste water treatment plants, Water environment federation, vol.1Management and support systems, sixth edition,2007
6. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse fourth Edition, McGraw-Hill,2017

CO-PO MAPPING

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CO2	3	3	2	2	3	2
CO3	2	2	2	2	2	2
CO4	2	3	3	2	2	2
CO5	3	2	2	3	3	3
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high

EM3015 RURAL WATER SUPPLY AND ONSITE SANITATION L T P C
3 0 0 3

UNIT I DEVELOPMENT OF WATER SOURCES 9

Sources of water — Alternate ways of water supply- Issues of water supply in rural areas-Surface and ground water sources – Traditional drinking water ponds- Development of deep bore wells-Estimation of yield–- Rain water harvesting – sanitation of rural wells - Types and selection of pumps for rural wells – system performance- Construction –Operation and maintenance.

UNIT II WATER TREATMENT 9

Quality of water - Standard conventional water treatment for rural areas– Technologies for removal of specific contaminants- Low cost filtration-Iron and manganese removal technologies– Arsenic removal - deflouridation- Nitrate removal- Disinfection – Alternatedisinfection methods.

UNIT III SANITATION AND PLUMBING 9

Basic requirement of sanitation- Swachh Bharat Abhiyan- on site sanitation technologies- Rural sanitation-Composting toilets-Ecological sanitation- small bore / settled effluent sewer - drainage in buildings – sanitary fixtures – plumbing systems for drainage in residential and commercial buildings.

UNIT IV DECENTRALISED WASTEWATER TREATMENT SYSTEMS 9

Fundamentals of sewage treatment- Decentralized sewage treatment- Ecology and self- purification effect-Septic tank with soil absorption systems - DEWATS components- Design of anaerobic baffled

reactors-Constructed wetland-Design aspects of vertical and horizontal flow planted gravel filter-Vertical sand filters- Operation and maintenance.

UNIT V SEPTAGE MANAGEMENT 9

Sources of Septage – characteristics- Elements of septage management- Pumping and Desludging Septic Tanks-Transportation- Treatment- Operation and maintenance - Planningand implementation of septage management schemes-Case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1 Ability to identify alternate sources of water for rural water supply scheme
CO2 Develop conceptual schematics required for the treatment of water forrural application.
CO3 Ability to function on a multi – disciplinary team.
CO4 Capability to identify pertinent criteria for the design of DEWATS system
CO5 Understand septage management

REFERENCES:

1. Manual for "Sewerage and Sewage Treatment Systems" CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
2. Metcalf & Eddy, INC, Wastewater Engineering – Treatment and Reuse, Fourth Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2017.
3. "Manual on water supply and Treatment", CPHEEO, Ministry of Urban Development,Government of India, New Delhi, 1999.
4. Todd, D.K. Ground Water Hydrology, John Wiley & Sons, New York, 2000.
5. Hand Book of Drinking Water Quality, 2nd Edition, DeZuane J. John Wiley & Sons, NewYork 2013.

CO-PO MAPPING

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CO2	3	3	2	2	3	2
CO3	2	2	2	2	2	2
CO4	2	3	3	2	2	2
CO5	3	2	2	3	3	3
Avg	**2**	**2**	**2**	**2**	**2**	**2**

• 1-low, 2-medium, 3-high