M.E. ENVIRONMENTAL ENGINEERING

OBJECTIVES

- To provide the engineering graduates with technical expertise in Environmental Engineering which will enable them to have a career and professional accomplishment in the public or private sector to :

  – Address the complexities of real life environmental engineering problems related to water supply, sewerage, sewage treatment, waste management, environmental impact assessment, industrial pollution prevention and control.
  – Identify, formulate, analyze, 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.

OUTCOMES

- By the time of their graduation, the students are expected to be able to :
  – identify, formulate, and solve environmental engineering problems using the techniques, skills, and modern engineering tools necessary for environmental engineering practice
  – design systems, processes, and equipment for control and remediation of water, air, and soil quality environment within realistic constraints of economic affordability and social acceptability
  – assess the potential environmental impacts of development projects and design mitigation measures
  – have basic knowledge about environment protection and operation of pollution control devices
  – design and conduct experiments, as well as interpret data and communicate effectively
  – function in multi-disciplinary teams and understand the ethical and professional responsibility
  – find professional level employment as Environmental Engineers or pursue higher studies
  – have a knowledge of contemporary environmental issues and an ability to engage in life-long learning

UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY :: CHENNAI 600 025

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M.E. ENVIRONMENTAL ENGINEERING

CURRICULUM AND SYLLABUS I TO IV SEMESTERS (FULL TIME)

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	EN8101	Design of Physico-Chemical Treatment Systems	3	0	0	3
2.	EN8102	Chemistry for Environmental Engineers	3	0	0	3
3.	EN8103	Environmental Microbiology	3	0	0	3
4.	EN8104	Transport of Water and Wastewater	3	0	0	3
5.	MA8161	Statistical Methods for Engineers	3	1	0	4
6.	EN8151	Solid and Hazardous Waste Management	3	0	0	3
PRACTICAL						
7.	EN8111	Environmental Chemistry Laboratory	0	0	3	2
8.	EN8112	Environmental Microbiology Laboratory	0	0	3	2
		TOTAL	**18**	**1**	**6**	**23**

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	EN8201	Design of Biological Treatment Systems	3	0	0	3
2.	EN8251	Air Pollution Control Engineering	3	0	0	3
3.	EN8252	Industrial Wastewater Pollution- Prevention and Control	3	0	0	3
4		Elective I	3	0	0	3
5.		Elective II	3	0	0	3
6.		Elective III	3	0	0	3
PRACTICAL						
7.	EN8211	Unit Operations and Processes Laboratory	0	0	6	3
		TOTAL	**18**	**0**	**6**	**21**

SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	EM8351	Environmental Impact and Risk Assessment	3	0	0	3
2.		Elective IV	3	0	0	3
3.		Elective V	3	0	0	3
PRACTICAL						
4.	EN8311	Industrial Training (4 weeks)	-	-	-	1
5.	EN8312	Project Work (Phase I)	0	0	12	6
6.	EN8313	Seminar	0	0	2	1
		TOTAL	**9**	**0**	**14**	**17**

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1.	EN8411	Project Work (Phase II)	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 73

ELECTIVES FOR M.E. ENVIRONMENTAL ENGINEERING

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1	EN8001	Advanced Oxidation Process	3	0	0	3
2	EN8002	Computing Techniques in Environmental Engineering	3	0	0	3
3	EN8003	Design of Environmental Engineering Structures	3	0	0	3
4	EN8004	Environmental Reaction Engineering	3	0	0	3
5	EN8005	Environmental System Analysis	3	0	0	3
6	EN8006	Resource and Energy recovery from waste	3	0	0	3
7	EM8071	Climate Change and Modeling	3	0	0	3
8	EM8072	Marine Pollution and Control	3	0	0	3
9	EM8073	Remote Sensing and GIS Applications in Environmental Management	3	0	0	3
10	EN8071	Air Quality Modeling And Mapping	3	0	0	3
11	EN8072	Landfill Engineering and Remediation Technology	3	0	0	3
12	EN8073	Membrane Separation for Water and Wastewater Treatment	3	0	0	3
13	EN8074	Rural Water Supply and Onsite Sanitation	3	0	0	3
14	EN8075	Water Quality Modeling	3	0	0	3

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M.E. ENVIRONMENTAL ENGINEERING

CURRICULUM AND SYLLABUS I TO VI SEMESTERS (PART - TIME)

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MA8161	Statistical Methods for Engineers	3	1	0	4
2	EN8101	Design of Physico-Chemical Treatment Systems	3	0	0	3
3	EN8102	Chemistry for Environmental Engineers	3	0	0	3
4	EN8103	Environmental Microbiology	3	0	0	3
5	EN8111	Environmental Chemistry Laboratory	0	0	3	2
		TOTAL	**12**	**1**	**3**	**15**

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	EN8201	Design of Biological Treatment Systems	3	0	0	3
2	EN8252	Industrial Wastewater Pollution- Prevention and Control	3	0	0	3
3		Elective I	3	0	0	3
4	EN8211	Unit Operations and Processes Laboratory	0	0	6	3
		TOTAL	**9**	**0**	**6**	**12**

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	EN8104	Transport of Water and Wastewater	3	0	0	3
2	EN8151	Solid and Hazardous Waste Management	3	0	0	3
3		Elective II	3	0	0	3
4	EN8112	Environmental Microbiology Laboratory	0	0	3	2
		TOTAL	**9**	**0**	**3**	**11**

SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	EN8251	Air Pollution Control Engineering	3	0	0	3
2		Elective III	3	0	0	3
3		Elective IV	3	0	0	3
		TOTAL	**9**	**0**	**0**	**9**

SEMESTER V

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	EM8351	Environmental Impact and Risk Assessment	3	0	0	3
2		Elective V	3	0	0	3
3	EN8311	Industrial Training (4 weeks)	-	-	-	1
4	EN8312	Project Work (Phase I)	0	0	12	6
5	EN8313	Seminar	-	-	2	1
		TOTAL	**6**	**0**	**14**	**14**

SEMESTER VI

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	EN8411	Project Work (Phase II)	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 73

ELECTIVES FOR M.E. ENVIRONMENTAL ENGINEERING

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1	EN8001	Advanced Oxidation Process	3	0	0	3
2	EN8002	Computing Techniques in Environmental Engineering	3	0	0	3
3	EN8003	Design of Environmental Engineering Structures	3	0	0	3
4	EN8004	Environmental Reaction Engineering	3	0	0	3
5	EN8005	Environmental System Analysis	3	0	0	3
6	EN8006	Resource and Energy recovery from waste	3	0	0	3
7	EM8071	Climate Change and Modeling	3	0	0	3
8	EM8072	Marine Pollution and Control	3	0	0	3
9	EM8073	Remote Sensing and GIS Applications in Environmental Management	3	0	0	3
10	EN8071	Air Quality Modeling And Mapping	3	0	0	3
11	EN8072	Landfill Engineering and Remediation Technology	3	0	0	3
12	EN8073	Membrane Separation for Water and Wastewater Treatment	3	0	0	3
13	EN8074	Rural Water Supply and Onsite Sanitation	3	0	0	3
14	EN8075	Water Quality Modeling	3	0	0	3

EN8101 DESIGN OF PHYSICO-CHEMICAL TREATMENT SYSTEMS L T P C
3 0 0 3

OBJECTIVE:

- To educate the students on the principles and process designs of various treatment systems for water and wastewater and students should gain competency in the process employed in design of treatment systems and the components comprising such systems, leading to the selection of specific process.

UNIT I INTRODUCTION 5

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

UNIT II TREATMENT PRINCIPLES 10

Physical treatment - Screening – Mixing, Equalization – Sedimentation – Filtration – Evaporation – Incineration – gas transfer – mass transfer coefficient Adsorption – Isotherms – Membrane separation, Reverse Osmosis, nano filtration, ultra filtration and hyper filtration electrodialysis, distillation – stripping and crystallization – Recent Advances.

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

UNIT IV DESIGN OF MUNICIPAL WATER TREATMENT PLANTS 10

Selection of Treatment – Design of municipal water treatment plant units – Aerators – chemical feeding – Flocculation – clarifier – tube settling – filters – Rapid sand filters, slow sand filter, pressure filter, dual media Disinfection - Displacement and gaseous type - Flow charts – Layouts –Hydraulic Profile, PID - construction and O&M aspects – case studies, Residue management – Upgradation of existing plants – Recent Trends.

UNIT V DESIGN OF INDUSTRIAL WATER TREATMENT PLANTS 10

Design of Industrial Water Treatment Units- Selection of process – Design of softeners – Demineralisers –Reverse osmosis plants –Flow charts – Layouts –Hydraulic Profile, PID - construction and O&M aspects – case studies, Residue management – Upgradation of existing plants – Recent Trends.

UNIT VI DESIGN OF WASTEWATER TREATMENT PLANTS 10

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

TOTAL: 45 PERIODS

OUTCOME:

- Developed conceptual schematics required for the treatment of water and wastewater and an ability to translate pertinent forcing criteria into physical and chemical treatment system.

REFERENCES:

1. Metcalf and Eddy, "Wastewater Engineering, Treatment and Reuse", Tata McGraw Hill, New Delhi, 2003.
2. Qasim, S.R., Motley, E.M. and Zhu.G. "Water works Engineering – Planning, Design and Operation", Prentice Hall, New Delhi, 2002.

3. Lee, C.C. and Shun dar Lin, "Handbook of Environmental Engineering Calculations", Mc Graw Hill, New York, 1999.
4. 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 York (2011).

EN8102 CHEMISTRY FOR ENVIRONMENTAL ENGINEERS L T P C
3 0 0 3

OBJECTIVES:

- To educate the students in the area of water, air and soil chemistry
- To impart knowledge on the transformation of chemicals in the environment

UNIT I INTRODUCTION 9

Stoichiometry and mass balance-Chemical equilibria, acid base, solubility product(Ksp) ,heavy metal precipitation, amphoteric hydroxides,CO_2 solubility in water and species distribution – Chemical kinetics , First order- 12 Principles of green chemistry

UNIT II AQUATIC CHEMISTRY 11

Water quality parameters- environmental significance and determination; Fate of chemicals in aquatic environment, volatilization, partitioning, hydrolysis, photochemical transformation– Degradation of synthetic chemicals-Metals, complex formation, oxidation and reduction , pE – pH diagrams, redox zones – sorption- Colloids, electrical properties, double layer theory, environmental significance of colloids, coagulation .

UNIT III ATMOSPHERIC CHEMISTRY 7

Atmospheric structure –-chemical and photochemical reactions – photochemical smog. Ozone layer depletion – greenhouse gases and global warming, CO_2 capture and sequestration – Acid rain- origin and composition of particulates. Air quality parameters-effects and determination

UNIT IV SOIL CHEMISTRY 9

Nature and composition of soil-Clays- cation exchange capacity-acid base and ion-exchange reactions in soil – Agricultural chemicals in soil-Reclamation of contaminated land; salt by leaching-Heavy metals by electrokinetic remediation.

UNIT V ENVIRONMENTAL CHEMICALS 9

Heavy metals-Chemical speciation –Speciation of Hg &As- Organic chemicals- Pesticides, Dioxins,PCBs,PAHs and endocrine disruptors and their Toxicity- Nano materials, CNT, titania, composites, environmental applications.

TOTAL: 45 PERIODS

REFERENCES:

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

OUTCOMES:

- Students will gain competency in solving environmental issues of chemicals based Pollution
- Able to determine chemicals need calculations for treatment purpose Ability to identify contaminating chemicals

EN8103 ENVIRONMENTAL MICROBIOLOGY L T P C
3 0 0 3

OBJECTIVES:

- The course provides a basic understanding on microbiology relevant to environmental engineering for candidates with little prior knowledge of the subject.
- The morphology, behavior and biochemistry of bacteria, fungi, protozoa, viruses, and algae are outlined.
- The microbiology of wastewater, sewage sludge and solid waste treatment processes is also provided. Aspects on nutrient removal and the transmission of disease causing organisms are also covered.
- An exposure to toxicology due to industrial products and byproducts are also covered.

UNIT I CLASSIFICATION AND CHARACTERISTICS 5

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

UNIT II MICROBES AND NUTRIENT CYCLES 10

Distribution of microorganisms – Distribution / diversity of Microorganisms – fresh and marine, terrestrial – microbes in surface soil, Air – outdoor and Indoor, aerosols, biosafety in Laboratory – Extreme Environment – archaebacteria – Significance in water supplies – problems and control. Transmissible diseases. Biogeochemical cycles-----Hydrological - Nitrogen, Carbon, Phosphorus, Sulphur, Cycle – Role of Micro Organism in nutrient cycle.

UNIT III METABOLISM OF MICROORGANISMS 10

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

UNIT IV PATHOGENS IN WASTEWATER 10

Introduction to Water Borne pathogens and Parasites and their effects on Human, Animal and Plant health, Transmission of pathogens – Bacterial, Viral, Protozoan,and Helminths, Indicator organisms of water – Coliforms - total coliforms, E-coli, Streptococcus, Clostridium, Concentration and detection of virus. Control of microorganisms; Microbiology of biological treatment processes – aerobic and anaerobic, □-oxidation, β-oxidation, nitrification and denitrification, eutrophication. Nutrients Removal – BOD, Nitrogen, Phosphate. Microbiology of Sewage Sludge.

UNIT V TOXICOLOGY 10

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

TOTAL: 45 PERIODS

REFERENCES:

1. S.C.Bhatia, "Hand Book of Environmental Microbiology", Part 1 and 2, Atlantic Publisher
2. Gabriel Bitton, Wastewater Microbiology, 2nd Edition ,
3. Raina M. Maier, Ian L. Pepper, Charles P. Gerba, "Environmental Microbiology", Academic Press.
4. SVS. Rana, "Essentials of Ecology and Environmental Science", 3rd Edition, Prentice Hall of India Private Limited
5. Stanley E. Manahan, "Environmental Science and Technology", Lewis Publishers.
6. Hurst, C.J. (2002) Manual of "Environmental Microbiology". 2nd Ed. ASM PRESS, Washington, D.C. ISBN 1-55581 - 199 - X.
7. Frank C. Lu and Sam Kacew, LU's Basic Toxicology, Taylor & Francis, London (4th Ed), 2002

OUTCOMES:

- The candidate at the end of the course will have a basic understanding on the basics of microbiology and their diversity and on the genetic material in the living cell.
- The candidate would be able to understand and describe the type of microorganisms in the environment and the role of microorganisms in the cycling of nutrients in an ecosystem.
- The candidate would have understood the role microbial metabolism in a wastewater treatment plant.
- The candidate would know the role of microorganisms in a contaminated water and the diseases caused.
- The candidate has the ability to conduct and test the toxicity due to various natural and synthetic products in the environment.

EN8104 TRANSPORT OF WATER AND WASTEWATER L T P C
3 0 0 3

OBJECTIVE:

- To educate the students in detailed design concepts related to water transmission mains, water distribution system, sewer networks and storm water drain and computer application on design.

UNIT I GENERAL HYDRAULICS AND FLOW MEASUREMENT 8

Fluid properties; fluid flow – continuity principle, energy principle and momentum principle; frictional head loss in free and pressure flow, minor heads losses, Carrying Capacity–Flow measurement.

UNIT II WATER TRANSMISSION AND DISTRIBUTION 10

Need for Transport of water and wastewater-Planning of Water System –Selection of pipe materials, Water transmission main design- gravity and pumping main; Selection of Pumps- characteristics-economics; Specials, Jointing, laying and maintenance, water hammer analysis; water distribution pipe networks Design, analysis and optimization – appurtenances – corrosion prevention – minimization of water losses – leak detection Storage reservoirs.

UNIT III WASTEWATER COLLECTION AND CONVEYANCE 10

Planning factors – Design of sanitary sewer; partial flow in sewers, economics of sewer design; Wastewater pumps and pumping stations- sewer appurtenances; material, construction, inspection and maintenance of sewers; Design of sewer outfalls-mixing conditions; conveyance of corrosive wastewaters.

UNIT IV STORM WATER DRAINAGE 7

Necessity- - combined and separate system; Estimation of storm water run-off Formulation of rainfall intensity duration and frequency relationships- Rational methods

UNIT V CASE STUDIES AND SOFTWARE APPLICATIONS 10

Use of computer software in water transmission, water distribution and sewer design – EPANET 2.0, LOOP version 4.0, SEWER, BRANCH, Canal ++ and GIS based softwares.

TOTAL: 45 PERIODS

REFERENCES:

1. Bajwa, G.S. "Practical Handbook on Public Health Engineering", Deep Publishers, Shimla, 2003
2. “Manual on water supply and Treatment”, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
3. “Manual on Sewerage and Sewage Treatment”, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1993.

OUTCOMES:

On Completion of the Course the student will

- be able to select various pipe materials for water supply main, distribution network and sewer
- be able to design water supply main, distribution network and sewer for various field conditions
- Troubleshooting in water and sewage transmission be able to use various computer software for the design of water and sewage network

MA8161 STATISTICAL METHODS FOR ENGINEERS L T P C
3 1 0 4

OBJECTIVE:

- To study and understand the concepts of Statistical methods and its applications in Engineering. To study the effect of estimation theory, testing of hypothesis, correlation and regression, randomized design, and multivariate analysis.

UNIT I ESTIMATION THEORY 9+3

Estimators: Unbiasedness, Consistency, Efficiency and Sufficiency – Maximum Likelihood Estimation – Method of moments.

UNIT II TESTING OF HYPOTHESIS 9+3

Tests based on Normal, t, X^2 and F distributions for testing of means, variance and proportions – Analysis of r x c tables – Goodness of fit.

UNIT III CORRELATION AND REGRESSION 9+3

Multiple and Partial Correlation – Method of Least Squares – Plane of Regression – Properties of Residuals – Coefficient of multiple correlation – Coefficient of partial correlation – Multiple correlation with total and partial correlations – Regression and Partial correlations in terms of lower order co-efficient.

UNIT IV DESIGN OF EXPERIMENTS 9+3

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

UNIT V MULTIVARIATE ANALYSIS 9+3

Random vectors and Matrices – Mean vectors and Covariance matrices – Multivariate Normal density and its properties – Principal components: Population principal components – Principal components from standardized variables.

L: 45 + T : 15 TOTAL : 60 PERIODS

OUTCOME:

- On completion of this course the students will be able to solve various problems in the field of engineering employing probability and statistical methods.

REFERENCES:

1. Gupta.S.C., and Kapoor, V.K., “Fundamentals of Mathematical Statistics”, Sultan Chand and Sons, Eleventh Edition, 2002
2. J.E. Freund, Mathematical Statistical”, 5th Edition, Prentice Hall of India, 2001.
3. Jay L.Devore, “Probability and statistics for Engineering and the Sciences”, 5th Edition, Thomson and Duxbury, Singapore, 2002
4. Murray.R. SpiegelandLarry J.Stephens, “Schaum’sou Tlines- Statistics”, Third Edition, Tata McGraw-Hill, 2000

5. R.A.Johnson and C.B.Gupta, “Miller & Freund’s Probability and Statistics for Engineers”, Pearson Education, Asia, 7th Edition, 2007
6. Richard A.Johnson and Dean W.Wichern, “Applied Multivariate Statistical Analysis”, Pearson Education, Asia, 6th Edition, 2007

EN8151 SOLID AND HAZARDOUS WASTE MANAGEMENT L T P C
3 0 0 3

OBJECTIVE:

- To impart knowledge and skills in the collection, storage, transport, treatment, disposal and recycling options for solid wastes including the related engineering principles, design criteria, methods and equipments.

UNIT I SOURCES, CLASSIFICATION AND REGULATORY FRAMEWORK 9

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

UNIT II WASTE CHARACTERIZATION AND SOURCE REDUCTION 8

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

UNIT III STORAGE, COLLECTION AND TRANSPORT OF WASTES 9

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

UNIT IV WASTE PROCESSING TECHNOLOGIES 10

Objectives of waste processing – material separation and processing technologies – biological and chemical conversion technologies – methods and controls of Composting - thermal conversion technologies and energy recovery – incineration – solidification and stabilization of hazardous wastes - treatment of biomedical wastes - Health considerations in the context of operation of facilities, handling of materials and impact of outputs on the environment-

UNIT V WASTE DISPOSAL 9

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

TOTAL: 45 PERIODS

OUTCOMES:

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

- Understand the characteristics of different types of solid and hazardous wastes and the factors affecting variation

- Define and explain important concepts in the field of solid waste management and suggest suitable technical solutions for treatment of municipal and industrial waste
- Understand the role legislation and policy drivers play in stakeholders' response to the waste and apply the basic scientific principles for solving practical waste management challenges

REFERENCES:

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

5 Paul T Williams, "Waste Treatment and Disposal", Wiley, 2005

EN8111	ENVIRONMENTAL CHEMISTRY LABORATORY	L	T	P	C
		0	0	3	2

OBJECTIVES:

- To train in the analysis of physico-chemical parameters with hands on experience

1. Good Laboratory Practices, Quality control, calibration of Glassware **3**
2. Sampling and Analysis of water (pH, alkalinity, hardness chloride, Sulphate, turbidity EC, TDS, nitrate, fluoride) **12**
3. Wastewater analysis (BOD, COD, Phosphate, TKN, Oil & Grease, Surfactant and heavy metals). **12**
4. Sampling and analysis of air pollutants Ambient & Stack (RSPM, SO_2 and NOx) **9**
5. Sampling and characterization of soil (CEC & SAR, pH and K). **9**

TOTAL: 45 PERIODS

OUTCOME:

- MAble to assess quality of environment

REFERENCES:

1. APHA, "Standard Methods for the Examination of Water and Wastewater", 21st Ed. Washington, 2005.
2. "Laboratory Manual for the Examination of water, wastewater soil Rump", H.H. and Krist, H. – Second Edition, VCH, Germany, 1992.
3. "Methods of air sampling & analysis" ,James P.Lodge Jr(Editor) 3rd Edition, Lewis publishers,Inc,USA,1989.

EN8112	ENVIRONMENTAL MICROBIOLOGY LABORATORY	L	T	P	C
		0	0	3	2

OBJECTIVE:

- To train the students in the analysis of various biological and microbiological techniques, enzymes assay, pollutant removal and bioreactors.

EXPERIMENTS:

1. Preparation of culture media,
2. Isolation, culturing and Identification of Microorganisms
3. Microorganisms from polluted habitats (soil, water and air)
4. Measurement of growth of microorganisms,
5. Assay of enzymes involved in biotransformation.
6. Biodegradation of organic matter in waste water Analysis of air borne microorganisms,
7. Staining of bacteria.
8. Effect of pH, temperature on microbial growth
9. Pollutant removal using microbes from industrial effluent.
10. Effect of pesticides on soil microorganisms.
11. Bacteriological analysis of wastewater (Coliforms, *E.coli, Streptococcus*) – MPN
12. Bacteriological analysis of wastewater (Coliforms, *Streptococcus)* - MF techniques, Effect of Heavy metals on microbial growth.
13. Detection of Anaerobic bacteria (*Clostridium* sp.)
14. Bioreactors

TOTAL: 45 PERIODS

OUTCOMES :

- The candidate at the end of the experimental exercise would be able to perform field oriented testing of water, wastewater and solid waste for microbial contamination.
- The candidate would be knowledgeable to perform toxicity test.
- The candidate would be able to observe and identify the microbes in the contaminated environment.

REFERENCES:

1. "Standard methods for the examination of water and wastewater", American Public Health Association (21st edition) 2005.
2. Charles P. Gerba, "Environmental Microbiology: A laboratory manual", Elsevier Publications, 2012.
3. Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills, and Linda D. Stetzenbach, "Manual of Environmental Microbiology", 3rd Edition, ASM Press, 2007.

EN8201 DESIGN OF BIOLOGICAL TREATMENT SYSTEMS L T P C
3 0 0 3

OBJECTIVE:

- To educate the students on the principles and process designs of various treatment systems for water and wastewater and students should gain competency in the process employed in design of treatment systems and the components comprising such systems, leading to the selection of specific process.

UNIT I INTRODUCTION 10

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

UNIT II AEROBIC TREATMENT OF WASTEWATER 10

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

UNIT III ANAEROBIC TREATMENT OF WASTEWATER 10

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

UNIT IV SLUDGE TREATMENT AND DISPOSAL 5

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

UNIT V CONSTRUCTION OPERATIONS AND MAINTENANCE ASPECTS 10

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

TOTAL: 45 PERIODS

OUTCOME:

- Developed conceptual schematics required for biological treatment of wastewater and an ability to translate pertinent criteria into system requirements.

REFERENCES:

1. Arceivala, S.J., "Wastewater Treatment for Pollution Control", TMH, New Delhi, Second Edition, 2000.
2. Manual on “Sewerage and Sewage Treatment” CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
3. Metcalf & Eddy, INC, ‘Wastewater Engineering – Treatment and Reuse, Fourth Edition, Tata Mc Graw-Hill Publishing Company Limited, New Delhi, 2003.
4. Qasim, S.R. "Wastewater Treatment Plant, Planning, Design & Operation", Technomic Publications, New York, 1994.
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 York (2011).

EN8251 AIR POLLUTION CONTROL ENGINEERING L T P C
3 0 0 3

OBJECTIVE:

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

UNIT I INTRODUCTION 7

Structure and composition of Atmosphere – 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 on the planet – Global Climate Change, Ozone Holes – Ambient Air Quality and Emission Standards – Air Pollution Indices – Emission Inventories – Ambient and Stack Sampling and Analysis of Particulate and Gaseous Pollutants.

UNIT II AIR POLLUTION MODELLING 5

Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability, Inversion, Wind profiles and stack plume patterns- Transport & Dispersion of Air Pollutants – Modeling Techniques – Air Pollution Climatology.

UNIT III CONTROL OF PARTICULATE CONTAMINANTS 11

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

UNIT IV CONTROL OF GASEOUS CONTAMINANTS 11

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

UNIT V INDOOR AIR QUALITY MANAGEMENT 11

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

TOTAL: 45 PERIODS

OUTCOMES:

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

- Apply sampling techniques
- Apply modeling techniques
- Suggest suitable air pollution prevention equipments and techniques for various gaseous and particulate pollutants to Industries. Discuss the emission standards

REFERENCES:

1. Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004.
2. Noel de Nevers, "Air Pollution Control Engg"., Mc Graw Hill, New York, 1995.
3. David H.F. Liu, Bela G. Liptak ‘Air Pollution’, Lweis Publishers, 2000.
4. Anjaneyulu. Y, ‘Air Pollution & Control Technologies’ Allied Publishers (P) Ltd.,India, 2002.
5. Arthur C.Stern, ‘Air Pollution (Vol.I – Vol.VIII)’, Academic Press, 2006.
6. Wayne T.Davis, ‘Air Pollution Engineering Manual’, John Wiley & Sons,Inc.,2000.
7. Daniel Vallero “ Fundamentals of Air Pollution”, Fourth Edition,2008.

EN8252 INDUSTRIAL WASTEWATER POLLUTION - PREVENTION AND CONTROL

L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge on the concept and application of Industrial pollution prevention, cleaner technologies, industrial wastewater treatment and residue management.
- Understand principles of various processes applicable to industrial wastewater treatment
- Identify the best applicable technologies for wastewater treatment from the perspective of yield production.

UNIT I INTRODUCTION 8

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

UNIT II INDUSTRIAL POLLUTION PREVENTION & WASTE MINIMISATION 8

Prevention vis a vis Control of Industrial Pollution – Benefits and Barriers – Waste management Hierarchy - Source reduction techniques – Periodic Waste Minimisation Assessments – Evaluation of Pollution Prevention Options – Cost benefit analysis – Pay-back period – Implementing & Promoting Pollution Prevention Programs in Industries.

UNIT III INDUSTRIAL WASTEWATER TREATMENT 10

Flow and Load Equalisation – Solids Separation – Removal of Fats, Oil & Grease- Neutralisation – Removal of Inorganic Constituents – Precipitation, Heavy metal removal, Nitrogen & Phosphorous removal, Ion exchange, Adsorption, Membrane Filtration, Eletrodialysis & Evaporation – Removal of Organic Constituents – Biological treatment Processes, Chemical Oxidation Processes, Advanced Oxidation processes – Treatability Studies.

UNIT IV WASTEWATER REUSE AND RESIDUAL MANAGEMENT 9

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

UNIT V CASE STUDIES 10

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

TOTAL: 45 PERIODS

OUTCOMES:

After completion of this course, the students is expected to be able to,

- Define the Principles of pollution prevention and mechanism of oxidation processes.
- Suggest the suitable technologies for the treatment of wastewater.
- Discuss about the wastewater characteristics
- Design the treatment systems

REFERENCES:

1. "Industrial wastewater management, treatment & disposal, Water Environment" Federation Alexandria Virginia, Third Edition, 2008.
2. Lawrance K.Wang, Yung . Tse Hung, Howard H.Lo and Constantine Yapijakis, " handlook of Industrial and Hazardous waste Treatment", Second Edition, 2004.
3. Metcalf & Eddy/ AECOM, "water reuse Issues, Technologies and Applications", The Mc Graw-Hill companies, 2007.
4. Nelson Leonard Nemerow, " industrial waste Treatment", Elsevier, 2007.
5. W.Wesley Eckenfelder, " Industrial Water Pollution Control", Second Edition, Mc Graw Hill, 1989.
6. Paul L. Bishop, 'Pollution Prevention: - Fundamentals and Practice', Mc-Graw Hill International, Boston, 2000.

EN8211 UNIT OPERATIONS AND PROCESSES LABORATORY L T P C

0 0 6 3

OBJECTIVE:

- To develop the skill for conducting Treatability studies of water and wastewater treatment by various Unit Operations and Processes using laboratory scale models.

LIST OF EXPERIMENTS

1. Coagulation and Flocculation **7**
2. Batch studies on settling **10**

3.	Studies on Filtration- Characteristics of Filter media	**7**
4.	Water softening	**7**
5.	Adsorption studies/Kinetics	**7**
6.	Reverse Osmosis- Silt Density Index	**7**
7.	Kinetics of suspended growth process (activated sludge process)- Sludge volume Index	**14**
8.	Anaerobic Reactor systems / kinetics (Demonstration)	**10**
9.	Advanced Oxidation Processes – (Ozonation, Photocatalysis)	**14**
10.	Disinfection for Drinking water	**7**

TOTAL: 90 PERIODS

REFERENCES:

1. Metcalf and Eddy. Inc. 'Wastewater Engineering, Treatment, Disposal and Reuse, Third Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
2. Lee, C.C. and Shun dar Lin. "Handbook of Environmental Engineering Calculations", Mc Graw Hill, New York, 1999.
3. Casey T.J., "Unit Treatment Processes in Water and Wastewater Engineering", John Wileys Sons, London, 1993.
4. David W.Hendricks, 'Water Treatment Unit Processes: Physical and Chemical', CRC Press, Boca Raton, 2006.

EM8351 ENVIRONMENTAL IMPACT AND RISK ASSESSMENT L T P C
3 0 0 3

OBJECTIVES:

- To expose the students to the need, methodology, documentation and usefulness of environmental impact assessment and to develop the skill to prepare environmental management plan.
- To provide knowledge related to the broad field of environmental risk assessment, important processes that control contaminant transport and tools that can be used in predicting and managing human health risks.

UNIT I INTRODUCTION 8

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

UNIT II IMPACT INDENTIFICATION AND PREDICTION 10

Matrices – Networks – Checklists –Cost benefit analysis – Analysis of alternatives – Software packages for EIA – Expert systems in EIA. Prediction tools for EIA – Mathematical modeling for impact prediction – Assessment of impacts – air – water – soil – noise – biological — Cumulative Impact Assessment –

UNIT III SOCIAL IMPACT ASSESSMENT AND EIA DOCUMENTATION 8

Social impact assessment - Relationship between social impacts and change in community and institutional arrangements. Individual and family level impacts. Communities in transition Documentation of EIA findings – planning – organization of information and visual display materials – Report preparation.

UNIT IV ENVIRONMENTAL MANAGEMENT PLAN 7

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

UNIT V ENVIRONMENTAL RISK ASSESSMENT AND MANAGEMENT 12

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

OUTCOMES:

- After the completion of course, the student will be able to understand the necessity to study the impacts and risks that will be caused by projects or industries and the methods to overcome these impacts.
- The student will also know about the legal requirements of Environmental and Risk Assessment for projects.

REFERENCES:

1. Canter, L.W., "Environmental Impact Assessment", McGraw Hill, New York. 1996
2. Lawrence, D.P., "Environmental Impact Assessment – Practical solutions to recurrent problems", Wiley-Interscience, New Jersey. 2003
3. World Bank –Source book on EIA
4. Cutter, S.L., "Environmental Risk and Hazards", Prentice-Hall of India Pvt. Ltd., New Delhi, 1999.
5. Kolluru Rao, Bartell Steven, Pitblado R and Stricoff “Risk Assessment and Management Handbook”, McGraw Hill Inc., New York,1996.
6. K. V. Raghavan and A A. Khan, "Methodologies in Hazard Identification and Risk Assessment", Manual by CLRI, 1990.
7. Sam Mannan, Lees' Loss Prevention in the Process Industries, Hazard Identification, Assessment and Control, 4th Edition, Butterworth Heineman, 2012.

EN8001 ADVANCED OXIDATION PROCESS L T P C
3 0 0 3

OBJECTIVES:

- Identify the most critical issues and challenges that limit the use of conventional treatment processes in planning, design and operation of modern water and wastewater treatment facilities.]
- Thorough understanding of the fundamentals of Advanced Oxidation Processes (AOPs) and also Photochemistry and ozone chemistry, its application to AOPs for the removal of contaminants or the detoxification of contaminated waters
  Develop in-depth knowledge that can be used to devise and design effective AOP treatment systems to meet not only current but also anticipated regulatory requirements, and enhance the independent learning and critical thinking skills.

UNITI Introduction to AOPs 8

Introduction to AOPs for water and wastewater treatment – mechanism – photo oxidation reactions – photocatalytic reactions, photo initiated oxidation – UV- H2O2 / ozonation, fenton / photofenton – photocatalysis – light source choice – used in AOPs and their spectral distributions.

UNIT II Heterogeneous Process 10

Introduction to nano & heterogeneous photocatalysis effect of system composition and process. Identification of degradation products, Photoreactors (liquid phase/ gas phase) – solar/ artificial light photo reactors – operation of pilot plants – comparing reactor efficiencies – system design – solar collectors – technology issues – slurry, supported catalyst – reuse – novel photocatalysts, Synthesis methods – bulk, chemical approaches, physical approaches, nanoporous materials – physic chemical methods for characterization of nano materials.

UNIT III Homogenous AOPs 8

Ozone, electro-chemical oxidation, ultrasonication, UV – Photolysis, Hydrogen Peroxide and Ultraviolet Radiation (H2O2/UV), Fenton and Photo Fenton's Oxidation, chemical and non-chemical AOPs, advantages and disadvantages of homogeneous processes.

UNIT IV Enhancement Of Quantum Yield 9

Non-thermal plasma-electron hydraulic cavitation and sonolysis- super water oxidation – γ rays-electron beams, Quantum yield improvement by additional oxidants – hydrogen peroxide persulphate – catalyst modification. case studies and applications semiconductor photolysis. Process fundamentals, applications and commercial process.

UNIT V Industrial Applications and Economic assessment of AOTs 10

Application of AOPs for industries like textile, petroleum pharmaceutical and petrochemical industry. Ground water decontamination – drinking water treatment – pilot & land fill photochemical – cost calculation – economic analysis.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, graduates are expected to attain the following outcomes:

- Apply AOPs to solve pollution problems
- Comprehend the basic principles of advanced water treatment processes, capabilities/constraints of their application in water treatment and have knowledge on the design and operation of these processes.
- Select an appropriate treatment process for a specific application, and identify appropriate pre-treatment and post treatment schemes, and cleaning protocols for these processes.

REFERENCES:

1. G. Cao, "Nanostructures & Nanomaterials: Synthesis, Properties &Applications" , Imperial College Press, 2004.
2. R.M.Rose, L.A.Shepard and J.Wulff, "The Structure and Properties of Materials", Wiley Eastern Ltd,
3. Simon Parsons, "Advanced oxidation processes for water and wastewater treatment", IWA Publishing, 2004
4. Thomas Oppenländer, "Photochemical Purification of Water and Air: Advanced Oxidation Processes (AOPs): Principles, Reaction Mechanisms, Reactor Concepts", Wiley-VCH Publishing, Published by, 2003

EN8002 COMPUTING TECHNIQUES IN ENVIRONMENTAL ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- To educate the students to know about computing techniques
- Develop the different numerical technique and logic like ANN, Fuzzy
- To educate the students on aspects data management
- Develop the model Applications for monitoring and management of environment

UNIT I COMPUTING PRINCIPLES 10

Introduction – computing techniques – Algorithms and Flowcharts, numerical methods - Solution to ordinary and partial differential equation using Finite difference and Method of Characterics- Finite element method , Numerical integration and differentiation Design of digital models for Environmental applications

UNIT II ARTIFICIAL INTELLIGENCE 8

Knowledge based Expert system concepts - Principle of Artificial Neural Network (ANN) – Neural Network Structure – Neural Network Operations – ANN Algorithm - Application of ANN Model to Environmental field – Genetic Algorithms

UNIT III FUZZY LOGIC 9

Fuzzy sets, fuzzy numbers, fuzzy relations, fuzzy measures, fuzzy logic and the theory of uncertainty and information; applications of the theory to inference and control, clustering, and image processing - Network analysis models - WATER CAD, SEWER CAD - EPANET

UNIT IV DATA MANAGEMENT 9

Data base structure - Data acquisition - Data warehouse - Data retrieval-Data format Attribute - RDBMS - Data analysis - Network data sharing - Statistical Analysis (SYSTAT) - Regression - factor analysis - histogram - scatter diagram - Goodness of fit

UNIT V SIMULATION SOFTWARE IN ENVIRONMENTAL STUDIES 9

Surface water quality models -HSPF, QUAL2K, Ground Water Flow models - Visual MODFLOW– FEFLOW - Atmospheric Dispersion Models - ARMOD, CALPUFF

TOTAL: 45 PERIODS

OUTCOMES:

- Ability to understand the computing techniques.
- Ability to apply the principle of soft computing for solving Environmental problems
- Ability to assess the Environmental Impacts using ANN and Fuzzy logic.
- Ability to employ modern advanced computing tools in environmental studies

REFERENCE:

1. Aliev R. A, and Aliev Rashad, "Soft Computing and its Applications", World Scientific Publications Co. Pte. Ltd. Singapore, 2001.
2. Chepra S. C. and Canele R. P., "Numerical Methods for Engineers", McGraw Hill, 1990.
3. Segerlind, L. J., "Applied Finite Element Analysis", John Wiley & Sons, 1984.
4. Abbot, M.A. and Vervey, "Computational Hydraulics", Elsevier Publications, 1996.
5. Kotteguda, N.T., and Renzo Resso, Statistics, "Probability and Reliability for Civil and Environmental Engineers", McGraw Hill Companies Inc., New York, 1998.
6. J. H. Mathews and K.D. Fink, "Numerical methods using MATLAB", Pearson Education.

EN8003 DESIGN OF ENVIRONMENTAL ENGINEERING STRUCTURES L T P C

3 0 0 3

OBJECTIVES:

- To educate the structural design principles
- To educate the students on aspects of water retaining structures design
- Educating the design of masonry and steel structures used in environmental engineering

UNIT I INTRODUCTION AND DESIGN OF PIPES 9

Environmental Engineering structures - Introduction -Concept of elastic method, ultimate load method and limit state method – Advantages of Limit State method over other methods – Limit State philosophy as detailed in current IS Code. Structural design of - Concrete, Prestressed Concrete, Steel and Cast-iron piping mains, - anchorage for pipes - massive outfalls, Advances in the manufacture of pipes

UNIT II DESIGN OF WATER RETAINING STRUCTURES 9

IS Codes for the design of water retaining structures - Design of concrete roofing systems – Cylindrical, Spherical and Conical shapes using membrane theory - Design of circular, rectangular, spherical and Intze type of tanks- Design of prestressed concrete cylindrical tank, Settling tanks, Clariflocculators, Filters

UNIT III DESIGN OF WASTEWATER RETAINING STRUCTURES 9

Structural design of wastewater treatment units - Grit chamber, Parshall flume, Aeration tank, Anaerobic baffle reactor, Sludge digester, UASBR, Sludge thickener, Sludge drying beds.

UNIT IV STEEL STRUCTURES 9

Design of Square bunker – Jansen's and Airy's theories – IS codal provisions – Design of side plates – Stiffeners – Hopper – Longitudinal beams – Design of cylindrical silo – Side plates – Ring girder – Stiffeners . Design of various types of foundation like isolated, combined and raft foundation for a Water tanks, Bunkers and Silo's.

UNIT V SPECIAL STRUCTURES 9

Design of masonry walls, pillars and footings as per NBC and IS Codes -Structural design of underground reservoirs and swimming pools, Intake towers - effect of earth pressure and uplift considerations – design of - Cyclone separator – Scrubber

TOTAL : 45 PERIODS

OUTCOMES:

- Ability to apply the principle of limit state design.
- Ability to do structural design of concrete and steel pipes
- Ability to do the structural design of a complete water and wastewater treatment plant.
- Ability to do air pollution control devices design
- Ability to design underground water storage structures

REFERENCES:

1. "Prestressed Concrete" by Krishna Raju, Tata McGraw Hill Publishing Co. 2nd Edition 1988.
2. "Reinforced Concrete" by N.C.Sinha & S.K.Roy - S.Chand and Co. 1985
3. Ramaswamy, G.S., "Design and Construction of Concrete shell roofs", CBS Publishers, India, 1986.
4. Green, J.K. and Perkins, P.H., "Concrete liquid retaining structures", Applied Science Publishers, 1981.
5. Rajagopalan K.,"Storage structures", Tata McGraw Hill, New Delhi, 1989.
6. Krishna Raju N., "Advanced Reinforced Concrete Design", CBS Publishers and Distributors, New Delhi, 1988.

EN8004 ENVIRONMENTAL REACTION ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- An ability to identify and address current and future societal problems related to environment within a broader framework of sustainable development.
- An ability to apply a multi-disciplinary approach to conceive, plan, design, and implement solutions to problems in the field of environmental reaction engineering.
- Understanding the impact of solutions to environmental engineering problems in a global, scientific, and societal systems context.

UNIT I INTRODUCTION 9

Reaction engineering principles with applications to environmental systems, general reaction mechanisms: Principles of Chemical treatment – Coagulation flocculation – Precipitation – flotation solidification and stabilization– Disinfection, Ion exchange, Electrolytic methods, Solvent extraction – advanced oxidation /reduction – Recent Trends. Rate relationships: Concepts and applications to homogenous systems and heterogeneous systems with respective chemical and biological reactions.

UNIT II POLLUTANTS AND REACTIONS IN ENVIRONMENT 10

Reaction leading to generation of pollutants, impact of pollutants and theirs reactions on environment, ozone depletion, smog formation, acid rain, chemical reactions in major treatment technologies- gas – solid catalytic reactions, catalytic oxidation of VOCs, incineration, selective catalytic reduction. Gas – liquid reaction FCC (fluid catalytic cracking) off gas cleaning, wet- gas scrubbing, H2S removal and spent caustic oxidation.

UNIT III REACTORS MODELLING AND DESIGN 8

Ideal systems modeling and design, reactor concepts, ideal reactors, reaction rate measurements, hybrid system modeling and design, sequencing batch reactor, reactors in series and reactors in recycle. Non-ideal system modeling and design, non-ideal reactor behavior, RTD analysis, PFDR model

UNIT IV MASS TRANSFER AND ITS APPLICATIONS IN ENVIRONMENTAL ENGINEERING 8

Principles of diffusion and mass transfer between phases, Gas absorption, humidification operations, leaching and extraction, drying of solids, fixed-bed separation, membrane separation process, fluid solid surface reactions, Gas-liquid bulk phase reaction, adsorption.

UNIT V BIOLOGICAL REACTION ENGINEERING 10

Biological kinetics, enzyme kinetics, Michaelis – Menden equation, bioreactors, Batch and continuous operation in bioreactors, Aerobic processes: Activated sludge, oxidation ditches, trickling filters, towers, rotating discs, rotating drums, oxidation ponds. b) Anaerobic processes : Anaerobic digestion, anaerobic filters, Up flow anaerobic sludge blanket reactor. bio concentration, bioaccumulation, biomagnification, bioassay, bio monitoring. Biotechnology in reduction of CO2 emission, Bioscrubbers, Biobeds, Biotrickling filters and their applications. Vermitechnology, Methane production, Root zone treatment, Membrane technology, Biodegradable plastics.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, graduates are expected to attain the following outcomes:

- Successfully apply advanced concepts of fundamental sciences and engineering to identify, formulate, and solve complex environmental engineering problems, also to design, analyze, and develop technologies to meet desired needs of society, both, professionally and ethically.
- Be knowledgeable of contemporary issues and research challenges/opportunities related to chemical and environmental engineering, and engage in life-long learning to keep abreast of such issues.
- Use advanced techniques, skills, and modern scientific and engineering tools for problems related to professional practice in the field of environmental reaction engineering.

REFERENCES

1. Weber, W.J and Di Giano, F.A., "Process Dynamics in Environmental systems", John Wiley sons Inc, 1996.
2. Metcalf and Eddy, "wastewater engineering, treatment, disposal and Reuse", Inc. Third edition McGraw – hill 1991.
3. Dunn I.J, Elmar Heinzle, John Ingham, Prenosil J.E, ‘Biological reaction engineering’, Wiley inter science, 2005.

EN8005 ENVIRONMENTAL SYSTEM ANALYSIS L T P C
3 0 0 3

OBJECTIVES:

- To introduce about ecological modeling, single and multi species modeling on a brief.
- To educate about the modeling of CSTR and the kinetics of reaction taking place in it.
- Introduce the concepts of river and stream water modeling, water quality parameters modeling.
- To educate about the microbial energetic in various reactors systems.
- To elaborate the computational techniques for modeling

UNIT I ECOLOGICAL SYSTEM 9

Basic concepts in ecology and ecological modeling, 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 CONTINUOUS-FLOW REACTOR MODELING 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 MODELING 9

Rivers and streams water quality modeling -dispersion and mixing- water quality modeling process-model sensitivity-assessing model performance; Models for dissolved oxygen and pathogens-Pollutant and nutrient dynamics -Dissolved Oxygen dynamics -Groundwater quality modeling.

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 SOLUTIONS 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

OUTCOME:

- Developed conceptual schematics required for system analysis and an ability to translate pertinent criteria into system requirements

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. Chapra, S.C. "Surface Water-Quality Modeling", McGraw-Hill, 1997.

EN8006 RESOURCE AND ENERGY RECOVERY FROM WASTE L T P C
3 0 0 3

OBJECTIVE:

- To understand the principles and design of recovering materials and energy from wastes through mechanical, biological and thermal methods and manage the undesirable by-products .

UNITI MECHANICAL PROCESSING FOR MATERIAL RECYCLING 10

Resource recovery for a sustainable development- Material and energy flow management and analysis - Systems and processes for reduction, reuse and recycling -Objectives of Waste Processing-Source Segregation and Hand Sorting-Waste Storage and Conveyance – Shredding – Pulping - Size Separation by Screens- Density Separation by Air Classification –magnetic and electromechanical separation processes- Design Criteria and Equipment selection

UNIT II BIOLOGICAL PROCESSING FOR RESOURCE RECOVERY 10

Mechanisms of Biological Processing – Aerobic Processing of Organic fraction - Composting methods and processes- factors affecting- Design of Windrow Composting Systems- In Vessel Composting-Compost Quality Control- Vermiculture: definition, scope and importance - common species for culture - Environmental requirements - culture methods- Applications of vermiculture- Potentials and constraints for composting in India-Largescale and decentralized plants.

UNIT III BIO-CHEMICAL CONVERSION OF WASTE TO ENERGY 9

Principles and Design of Anaerobic Digesters – **Process characterization and control-** The biochemistry and microbiology of anaerobic treatment - Toxic substances in anaerobic treatment - Methane generation by Anaerobic Digestion- Anaerobic reactor technologies - Commercial anaerobic Technologies- Single stage and multistage digesters- Digester design and performance-Gas collection systems-Methane Generation and Recovery in Landfills – Biofuels from Biomass

UNIT IV THERMO-CHEMICAL CONVERSION OF WASTE TO ENERGY 8

Principles and Design of Energy Recovery Facilities -Types and principles of energy conversion processes - Incinerator design - Mass Burn and RDF Systems- Composition and calorific value of fuels and waste, Determination of the stoichiometric air consumption, Calculation of the flue gas composition - grate firing designs, boiler design, removal of bottom ash, heat recovery- Emission Controls – flue gas cleaning, de-dusting, flue gas scrubbers, DeNOx processes, dioxins and furans - Alternative thermal processes: co-incineration, pyrolysis, gasification, plasma arc - Process characterization and control- waste heat recovery- Bottom ash: Quantity, quality, treatment, utilization, disposal- Facility design- decentralized mobile plants- Planning and construction of incineration plants

UNIT V CASE STUDIES ON WASTE RECYCLING 8

Recycling technologies for paper, glass, metal, plastic – Used Lead Acid Battery Recycling –End of Life Vehicle Recycling – Electronic Waste Recycling – Waste Oil Recycling – Solvent Recovery - Drivers and barriers for material recycling: social, legal and economic factors - Environmental impacts of waste recycling - Design for the environment: the life cycle approach

TOTAL: 45 PERIODS

OUTCOMES:

On Completion of the Course, the Candidate should:

- Understand the fundamental principles of existing and emerging technologies for the treatment of waste and recovery of materials and energy from waste;
- Appreciate the increasing importance of waste and resource management in achieving environmental sustainability.

  Be able to analyse and describe the potential of solid waste as a secondary raw material, and the associated problems and possibilities in a sustainable society.

REFERENCES:

1 Aarne Veslind and Alan E Rimer (1981), “Unit operations in Resource Recovery Engineering “, Prentice Hall Inc., London

2 Manser A G R, Keeling A A (1996). Practical handbook of processing and recycling on municipal waste. Pub CRC Lewis London, ISBN 1-56670-164

3 Chiumenti, Chiumenti, Diaz, Savage, Eggerth, and Goldstein *, Modern Composting Technologies* JG Press October 2005

4 Charles R Rhyner (1995),Waste Management and Resource Recovery, Lewis Publishers

5 Gary C. Young (2010)Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons , John Wiley & Sons

EM8071 CLIMATE CHANGE AND MODELLING L T P C
3 0 0 3

OBJECTIVE:

- To introduce the emerging concepts of climate modeling and projecting future climate change, understand data analysis and application.

UNIT I Climate Change and Climate Variability 9

Introduction – Atmosphere - weather and Climate - climate parameters (Temperature ,Rainfall, Humidity, Wind etc) – Equations governing the atmosphere - Numerical Weather Prediction Models - Introduction to GCMs - Application in Climate Change Projections.

UNIT II IPCC SRES Scenarios 9

Intergovernmental Panel on Climate Change (IPCC) - An Overview - Key Assumptions - Scenario Family - Storyline (A1, B1, A2, B2).

UNIT III Global Climate Model (GCM) and Regional Climate Model (RCM) 9

Some typical GCMs (HadCM3Q-UK Met Office) - Issues with GCMs - Introduction to RCMs and LAMs - some typical RCMs like PRECIS, SimCLIM, MAGICC/SCENGENE - Advantages and Disadvantages of GCMs and RCMs.

UNIT IV Downscaling Global Climate Model - An Overview 9

Need for downscaling - 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) - examples from each and their limitations.

UNIT V Analysis /Post processing 9

a. Model validation - post processing – Introduction to Analysis tools - Ferret, R, Grads, IDL, SPSS, ArcGIS
b. Climate change Impact - Vulnerability assessment – adaptation strategies.

TOTAL: 45 PERIODS

REFERENCES:

1. IPCC Fourth Assessment Report, Cambridge University Press, Cambridge, UK.
2. McGuffie, K. and Henderson-Sellers, A. (2005) “A Climate Modelling Primer, Third Edition, John Wiley & Sons, Ltd, Chichester, UK.
3. Neelin David J, “Climate Change and Climate Modelling”, Cambridge University Press
4. Thomas Stocker, “Introduction to Climate Modelling”, Advances in Geophysical and Environmanetal Mechanics and Mathematics. Springer Publication.

EM8072 MARINE POLLUTION AND CONTROL L T P C
3 0 0 3

OBJECTIVES:

- To educate the Coastal and Marine environment.
- To educate the ocean dynamics
- To sources of marine pollution and methods for monitoring, modeling and control.

UNIT I MARINE ENVIRONMENT 7

Seas and oceans, Continental area, Coastal zone, Properties of sea water, Principles of Marine Geology, coastal features – Beaches, Estuaries, Lagoons–The oceans and climate

UNIT II OCEAN HYDRODYNAMICS 10

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

UNIT III MARINE POLLUTION SOURCES AND EFFECTS 8

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

UNIT IV MONITORING OF MARINE POLLUTION 10

Basic measurements - Sounding boat, lead lines, echo sounders – current meters - tide gauge - use of GPS – Measurement of coastal water characteristics – sea bed sampling – Modeling 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 AND ICZM 10

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

TOTAL: 45 PERIODS

OUTCOMES:

- Ability to know about marine environment. And learnt the physical concepts lying behind the oceanic currents and natural processes of various activities happening over the marine environment.
- Acquired knowledge on the marine pollution and the effect of the same on the ecology.
- Should have gained knowledge on remote sensing and various other techniques for measuring and monitoring oceanic environment parameters.
- Should have acquired knowledge on control of marine pollution and sustainable development.

REFERENCES:

1. "Marine Pollution (5th Edition) R.B. Clark, C. Frid and M Atttrill Oxford Science Publications, 2001
2. Marine pollution Dr.P.C.Sinha , Anmol Publications Pvt. Ltd, 1998.
3. "Problems of Marine Pollution" : India and Canada, Raghavan, Sudha , Eastern Book Corporation, Delhi, India,
4. Laws, E.A., "Aquatic pollution", an introductory text. John Wiley and Sons, Inc., New York, 2000.

EM8073 REMOTE SENSING AND GIS APPLICATIONS IN ENVIRONMENTAL MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVES:

- To educate the students on aspects of Remote Sensing
- Develop the different remote sensing technique
- To educate the students on aspects of GIS and data management.
- Develop the GIS Applications for monitoring and management of environment

UNIT I REMOTE SENSING ELEMENTS 8

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

UNIT II REMOTE SENSING TECHNOLOGY 9

Classification of Remote Sensing Systems, , Aerial photographs, Photographic systems – Across track and along track scanning, Multispectral remote sensing, Thermal remote sensing, Microwave remote sensing – Active and passive sensors, RADAR, LIDAR

UNIT III SATELLITE REMOTE SENSING 10

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

UNIT IV IMAGE PROCESSING AND GEOGRAPHICAL INFORMATION SYSTEM 10

Photogrammetry – Visual image interpretation, Digital image processing – Image rectification, enhancement, transformation, Classification, Data merging, GIS Concepts – Spatial and non spatial data, Vector and raster data structures, Data analysis, Database management – RS – GIS Integration, Image processing software, GIS software

UNIT V CASE STUDIES 9

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

TOTAL: 45 PERIODS

OUTCOMES:

- Ability to identify the environmental problems using Remote sensing
- Ability to apply the principle of RS and GIS for solving Environmental problems
- Ability to assess the Environmental Impacts using RS and GIS
- Ability to employ modern engineering tools in environmental studies
- Ability to function on a multi-disciplinary team

REFERENCES:

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

EN8071 AIR QUALITY MODELING AND MAPPING L T P C
3 0 0 3

OBJECTIVES:

- To introduce the fundamentals of air pollution with a background on historical perspective on air pollution.
- To introduce the theory of dispersion of air pollution in the atmosphere. To discuss the major approaches for air pollution modeling
- To demonstrate the features and the use of most widely used commercial and freely available air quality models

UNITI MODELING CONCEPT 8

Overview of different types of models-deterministic and stochastic approach- Steps in model development- numerical and simulations models- calibration and validation of models- Limitations- Transport phenomena- Mass balance analysis-Model development and decision making.

UNIT II AIR POLLUTION MODELING 11

Chemistry of air Pollutants - Atmospheric reactions, sinks for air pollution –Transport of air Pollutants - Meteorological settling for dispersal of air pollutants – Vertical structure of temperature and stability, atmospheric motions, Wind and shear, self cleaning of atmosphere; transport and diffusion of stack emissions – atmospheric characteristics significant to transport and diffusion of stack emission – stack plume characteristics.

UNIT III AIR QUALITY MODELS 12

Types modeling technique, modeling for nonreactive pollutants, single source, short term impact, multiple sources and area sources, Fixed box models- diffusion models – Gaussian plume derivation-modifications of Gaussian plume equation- long term average-multiple cell model- receptor oriented and source oriented air pollution models- model performance, accuracy and utilization-air Quality Index -air quality mapping

UNIT IV INDOOR AIR QUALITY MODELS 8

Indoor Air Pollutants - Volatile Organic Compounds , Inorganic Gaseous Pollutants Respirable Particulates ,Bioaerosols, Radon and its decay products-Infectious disease transmission- A/C units in indoor- Odours and sick building syndrome-Indoor Air quality Models.

UNIT V SOFTWARE PACKAGE APPLICATIONS 6

Commercial air quality models -ADMS, Airviro and USEPA models

TOTAL: 45 PERIODS

OUTCOME:

- Developed conceptual schematics required for air quality modeling and an ability to translate pertinent criteria into air pollution control.

REFERENCES:

1. Zanneti, P. 1990. **"**Air Pollution Modeling Theories", Computational Methods and Available Software. Van Nostrand Reinhold, New York.
2. R.W.Boubel, D.L. Fox, D.B. Turner & A.C. Stern, "Fundamentals of Air Pollution" Academic Press, New York, 1994
3. J.L.Schnoor, "Environmental Modeling Fate and Transport of Pollutants in Water, Air and Soil", John Wiley & Sons Inc., New York, 1996.
4. Arthur C.Stern Air Pollution (3rd Ed.) Volume I – Air Pollutants, their transformation and Transport, (Ed.), Academic Press, 2006.
5. Deaton and Wine Brake, “Dynamic Modeling of Environmental Systems”, Wiley & Sons, 2002.

EN8072 LANDFILL ENGINEERING AND REMEDIATION TECHNOLOGY L T P C

3 0 0 3

OBJECTIVE:

- To understand the important characteristics and design principles of the waste containment and remediation industry as well as know the relevant regulations and engineering design requirements of landfills and contaminated site remediation

UNIT I LANDFILL BASICS 8

Waste management Hierarchy- Need for landfills –Environmental Protection by Landfills- Landfill Classification – Sanitary and Secure Landfills - Components and Configuaration - Legal framework for landfilling – Landfill Site investigation- Regional Landfills- Environmental control using site design – - Landfill Design Tasks

UNIT II LANDFILL LINERS AND COVER SYSTEMS 10

Landfill barrier system components – Design of Compacted clay liners: Factors affecting hydraulic conductivity , Water content-density criteria, Thickness, Desiccation - Geosynthetic Clay Liners and Geomembranes; types, manufacturing, handling, seaming and testing - Asphalt Barriers and Capillary barrier - Composite Liner system design- liner construction and quality control- Leakage through Liners- vapor transmission and chemical compatibility - Installation of Geomembranes - Liner Leakage Mechanism – Diffusion - Controls on advection through liners - Single phase flow-advection-diffusion- Landfill cover systems- Design of Cover Systems – Daily Cover – Intermediate Cover – Final Cover - Flow through Landfill Covers- Design and Analysis of Slope Stability- Anchor Trenches- Access ramps - Erosion control

UNIT III LEACHATE AND LANDFILL GAS MANAGEMENT 9

Waste decomposition in landfills - Factors affecting leachate and landfill gas generation – Factors affecting Leachate Quantity in active and post closure conditions- Hydrologic Evaluation of *Landfill* Performance (HELP) model – Leachate Drainage Layer – Geotextile and Geonet design – Leachate Collection and Removal systems-Temporal trends in leachate composition – Design of Landfill gas collection and removal systems- Gas condensate issues & knockouts - Leachate treatment methods (biological and physico-chemical)- Leachate re-circulation & bioreactor landfills- monitoring and control of leachate and Landfill gas- Landfill Settlement

UNIT IV LANDFILL OPERATION AND CLOSURE 8

Landfill Construction and Opeartional Controls – Fill Sequencing Plans – Cell Construction- Dozer and Compactor operations-Selection of Landfill Equipment- Landfill Administration-Record Keeping - Topographic mapping-Environmental Controls – Odour, Vector and Litter Control – Landfill Safety - Fire Control – Ground and Surface water Monitoring – Methane Gas monitoring - Audits of landfill environmental performance and management – Post Closure care and use of landfills – Landfill Economics- landfill construction and operational cost estimation – establishing tipping fees

UNIT V CONTAMINATED SITE REMEDIATION 10

Contaminaed sites - Fate and behaviour of toxics and persistent substances in the environment – Engineering Issues in Site Remediation - Site Characterization - Framework for risk assessment at landfill sites - Remediation Principles: Source Control and Management of Migration Covers, Cut-off Walls, Solidification / Stabilization - Pump-and-Treat Systems - Solvent Vapor Extraction, Air Sparging, Soil Flushing – Bioremediation - Natural Attenuation - Remedy Selection and Risk Assessment – Geotechnical Aspects of In Situ Remediation Technology - Specific case studies in contaminated site remediation – Rehabilitation of Open dumps- Landfill Mining

TOTAL: 45 PERIODS

OUTCOMES:

On Completion of the Course, the Candidate should:

- Have an overview of the Indian and international landfill regulations and guidelines for the design, construction, operation and management of landfills
- understand the design and construction of landfills, processes in landfills, methods for management and treatment of landfill gas and leachate
- have an in-depth understanding of the key pollutants in leachate and gas, their potential environmental impacts and the engineering design and performance of control systems used to manage and treat pollutant and waste emissions from sites.
- Be able to apply a risk based assessment of contaminated sites and implement site remediation technologies

REFERENCES:

1. Robert M. Koerner and Donald H Gray (2002), "Geotechnical aspects of Landfill Design and Construction", Prentice Hall, New Jersy.
2. Neal Bolton P.E (1995), “The Handbook of Landfill Operations”, Blue Ridge Services Inc., Atascadro, CA – ISBN 0-9646956-0-x

3. David E Daniel and Robert M. Koerner (2007), "Waste Containment Facilities –Guidance for construction Quality Assurance and Construction Quality Control of Liner and Cover Systems, American Socirty of Civil Engineers, ASCE Press.
4. Donald L Wise and Debra J Trantolo (1994), "Remediation of Hazardous Waste Contaminated Soils, Marcel Dekker Inc., New York
5. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, "Integrated Solid Waste Management, Mc-Graw Hill International edition, New York, 1993.
6. Hari D Sharma and Krishna R. Reddy (2004), Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Techonolgies, John Wiely, New Jersy
7. Oweis, I.S. and Khera, R.P (1998) *Geotechnology of Waste Management*, 2nd Edition, PWS Publishing Co., Boston, MA

EN8073 MEMBRANE SEPARATION FOR WATER AND WASTEWATER TREATMENT **L T P C 3 0 0 3**

OBJECTIVE:

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

UNIT I MEMBRANE FILTRATION PROCESSES **10**

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

UNIT II MEMBRANE SYSTEMS **10**

Microfiltration principles and applications – Ultrafiltration principles and applications - Nano Filtration principles and applications – Reverse Osmosis: Theory and design of modules, assembly, plant process control and applications – Electro dialysis : Ion exchange membranes, process design- Pervaporation – Liquid membrane – Liquid Pertraction – Supported Liquid Membrane and Emulsion Liquid membrane - Membrane manufatures – Membrane Module/Element designs – Membrane System components – Design of Membrane systems - pump types and Pump selection – Plant operations – Economics of Membrane systems

UNIT III MEMBRANE BIOREACTORS **9**

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

UNIT IV PRETREATMENT SYSTEMS **8**

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

UNIT V CASE STUDIES **8**

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

TOTAL: 45 PERIODS

OUTCOMES:

On Completion of the Course the student will

- be familiar with main membrane processes, principles, separation mechanisms, and applications
- understand the selection criteria for different membrane processes
- know the principle of the most common membrane applications and
- carry out design of project for a particular membrane technology application.

REFERENCES:

1. Water Environment Federation (WEF), "Membrane Systems for Wastewater Treatment", McGraw-Hill, USA, 2005.
2. Symon Jud, MBR Book – "Principles and application of MBR in water and wastewater treatment", Elservier, 2006.
3. K. Yamamoto and Urase T, "Membrane Technology in Environmental management", special issue, Water Science and technology, Vol.41, IWA Publishing, 2000.
4. Jorgen Wagner, "Membrane Filtration handbook, Practical Tips and Hints, 2nd Edition, Revision2, Osmonics Inc., 2001.
5. Baker, R.W., "Membrane technology and applications", 2nd., John Wiley 2004
6 Noble, R.D. and Stern, S.A., "Membrane Separations Technology: Principles and Applications", Elservier,Netherlands,1995.
7. Stephenson, T., Brindle, K., Judd, S., Jefferson, B."Membrane Bioreactors for Wastewater Treatment", IWA Publishing, London , 2000

REFERENCES:

1. Steven C.Chapra, "Surface Water Quality Modelling", The McGraw-Hill Companies, Inc., New Delhi, 1997.
2. J.L.Schnoor, "Environmental Modeling Fate and Transport of Pollutants in Water, Air and Soil", John Wiley & Sons Inc., New York, 1996.
3. Deaton and Wine Brake, “Dynamic Modeling of Environmental Systems”, Wiley & Sons, 2002.
4. Hipel, K.W and A.I. McLeod. 1994. "Time Series Modelling of Water Resources and Environmental Systems". Elsevier Science.
5. Thomann, R.V. and J.A. Mueller. 1987 ."Principles of Surface Water Quality Modelling and Control", Harper and Row.

EN8074 RURAL WATER SUPPLY AND ON SITE SANITATION L T P C
3 0 0 3

OBJECTIVE:

- To educate the students on the principles of rural water supply and sanitation and to develop understanding of factors governing the aspects in rural water supply and sanitation.

UNIT I DEVELOPMENT OF WATER SOURCES 9

Sources of water – Surface and ground water sources – Development of deep bore wells; Estimation of yield – Alternate sources of water supply – Rain water harvesting - pumps – Types and selection of pumps for deep bore wells – Construction, operation and maintenance.

UNIT II WATER TREATMENT 9

Quality of water – Standards - conventional water treatment – Technologies for removal of specific contaminants; Iron, Arsenic, Fluoride, T.D.S; Disinfection – Alternate disinfection methods – solar disinfection.

UNIT III SANITATION 9

Basic requirement of sanitation; Decentralized / onsite wastewater management; small bore / settled effluent sewer system – Design and operation.

UNIT IV SEWAGE TREATMENT 9

Fundamentals of sewage treatment; Decentralized sewage treatment; Septic tank with depression pit – DEWATS, Intermittent sand filters – Anaerobic filters – Waste stabilization ponds – Design and operation.

UNIT V SEWAGE DISPOSAL AND REUSE 9

Methods of disposal, Land disposal, sewage farms – Artificial recharge of ground water; Recycle and Reuse of sewage – Grey water Harvesting – Salt water intrusion and remediation – Ground water pollution and remediation.

TOTAL: 45 PERIODS

OUTCOME:

- Ability to identify problems in rural water supply and sanitation and to develop conceptual schemes required for the treatment of water and wastewater for rural applications.

REFERENCES:

1. CPHEEO Manual on "Water Supply and Treatment", Govt. of India (2003).
2. CPHEEO Manual on "Sewerage and Sewage Treatment", Govt. of India (1999).
3. Metcalf & Eddy, "Wastewater Engg. Treatment and Reuse", Tata McGraw Hill, New Delhi (2003).
4. Todd, D.K. "Ground Water Hydrology", John Wiley & Sons, New York (2000).
5. F.R. Spellman, "Hand Book of Water and Wastewater Treatment Plant operations" CRC Press, New York (2009).

EN8075 WATER QUALITY MODELING L T P C
3 0 0 3

OBJECTIVES:

- To introduce the fundamentals of mathematical models for water quality and the importance of model building.
- To acquaint with various water flow models and their kinetics.
- To educate about the water parameters modeling and various ground water quality modeling.
- To demonstrate the features and the use of most widely used computerized models for water quality

UNIT I MODELING CONCEPTS 9

Engineers and water quality-Mathematical models-Overview of different types of models-- Steps in model development - Importance of model building.- balance –calibration and verification of models-conservation of mass- mass balance analysis -chemical reaction kinetics – Law of mass action, Rate constants, reaction order, types of reactions, equilibrium principles.

UNITII COMPLETELY AND INCOMPLETELY MIXED SYSTEM 10

Transport phenomena – Advection, diffusion, dispersion- simple transport models – Plug flow models-Application of PFR model to streams-MFR model to estuaries-Steady state and time variable solutions-completely mixed systems, concept and models in Completely Stirred Tank Reactors, mass balance equations, loading types, feed forward vs. feedback reactor systems.

UNIT III WATER QUALITY ENVIRONMENTS 12

Lakes and impoundments – Water quality response to input ; water quality modeling process – model sensitivity – assessing model performance; Models for dissolved oxygen, pathogens and BOD-Streeter Phelps equations for point and distributed sources - Modified Streeter Phelps equations - Toxicant modeling in flowing water-Eutrophication model-Trophic state correlations.

UNIT IV GROUNDWATER QUALITY MODELING 8

Mass transport of solutes, degradation of organic compounds, application of concepts to predict groundwater contaminant movement, seawater intrusion – basic concepts and modeling

UNIT V COMPUTER METHODS 6

Exposure to computer models for surface water and groundwater quality - QUAL2E Model and its application

TOTAL: 45 PERIODS

OUTCOME:

- Developed conceptual schematics required for modeling and an ability to translate pertinent criteria into system requirements