ANNA UNIVERSITY, CHENNAI

NON-AUTONOMOUS AFFILIATED COLLEGES

REGULATIONS 2021

M. E. ENVIRONMENTAL ENGINEERING

CHOICE BASED CREDIT SYSTEM

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

Graduates of the Programme **M. E Environmental Engineering** will

PEO1 Gain knowledge and skills in environmental engineering which will enable them to have a career and professional accomplishment in the public or private sector organisations

PEO2 Become consultants on complex real life Environmental Engineering problems related to water supply, sewerage, sewage treatment, solid waste management, air pollution control, environmental impact assessment, industrial pollution control.

PEO3 Become entrepreneurs 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 Perform investigation for solving environmental problems by conducting research using modern equipment and software tools.

PEO5 Function in multi-disciplinary teams and advocate policies, systems, processes and equipment for control and remediation of pollution.

2. PROGRAMME OUTCOMES (POs)

PO #	Graduate Attribute	Programme Outcomes
1	Research Aptitude	An ability to independently carry out research/investigation and development work to solve practical problems
2	Technical documentation	An ability to write and present a substantial technical report/document
3	Technical competence	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

3. PROGRAMME SPECIFIC OUTCOMES (PSOs)

	Graduate Attribute	PROGRAMME SPECIFIC OUTCOMES (PSOs)
1	Handle complex problems	Use research based knowledge, methods, appropriate techniques, resources and tools to solve complex engineering issues with an understanding of the limitations.
2	Environmental Sustainability and societal Ethics	Ensure development of socially relevant and eco-friendly indigenous products by applying technical knowledge, ethical principles and sound engineering practices
3	Life-long learning	Recognize the need for independent, life-long learning and engage in the broadest context of technological change.

PEO/PO Mapping:

PEO	PO & PSO					
	PO1	PO2	PO3	PSO1	PSO2	PSO3
I.	1	1	3	3	1	2
II.	1	1	3	3	3	1
III.	2	2	3	3	2	1
IV.	3	2	3	2	2	1
V.	1	1	2	2	2	1

(3-High, 2- Medium, 1- Low)

MAPPING OF COURSES OUTCOMES AND PROGRAMME OUTCOMES

		COURSE NAME	PO1	PO2	PO3	PSO1	PSO2	PSO3
YEAR I	SEMESTER I	Statistical Methods For Engineers	-	-	-	-	-	
		Environmental Chemistry	2	1	3	2	2	1
		Environmental Microbiology	3	1	2	2	2	1
		Physical and Chemical Treatment systems for water and wastewater	2	1	3	2	3	1
		Water transmission, water distribution and sewerage systems	1	1	3	3	2	1
		Research Methodology and IPR	2	2	3	2	2	2
		Audit Course I*	-	-	-	-	-	-
		Environmental Chemistry Laboratory	2	1	3	3	1	2
		Environmental Microbiology Laboratory	2	2	3	2	2	1
	SEMESTER II	Biological Treatment process for Wastewater	3	3	3	2	2	2
		Air and Noise Pollution Control Engineering	3	2	3	3	2	2
		Industrial Wastewater Pollution- Prevention and Control	3	2	3	2	2	2
		Professional Elective I	-	-	-	--	-	-
		Professional Elective II	-	-	-	--	-	-
		Professional Elective III	-	-	-	--	-	-
		Audit Course –II	-	-	-	--	-	-
		Environmental and Processes Monitoring Laboratory	3	2	3	2	2	1
YEAR II	SEMESTER III	Program Elective IV	-	-	-	--	-	-
		Program Elective V	-	-	-	--	-	-
		Open Elective	-	-	-	--	-	-
		Technical Seminar-	-	-	-	--	-	-
		Industrial Training (2 Weeks)	-	-	-	--	-	-
		Project Work I	-	-	-	--	-	-
	SEMESTER IV	Project Work II	-	-	-	--	-	-

PROGRAM ELECTIVE COURSES [PEC]

S. NO.	COURSE TITLE	PO1	PO2	PO3	PSO1	PSO2	PSO3
1.	Solid and hazardous waste management	2	1	3	3	3	2
2.	Natural Systems for Wastewater Treatment	2	1	3	2	3	1
3.	Environmental System Analysis	2	1	3	2	1	1
4.	Environmental impact Assessment	3	3	3	3	2	2
5.	SEPTAGE and Onsite wastewater treatment technologies	2	1	3	1	2	2
6.	Sustainability Engineering	1	1	3	2	3	1
7.	Project formulation and implementation	2	2	3	3	1	1
8.	Advanced Oxidation Process	2	2	3	2	1	1
9.	Computing Techniques in Environmental Engineering	1	2	3	3	2	2
10.	Geo Environmental Engineering	2	1	3	3	1	1
11.	Environmental Monitoring Instruments	2	1	3	3	2	2
12.	Water Quality Modeling	2	2	3	3	1	1
13.	Marine Pollution and Control	2	1	2	3	2	2
14.	Climate change and Modeling	2	1	2	2	1	1
15.	Operation and Maintenance of Water and Wastewater Treatment Systems	1	1	2	3	2	1
16.	Air Quality Modeling	3	1	3	3	2	1
17.	Fate and remediation of Emerging Contaminants	2	2	3	3	1	1
18.	Environmental Reaction Engineering	3	1	3	2	1	1
19.	Membrane Separation for Water and Wastewater Treatment	2	2	3	3	2	1

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NON-AUTONOMOUS AFFILIATED COLLEGES
M. E. ENVIRONMENTAL ENGINEERING
REGULATIONS 2021
CHOICE BASED CREDIT SYSTEM
I TO IV SEMESTERS CURRICULA AND SYLLABUS
SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA4159	Statistical Methods for Engineers	FC	4	0	0	4	4
2.	EV4101	Environmental Chemistry	PCC	3	0	0	3	3
3.	EV4102	Environmental Microbiology	PCC	3	0	0	3	3
4.	EV4103	Physical and Chemical Treatment Systems for Water and Wastewater	PCC	3	0	0	3	3
5.	EV4104	Water Transmission, Water Distribution and Sewerage Systems	PCC	3	0	0	3	3
6.	RM4151	Research Methodology and IPR	RMC	2	0	0	2	2
7.		Audit Course I*	AC	2	0	0	2	0
PRACTICALS								
8.	EV4111	Environmental Chemistry Laboratory	PCC	0	0	4	4	2
9.	EV4112	Environmental Microbiology Laboratory	PCC	0	0	4	4	2
			TOTAL	**20**	**0**	**8**	**28**	**22**

*** Audit Course is optional**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	EV4201	Biological Treatment Process for Wastewater	PCC	3	0	0	3	3
2.	EV4202	Air and Noise Pollution Control Engineering	PCC	3	0	0	3	3
3.	EV4203	Industrial Wastewater Pollution-Prevention and Control	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
7.		Audit Course II*	AC	2	0	0	2	0
PRACTICALS								
8.	EV4211	Environmental and Processes Monitoring Laboratory	PCC	0	0	6	6	3
			TOTAL	**20**	**0**	**6**	**26**	**21**

*** Audit Course is optional**

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.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
4.	EV4311	Technical Seminar	EEC	0	0	2	2	1
5.	EV4312	Industrial Training (2 Weeks)	EEC	0	0	0	0	1
6.	EV4313	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**14**	**23**	**17**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	EV4411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS: 72

FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	MA4159	Statistical Methods for Engineers	4	0	0	4	1

PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	EV4101	Environmental Chemistry	3	0	0	3	1
2.	EV4102	Environmental Microbiology	3	0	0	3	1
3.	EV4103	Physical and Chemical Treatment Systems for Water and Wastewater	3	0	0	3	1
4.	EV4104	Water Transmission, Water Distribution and Sewerage Systems	3	0	0	3	1
5.	EV4111	Environmental Chemistry Laboratory	0	0	4	2	1
6.	EV4112	Environmental Microbiology Laboratory	0	0	4	2	1
7.	EV4201	Biological Treatment process for Wastewater	3	0	0	3	2
8.	EV4202	Air and Noise Pollution Control Engineering	3	0	3	3	2
9.	EV4203	Industrial Wastewater Pollution-Prevention and Control	3	0	0	3	2
10.	EV4211	Environmental and Processes Monitoring Laboratory	0	0	6	3	2
					TOTAL	**28**	

LIST OF PROFESSIONAL ELECTIVE COURSES [PEC]

SEMESTER II, ELECTIVE I

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1.	EV4001	Solid and Hazardous Waste Management	3	0	0	3	3
2.	EV4002	Natural Systems for Wastewater Treatment	3	0	0	3	3
3.	EV4003	Environmental System Analysis	3	0	0	3	3

SEMESTER II, ELECTIVE II

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1.	EV4004	Environmental Impact Assessment	3	0	0	3	3
2.	EV4005	Septage and Onsite Wastewater Treatment Technologies	3	0	0	3	3
3.	EV4006	Sustainability Engineering	3	0	0	3	3
4.	EV4007	Project Formulation and Implementation	3	0	0	3	3

SEMESTER II, ELECTIVE III

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1.	EV4008	Advanced Oxidation Process	3	0	0	3	3
2.	EV4009	Computing Techniques in Environmental Engineering	3	0	0	3	3
3.	EV4010	Geo Environmental Engineering	3	0	0	3	3
4.	EV4011	Environmental Monitoring Instruments	3	0	0	3	3

SEMESTER III, ELECTIVE IV

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1.	EV4012	Water Quality Modeling	3	0	0	3	3
2.	EV4013	Marine Pollution and Control	3	0	0	3	3
3.	EV4014	Climate Change and Modeling	3	0	0	3	3
4.	EV4015	Operation and Maintenance of Water and Wastewater Treatment Systems	3	0	0	3	3

SEMESTER III, ELECTIVE V

S NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1.	EV4016	Air Quality Modeling	3	0	0	3	3
2.	EV4017	Fate and Remediation of Emerging Contaminants	3	0	0	3	3
3.	EV4018	Environmental Reaction Engineering	3	0	0	3	3
4.	EV4019	Membrane Separation for Water and Wastewater Treatment	3	0	0	3	3

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	RM4151	Research Methodology and IPR	2	0	0	2	1
					TOTAL CREDITS	**2**	

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	EV4311	Technical Seminar	0	0	2	1	3
2.	EV4312	Industrial Training (2 Weeks)	0	0	0	1	3
3.	EV4313	Project Work I	0	0	12	6	3
4.	EV4411	Project Work II	0	0	24	12	4
					TOTAL CREDITS	**20**	

AUDIT COURSES (AC)
Registration for any of these courses is optional to students

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	AX4091	English for Research Paper Writing	2	0	0	0	**1/2**
2.	AX4092	Disaster Management	2	0	0	0	
3.	AX4093	Constitution of India	2	0	0	0	
4.	AX4094	நற்றமிழ் இலக்கியம்	2	0	0	0	

SUMMARY

S. No.	Name of the Programme: M.E. ENVIRONMENTAL ENGINEERING					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	FC	04	00	00	00	04
2.	PCC	16	12	0	00	28
3.	PEC	00	9	6	00	15
4.	RMC	02	00	00	00	02
5.	OEC	00	00	3	00	03
6.	EEC	00	00	08	12	20
7.	Non Credit/Audit Course	✓	✓	00	00	00
8.	**TOTAL CREDIT**	**22**	**21**	**17**	**12**	**72**

MA4159 STATISTICAL METHODS FOR ENGINEERS

L	T	P	C
4	0	0	4

OBJECTIVES :

- This course is designed to provide the solid foundation on topics in various statistical methods which form the basis for many other areas in the mathematical sciences including statistics, modern optimization methods and risk modeling. It is framed to address the issues and the principles of estimation theory, testing of hypothesis, correlation and regression, design of experiments and multivariate analysis.

UNIT I ESTIMATION THEORY 12

Estimators : Unbiasedness, Consistency, Efficiency and sufficiency – Maximum likelihood estimation – Method of moments.

UNIT II TESTING OF HYPOTHESIS 12

Sampling distributions - Small and large samples -Tests based on Normal, t, Chi square, and F distributions for testing of means, variance and proportions – Analysis of r x c tables – Goodness of fit.

UNIT III CORRELATION AND REGRESSION 12

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 12

Analysis of variance – One way and two way classifications – Completely randomized design – Randomized block design – Latin square design - 2^2 Factorial design.

UNIT V MULTIVARIATE ANALYSIS 12

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.

TOTAL: 60 PERIODS

OUTCOMES :

After completing this course, students should demonstrate competency in the following topics:

- Consistency, efficiency and unbiasedness of estimators, method of maximum likelihood estimation and Central Limit Theorem.
- Use statistical tests in testing hypotheses on data.
- Concept of linear regression, correlation, and its applications.
- List the guidelines for designing experiments and recognize the key historical figures in Design of Experiments.
- Perform exploratory analysis of multivariate data, such as multivariate normal density, calculating descriptive statistics, testing for multivariate normality.

The students should have the ability to use the appropriate and relevant, fundamental and applied mathematical and statistical knowledge, methodologies and modern computational tools.

REFERENCES :

1. Gupta.S.C., and Kapoor, V.K.,"Fundamentals of Mathematical Statistics", 12th Edition, Sultan Chand and Sons, 2020.
2. Jay L. Devore, "Probability and statistics for Engineering and the Sciences", 8th Edition, Cengage Learning, 2014.
3. Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics for Engineers", 9th Edition, Pearson Education, Asia, 2016.

4. Johnson, R.A. and Wichern, D. W. “Applied Multivariate Statistical Analysis”, 6th Edition, Pearson Education, Asia, 2012.
5. Rice, J.A. "Mathematical Statistics and Data Analysis", 3rd Edition, Cengage Learning, 2015.

EV4101 ENVIRONMENTAL CHEMISTRY L T P C
3 0 0 3

OBJECTIVES:

- To educate the students in the area of water, air and soil chemistry
- To explain the theoretical basis and observational methods for study of contaminants and interactions in the environment

UNIT I FUNDAMENTALS 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 – Ocean acidification, Chemical kinetics , First order- 12 Principles of green chemistry.

UNIT II AQUATIC CHEMISTRY 11

Water and wastewater 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. black carbon, air quality parameters 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 EMERGING POLLUTANTS 9

Heavy metals-chemical speciation –Speciation of Hg & As- endocrine disturbing chemicals-Pesticides, Dioxins & Furan, PCBs , PAHs and Fluro compounds toxicity- Nano materials, CNT, titania, composites ,environmental applications.

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Students will gain competency in solving environmental issues of chemicals based pollution
CO2: Ability to determine chemicals mobility in aquatic systems
CO3: Ability to identify contaminating chemicals in air and their fate
CO4: Understand the type of soil contaminants and provide remediation
CO5: Identify emerging environmental contaminants including speciation

REFERENCES:

1. Sawyer, C.N., Mac Carty, 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, 5th Edition,2012.
3. Manahan, S.E., "Environmental Chemistry", Ninth Edition, CRC press, 2009.
4. Ronald A. Hites ,"Elements of Environmental Chemistry", Wiley, 2nd Edition,2012.

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	3	1	2	-	2	1
2	2	1	3	3	2	1
3	2	1	2	2	2	1
4	2	1	3	2	2	-
5	2	2	3	2	2	1

EV4102 ENVIRONMENTAL MICROBIOLOGY L T P C
3 0 0 3

OBJECTIVES:

- To provide a basic understanding on microbiology relevant to environmental engineering for candidates.
- To gain knowledge on morphology, behaviour and biochemistry of bacteria, fungi, protozoa, viruses, and algae .
- To understand the microbiology of wastewater, sewage sludge and solid waste treatment processes. And to understand the aspects of nutrient removal and the transmission of disease causing organisms .
- To have an exposure to toxicology due to industrial products and byproducts .

UNIT I FUNDAMENTALS OF MICROBIOLOGY 10

Classification of microorganisms – prokaryotic, eukaryotic, cell structure, characteristics, importance, introduction to water, soil and air borne pathogens and Parasites and their effects on human, animal and plant health, transmission of pathogens, transmissible diseases – bacterial, viral, protozoan, and helminths parasites, concentration and detection of virus. Control of microorganisms preservation of microorganisms, DNA, RNA, replication, recombinant DNA technology, their potential applications and intellectual property rights.

UNIT II MICROBIAL DIVERSITY AND NUTRIENT TURNOVER 10

Distribution of microorganisms in different environments – diversity of microorganisms – fresh and marine, terrestrial – microbes in surface soil, air – outdoor and Indoor, aerosols, bio safety in laboratory – extreme environment – archae bacteria – occurrence in water supplies – problems and control. biogeochemical cycles-nitrogen, carbon, phosphorus, sulphur – Role of Microorganism in nutrient cycle.

UNIT III METABOLISM OF MICROORGANISMS 9

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, disruption in metabolism and disease. biodegradation of organic pollutants

UNIT IV MICROBIOLOGY OF WASTEWATER TREATMENT SYSTEMS 8

Microbiology of biological treatment processes – aerobic and anaerobic, **α**-oxidation, β-oxidation, nitrification and denitrification, eutrophication. nutrients removal – BOD, nitrogen, phosphate. microbiology of sewage sludge - indicator organisms of water – coliforms - total coliforms, E-coli, streptococcus, clostridium, Bioleaching

UNIT V TOXICOLOGY 8

Ecotoxicology – toxicants and toxicity, factors influencing toxicity. Effects – acute, chronic, test organisms – toxicity testing-lab and field testing methods, bioconcentration – Bioaccumulation, biomagnification, bioassay, biomonitoring.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Explain the basic importance and functional elements of environmental microbiology including the potential applications in the environment and intellectual property rights.

CO2 Understand and describe the type of microorganisms in the environment, their importance in water supplies and the role of microorganisms in the cycling of nutrients in an ecosystem.

CO3 Understand the metabolic processes on carbohydrates, protein and lipids, importance of enzymes, production of energy and the various additional metabolic processes.

CO4 Select and apply appropriate methods for assessing the water, air and soil borne pathogens, their health implications, and importance of microbes in aerobic and anaerobic cycles and deterioration of water bodies.

CO5 Conduct testing and research on toxicology, understand the importance of test organisms, environmental applications such as biomagnifications, biomonitoring and in developing risk based standards.

REFERENCES:

1. Bhatia S.C. "Hand Book of Environmental Microbiology", Part 1 and 2, Atlantic Publisher, 2008
2. Gabriel Bitton, Wastewater Microbiology, 2nd Edition, 3. Raina M. Maier, Ian L. Pepper, Charles P. Gerba, "Environmental Microbiology", Academic Press, 2000
4. Volodymyr Ivanov,Environmental Microbiology for Engineers 2nd Edition, CRC Press, 2015, ISBN 9781498702126
5. Nduka Okafor, Environmental Microbiology of Aquatic and Waste systems. Springer Publishers, 2011, ISBN 978-94-007-1459-5
6. Stanley E. Manahan, "Environmental Science and Technology", Lewis Publishers, 2008.
7. Hurst, C.J. Manual of "Environmental Microbiology". 2nd Ed. ASM PRESS, Washington, D.C. ISBN 1-55581 - 199 - X. 2002
8. Frank C. Lu and Sam Kacew, LU"s Basic Toxicology, Taylor & Francis, London 4th Ed, 2002.

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	3	1	2	1	1	1
2	3	1	3	3	2	1
3	3	1	2	1	3	1
4	2	1	2	2	2	2
5	3	2	3	2	2	1

EV4103 PHYSICAL AND CHEMICAL TREATMENT SYSTEMS FOR WATER AND WASTEWATER **L T P C**
3 0 0 3

OBJECTIVE:

- To understand about the various pollutants present in water and wastewater and to choose the respective physico-chemical systems for effective treatment
- To apply the knowledge for municipal, industrial water and wastewater treatment plants and design suitable treatment schemes
- To gain advance knowledge on the emerging environmental issues on treatment systems and conduct research to identify most appropriate treatment schemes

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, nanofiltration, ultrafiltration and 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 III 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 filter – disinfection flow charts– layouts –hydraulic profile ,PID-construction and O&M aspects–case studies, residue management – upgradation of existing plants – recent trends.

UNIT IV 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 V DESIGN OF WASTEWATER TREATMENT PLANTS 10

Design of municipal wastewater treatment units-screens- 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 - flowcharts – layouts – hydraulic profile, PID, construction and O&M aspects – case studies, retrofitting - residue management – upgradation of existing plants – recent trends.

TOTAL: 45 PERIODS

OUTCOME:

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

CO1 Explain the significance of various pollutants present in water, wastewater and develop the kinetics for reactor design

CO2 Choose the relevant physico-chemical systems for effective water and wastewater treatment

CO3 Design the treatment scheme for municipal and industrial water, wastewater to meet the specific needs on residue management and up gradation of existing plants

CO4 Identify environmental issues in the society on wastewater treatment and formulate technical solutions that are economically feasible and socially acceptable

CO5 Conduct research to identify and design most appropriate treatment schemes for the emerging environmental issues on treatment systems in collaboration with municipalities, corporation, pollution control boards and industries

REFERENCES:

1. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
2. Lee, C.C. and Shun dar Lin, "Handbook of Environmental Engineering Calculations", McGraw Hill, New York, 1999.
3. Qasim.S.R., Guang Zhu., “Wastewater Treatment and Reuse” – Volume 1& 2 2018.
4. CPHEEO manual – “Manual for sewerage and sewage treatment systems” – Part A,B,C, Ministry of Urban development, New Delhi,2013.
5. CPHEEO manual – “Manual for water supply and treatment” –Ministry of Urban development, New Delhi, 1999.

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	2	1	3	2	3	1
2	1	1	3	2	3	1
3	1	1	3	2	3	1
4	2	1	3	2	3	1
5	2	2	3	3	3	1

EV4104 WATER TRANSMISSION, WATER DISTRIBUTION AND SEWERAGE SYSTEMS

L T P C
3 0 0 3

OBJECTIVE:

- To educate the students on economic design of water mains, distribution system and sewer networks

UNIT I GENERAL HYDRAULICS 8

Fluid properties; fluid flow – continuity principle, energy principle and momentum principle; frictional head loss in free and pressure flow, minor head losses, carrying capacity– flow measurement. need for transport of water and wastewater and types

UNIT II WATER TRANSMISSION MAINS 9

Planning of water system – design of storage reservoirs - water transmission main design- compound gravity and pumping main; selection of pumps and characteristics curve - economics; specials, jointing, laying and maintenance, water hammer analysis;

UNIT III WATER DISTRIBUTION 9

Service reservoirs-types and design. water distribution pipe networks design, analysis and optimization – appurtenances – corrosion prevention – minimization of water losses – leak detection. plumbing for water supply in high rise buildings. use of computer software in water transmission, water distribution design – EPANET 2.0, LOOP version 4.0, BRANCH,

UNIT IV 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. plumbing for drains in high rise buildings

UNIT V STORM WATER DRAINAGE 9

Necessity- combined and separate system; estimation of storm water runoff - formulation of rainfall intensity duration and frequency relationships- rational methods. use of computer software in sewer design–sewer. SewerCAD, SewerGEMS

TOTAL: 45 PERIODS

OUTCOMES:

- On Completion of the Course the student will be able to

CO1 Understand general hydraulics and need for proper collection and conveyance of water and wastewater

CO2 Design economic diameters of gravity and pumping mains and storage reservoirs

CO3 Design and analysis of water distribution networks and apply computer softwares

CO4 Design sewer networks for various flow conditions

CO5 Design storm water drain and apply computer softwares for design of sewers.

REFERENCES:

1. Pramod R. Bhave, Rajesh Gupta. “Analysis of Water Distribution Networks”, Alpha Science International, 2006
2. Bajwa, G.S. "Practical Handbook on Public Health Engineering", Deep Publishers, Shimla, 2003
3. “Manual on water supply and Treatment”, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
4. “Manual on Sewerage and Sewage Treatment Part-A Engineering”, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	2	-	3	2	2	1
2	1	1	3	3	1	1
3	1	1	3	3	2	1
4	1	1	3	3	1	1
5	1	1	3	3	2	1

RM4151 RESEARCH METHODOLOGY AND IPR L T P C
2 0 0 2

UNIT I RESEARCH DESIGN 6

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys.

UNIT II DATA COLLECTION AND SOURCES 6

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT III DATA ANALYSIS AND REPORTING 6

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

UNIT IV INTELLECTUAL PROPERTY RIGHTS 6

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT V PATENTS 6

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents.

TOTAL :30 PERIODS

REFERENCES

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

EV4111 ENVIRONMENTAL CHEMISTRY LABORATORY L T P C
0 0 4 2

OBJECTIVES:

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

1.	Good Laboratory Practices, Quality control, calibration of Glassware	8
2.	Sampling and Analysis of water (pH, alkalinity, hardness, chloride, Sulphate, turbidity EC, TDS,TS, nitrate, fluoride and Iron)	20
3.	Sampling and Wastewater analysis (BOD, COD, Phosphate, Ammonia, TKN, Oil & Grease, Surfactant and heavy metals)	20
4.	Sampling and characterization of soil (Moisture, EC, pH ,Na and K)	12

TOTAL: 60 PERIODS

OUTCOME:

CO1 : Ability to calibrate and standardize the equipments
CO2 : Abiltiy to collect proper sample for analysis
CO3 : The candidate ability to perform field oriented testing of water, wastewater and soil
CO4 : Able to perform soil testing
CO5 : Able to perform analysis of water and wastewater

REFERENCES:

1. APHA, "Standard Methods for the Examination of Water and Wastewater", 22nd Ed. Washington, 2012.
2. "Laboratory Manual for the Examination of water, wastewater soil Rump", H.H. and Krist, H. – Second Edition, VCH, Germany, 3rd Edition, 1999.
3. "Methods of air sampling & analysis", James P.Lodge Jr(Editor) 3rd Edition, Lewis publishers,Inc,USA,1989.

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	1	-	2	2	1	3
2	1	1	2	2	1	3
3	2	1	3	3	1	1

EV4112 ENVIRONMENTAL MICROBIOLOGY LABORATORY L T P C
0 0 4 2

OBJECTIVE:

- To train the students in the analysis of various microbiological techniques, microbiological analysis, enzyme assay, pollutant analysis and operation of bioreactors.

EXPERIMENTS:

1. Preparation of culture media,
2. Isolation and culturing of microorganisms
3. Microscopical identification of Microorganisms (algae, bacteria and fungi)
4. Measurement of growth of microorganisms,
5. Analysis of air borne microorganisms,
6. Staining of bacteria.

7. Effect of pH, temperature on microbial growth
8. Bacteriological analysis of wastewater (Coliforms, *E.coli, Streptococcus*) – MPN
9. Bacteriological analysis of wastewater (Coliforms, *Streptococcus)* - MF techniques,
10. Effect of Heavy metals on microbial growth.
11. Detection of Anaerobic bacteria (*Clostridium* sp.)
12. Bioreactors (cultivation of microorganisms)

TOTAL: 60 PERIODS

OUTCOMES:

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

CO1 Explain the basic importance and functional elements of environmental microbiology including the types of microorganisms in air, water and soil.

CO2 Understand and describe the type of microorganisms in the environment, their importance and the method of culturing of microorganisms in the laboratory.

CO3 Understand the basic biochemical method of identification of microorganisms and to identify them using microscopial tool.

CO4 Select and apply appropriate methods for detection in the water, air and soil borne pathogens, their health implications, importance of microbes in our daily life.

CO5 Conduct testing and research on toxicology, the importance of test organisms, environmental applications of such microorganisms in toxicological studies and in developing risk based standards.

REFERENCES:

1. APHA, "Standard Methods for the Examination of Water and Wastewater", 22nd Ed. Washington, 2012.
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.

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	1	-	3	2	2	1
2	3	1	2	2	1	1
3	3	2	3	2	2	1

EV4201 BIOLOGICAL TREATMENT PROCESS FOR WASTEWATER L T P C
3 0 0 3

OBJECTIVES:

- To educate the students on the principles and process designs of various treatment systems for wastewater
- To 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 REACTION KINETICS AND BIO REACTORS 9

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 - enzyme kinetics biodegradability assessment - selection of process- reactors- biokinetics - batch reactor - continuous flow stirred tank reactor-plug flow reactor - flow charts, layout, PID, hydraulic profile

UNIT II CONVENTIONAL AEROBIC TREATMENT PROCESSES 9

Design of sewage treatment plant units –activated sludge process and variations - trickling filters- bio-tower- RBC- fluidized bed reactors, aerated lagoons, waste stabilization ponds – natural treatment systems, constructed wetland – nutrient removal systems- disposal options – reclamation and reuse – recent trends.

UNIT III ADVANCED AEROBIC TREATMENT PROCESSES OF WASTEWATER 9

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-case studies

UNIT IV ANAEROBIC TREATMENT OF WASTEWATER 9

Attached and suspended growth process - design of units – UASB – post treatment systems for UASB reactor-anaerobic filters – expanded bed and fluidized bed anaerobic systems - septic tank and soil disposal system - anaerobic baffled reactor – design of nutrient removal systems - anaerobic ammonium oxidation process - recent trends.

UNIT V SLUDGE TREATMENT, OPERATION AND MAINTENANCE 9

Sources and its characteristics-design of sludge management facilities, sludge thickening- sludge digestion - biogas generation- sludge dewatering- mechanical – ultimate residue disposal – recent advances-construction and operational maintenance problems in STPs– trouble shooting – planning, organizing and controlling of plant operations – capacity building - retrofitting case studies

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Understand the microbial process and its kinetics

CO2 Design and size the different components of conventional aerobic treatment systems.

CO3 Design and size the different components of advanced aerobic treatment systems.

CO4 Understand in detail about the anaerobic treatment of wastewater which includes the design of attached and suspended growth processes.

CO5 Design the different elements of sludge treatment systems and understand the importance O&M issues pertaining to biological treatment systems

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 for “Sewerage and Sewage Treatment Systems” CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 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. Qasim, S. R. and Guang Zhu "Wastewater Treatment and Reuse. Theory and Design Examples", 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 York 2011.

CO-PO MAPPING

CO	PO			PSO		
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EV4202 AIR AND NOISE POLLUTION CONTROL ENGINEERING L T P C
3 0 0 3

OBJECTIVE:

- To impart knowledge on types and sources of air pollution, its effects and design of control methods

UNIT I INTRODUCTION 8

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 – Longterm effects– global climate change, Ozone Holes – ambient air quality and emission standards – air pollution indices – emission inventories.

UNIT II AIR POLLUTION MONITORING AND MODELLING 8

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 10

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 10

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; process control and monitoring - operational considerations - costing of APC equipment –emerging trends,

UNIT V AUTOMOBILE AND NOISE POLLUTION 9

Vehicular Pollution: Automobile emission- types of emissions- prevention and control of vehicular pollution.

Noise Pollution: Sources and effects of noise pollution – measurement – standards –control and preventive measures.

Indoor Air Pollution: Sources and effects –control and preventive measures

TOTAL: 45 PERIODS

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 their modeling
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", McGraw 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.

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	2	2	3	3	3	2
2	3	2	3	2	2	2
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5	3	2	3	2	2	2

EV4203 INDUSTRIAL WASTEWATER POLLUTION - PREVENTION AND CONTROL **L T P C 3 0 0 3**

OBJECTIVES:

- To understand the principle of various processes applicable to industrial wastewater treatment
- To impart knowledge on the concept and application of Industrial pollution prevention, cleaner technologies, industrial wastewater treatment and residue management.
- To 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, electro dialysis & 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

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 Apply knowledge and skills to design industrial wastewater treatment schemes

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. "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, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
4. Nelson Leonard Nemerow, " industrial waste Treatment", Elsevier, 2007.
5. Wesley Eckenfelder W., " Industrial Water Pollution Control", Second Edition, Mc Graw Hill, 2000.
6. Paul L. Bishop, Pollution Prevention: - Fundamentals and Practice', Mc-Graw Hill International, Boston, 2000.
7. Waste water Treatment for pollution control and reuse by Soli. J. Arceivala, Shyam. R. Asolekar, Tata Mcgraw Hill, 2007

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	2	2	3	2	2	2
2	3	2	3	2	1	1
3	3	2	3	2	2	3
4	2	3	3	2	2	3
5	3	3	2	2	2	1

EV4211 ENVIRONMENTAL AND PROCESSES MONITORING LABORATORY L T P C
0 0 6 3

OBJECTIVE:

- To develop the skill for conducting treatability studies of water and wastewater and monitoring of ambient air and noise quality

Sl. No.	Name of Experiment	Hours
1.	Coagulation and Flocculation	6
2.	Batch studies on settling	6
3.	Studies on Filtration- Characteristics of Filter media	6
4.	Water softening	6
5.	Adsorption studies/Kinetics	6
6.	Langelier Saturation Index and Silt Density Index- For Membrane Filtration	6
7.	Kinetics of suspended growth process (activated sludge process)-and Sludge volume Index	12
8.	Sludge Filterability Test	6
9.	Anaerobic Reactor systems / kinetics (Demonstration)	6

10.	Advanced Oxidation Processes – (Photo catalysis)	6
11.	Disinfection for Drinking water (Chlorination)	6
12.	Ambient Air Sampling-Determination of PM10, PM2.5, SO_2 and NO_2	12
13.	Noise Monitoring-Determination of Equivalent Noise Level	6
	TOTAL PERIODS	**90**

OUTCOME:

After the completion of the course the students will be able

CO1 To conduct treatability studies on water and wastewater treatment

CO2 To determine the removal / degradation of pollutants from water and wastewater and arrive at kinetics

CO3 To design scaled up reactors for treatment of water and wastewater treatment based on laboratory studies

CO4 To determine ambient air quality of given study area in terms of Particulate and Gaseous Pollutants

CO5 To determine Equivalent Noise Level by noise monitoring

REFERENCES:

1. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
2. Lee, C.C. and Shundar Lin. "Handbook of Environmental Engineering Calculations", Mc Graw Hill, New York, 1999.
3. AEESP Environmental Processes Laboratory Manual, Association of Environmental Engineering and Science Professors Foundation, Washington, 2002.
4. Aery N C., “Manual of Environmental Analysis”, Ane Books Pvt. Ltd. New Delhi, 2014
5. CPCB, Guidelines for the Measurement of Ambient Air Pollutants, Volume I, Central Pollution Control Board, Ministry of Environment and Forests, Government of India, 2001

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	2	1	3	3	2	1
2	3	2	3	2	1	1
3	3	2	3	2	2	2

EV4001 SOLID AND HAZARDOUS WASTE MANAGEMENT L T P C
3 0 0 3

OBJECTIVE

- To impart knowledge and skills relevant to minimization, storage, collection, transport, recycling, processing and disposal of solid and hazardous wastes including the related regulations, engineering principles, design criteria, methods and equipment.

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, 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.

UNIT II 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, C&D wastes and E wastes.

UNIT III 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 - magenetic separation – compaction – principles and design of material recovery facilities – physico chemical treatment of hazardous wastes - solidification and stabilization – case studies on waste collection and material recovery

UNIT IV 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

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 cultural issues 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 the factors affecting variation and assess performance of waste treatment and disposal systems

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

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

CO5 Conduct research pertinent to solid and hazardous waste management and 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 , Government of 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

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	1	1	3	2	3	3
2	2	1	3	2	3	2
3	2	1	3	3	3	1
4	2	2	3	3	2	1
5	3	1	3	3	3	3

EV4002 NATURAL SYSTEMS FOR WASTEWATER TREATMENT L T P C
3 0 0 3

OBJECTIVE

- To gain knowledge and understanding of wetlands -types of wetland, constructed wetland - application, design, method of treatment of both domestic and industrial wastewaters and case studies.
- To gain knowledge on design, construction and operation of waste stabilization pond and sludge disposal.

UNIT I INTRODUCTION TO WETLAND TREATMENT SYSTEM 9

Definition and concept of wetland - types of wetland. Wetland - ecology, flora and fauna, ecological aspects, human health and wetland, onsite applications. introduction to constructed wetland-types-free water surface, subsurface wetland-horizontal and vertical flow- wastewaters and their application in wetland - constructed wetland plants-media – in constructed wetland.

UNIT II CONSTRUCTED WETLAND AND REMOVAL MECHANISMS 9

Site identification- construction and design of constructed wetland, startup, operation and maintenance of wetland system-wetland hydrology- hydraulics. Treatment of domestic wastewater and its performance, mechanisms of pollutant removal- suspended solids, organic matter, nitrogen, phosphorus, pathogen and other contaminants. Reuse of treated wastewater and its applications-limitation of constructed wetland system.

UNITIII CASE STUDIES ON CONSTRUCTED WETLAND SYSTEM 8

Constructed wetland- treatment of domestic wastewater- greywater - landfill leachate – treatment of industrial wastewaters- textile wastewater – dairy wastewater and its performance. Removal of specific pollutants such as heavy metals, aromatics and emerging contaminants etc. Use of amendments in wetland construction, and its performance. Capital and maintenance costs.

UNITIV DESIGN OF WASTEWATER POND SYSTEMS. 10

Introduction- facultative -partial -mix aerated- ponds -complete -mix aerated pond systems - anaerobic ponds -nitrogen removal in lagoons. Modified high -performance aerated pond systems for nitrification and denitrification - nitrogen removal in ponds coupled with wetlands and gravel bed nitrification filters -Control of algae and design of settling basins. Hydraulic control of ponds -removal of phosphorous -removal of pharmaceuticals and personal care products and antibiotic resistant genes.

UNIT V SLUDGE MANAGEMENT AND TREATMENT 9

Sludge quantity and characteristics - stabilization and dewatering -sludge freezing -reed beds - vermi stabilization -comparison of bed type operations -composting land application and surface disposal of bio solids onsite wastewater systems -effluent disposal and reuse. Sludge quantity and characteristics-stabilization and dewatering-sludge freezing reed beds-vermi stabilization-Comparison of bed-type operations-composting land application and surface disposal of biosolids-on-site wastewater systems- effluent disposal and reuse.

TOTAL : 45 PERIODS

OUTCOMES:

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

CO1 Explain the various aspects of wetland system, its function and its application in the treatment of wastewaters

CO2 Apply the knowledge of science and engineering fundamentals to know the types of wetlands, construction and operation of wetlands, wetland hydraulics and design of wetland and its performance Understand the process of treatment of domestic waste in the removal of solids, organic matter, phosphate, nitrogen, pathogens and its reuse

CO3 Understand the process of treatment of industrial wastewater in the removal of solids, organic matter, phosphate, nitrogen, heavy metals, phenolics and feasibility for reuse

CO4 Understand the various pond system available for wastewater treatment. design of pond system -removal mechanism

CO5 Manage and dispose the sludge naturally and economically.

REFERENCES:

1. EPA- Design Manual on constructed wetland and aquatic plant system for municipal wastewater treatment system
2. Treatment wetlands by Robert .H.Kadlec, Scott Wallace , CRC press published July 22, 2008
3. Natural Wastewater Treatment Systems, Ronald W. Crites, E. Joe Middlebrooks, Robert K. Bastia, 2nd Edition, CRC PressPublished March 14, 2014
4. Waste water treatment in constructed wetlands with horizontal sub- surface flow by Jan Vyamazal and Lenka Kropfelova, Springer 2010.
5. Constructed wetlands for industrial wastewater treatment system by Alexandros I.Stefanakis (editor), Wiley black well.2018

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	2	1	3	3	3	1
2	2	1	3	2	3	1
3	3	1	3	3	3	1
4	2	2	3	2	2	1
5	1	1	3	2	2	1

EV4003 ENVIRONMENTAL SYSTEM ANALYSIS L T P C
3 0 0 3

OBJECTIVES:

- To introduce the modelling concept in various environmental field like ecological modelling, CSTR modelling and the kinetics of reaction
- To gain knowledge on river and stream water modelling and soft computing techniques.

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 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

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

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	1	2	3	3	1	1
2	1	1	3	3	1	1
3	2	1	2	2	1	1
4	2	1	3	2	1	1
5	2	2	3	2	2	1

EV4004 ENVIRONMENTAL IMPACT ASSESSMENT L T P C
3 0 0 3

OBJECTIVES:

- To make the students to understand environmental clearance, its legal requirements and to provide knowledge on overall methodology of EIA, prediction tools and models, environmental management plan and case studies.

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. Cross sectoral issues –public hearing in EIA- EIA consultant accreditation.

UNIT II IMPACT INDENTIFICATION AND PREDICTION 10

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 8

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

UNIT V CASE STUDIES 9

Mining, power plants, cement plants, highways, petroleum refining industry, storage & handling of hazardous chemicals, common hazardous waste facilities, CETPs, CMSWMF, building and construction projects

TOTAL: 45 PERIODS

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

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 and Climate 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 recurrent problems, Wiley-Interscience, New Jersey. 2003
5. Lee N. and George C. 2000. Environmental Assessment in Developing and Transitional 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

CO	PO			PSO		
	1	2	3	1	2	3
1	1	1	2	2	3	1
2	1	1	3	2	3	1
3	1	1	2	3	1	1
4	2	3	2	3	2	2
5	3	2	3	2	2	1

EV4005 SEPTAGE AND ONSITE WASTEWATER TREATMENT TECHNOLOGIES L T P C
3 0 0 3

OBJECTIVE:

- To understand on the principles and process designs aspects of onsite sanitation and decentralized wastewater management systems.
- To gain competency in the process employed in sludge and septate management systems and the components comprising such systems, leading to the selection of specific process.

UNIT I URBANIZATION AND SANITATION 9

Sanitation Infrastructure in Urban India - Emerging Recognition of Faecal Sludge and Septage Management -Sanitation Service Chain -Faecal Sludge and Septage -Need for Faecal Sludge and Septage Management -Septage Management and Sewerage Systems -Components of Sanitation Value Chain- Approach to Septage Management in Cities

UNIT II DESLUDGING AND CONVEYANCE OF SEPTAGE 9

Planning for Emptying Services - Current Status of Emptying Services -Need for Periodic Cleaning of Septic Tanks - Prohibition of Employment as Manual Scavengers and their Rehabilitation Act-Technologies for Desludging - Parameters for Assessing Conveyance Options - Demand Based Desludging - Schedule Based Desludging - Private Sector Participation .

UNIT III SEWAGE TREATMENT 9

Unit Operations and Processes – Selection of treatment processes — Onsite sanitation – Septic tank- Grey water harvesting- Decentralized sewage treatment – Design of septic tank with depression pit – DEWATS, Intermittent sand filters – Anaerobic filters – Waste stabilization ponds – Design and operation.

UNIT IV SLUDGE STABILIZATION 9

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

UNIT V 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- Lagooning- Landfilling-land farming-Composting-windrow composting -Vermicomposting -Laws and regulations on sludge management

TOTAL: 45 PERIODS

OUTCOMES:

CO1 Understand the sanitation value chain with challenges and need for addressing septage
CO2 Know about desludging and conveyance of septage
CO3 Plan and implement decentralized sewage treatment scheme
CO4 Understand technology options for sludge stabilization
CO5 Know about the requirements and associated risk while reusing sewage sludge

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. Septage management in urban India, National Urban Sanitation policy, Ministry of Urban Development Government of India, 2013.
4. National Policy on Faecal Sludge and Septage Management (FSSM) Ministry of Urban Development Government of India, 2017
5. A.F. Ismail, Takeshi Matsuura, Membrane Technology for Water and Wastewater Treatment, Energy and Environment, CRC Press, 2016
6. Michael D. Nelson, Chair, Operation of municipal wastewater treatment plants, Water environment federation, vol.2 liquid process.

7. Michael D. Nelson, Chair, Operation of municipal wastewater treatment plants, Water environment federation, vol.1Management and support systems, sixth edition.
8. Arceivala S.J., and Asolekar S.R "Wastewater Treatment for Pollution Control and reuse "McGraw Hill , third Edition, New Delhi, 2007.

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	2	1	2	1	3	1
2	2	1	3	1	2	1
3	2	2	3	1	2	3
4	2	1	3	2	2	2
5	2	1	2	2	3	2

EV4006 SUSTAINABILITY ENGINEERING L T P C
3 0 0 3

OBJECTIVES

- To learn about the principles, indicators and general concept of sustainability.
- To apprehend the local, regional and global impacts of unsustainable designs, products and processes.
- To apply the sustainability concepts in engineering.

UNITI SUSTAINABILITY 9

Introduction to sustainability concepts, the magnitude of the pressures on resources and ecosystems, Roles of engineers in developing sustainable society, Energy, Materials use, Environmental emissions –ozone depletion, global warming, air quality, water quality, wastes in the India – water, air, solid.

UNIT II RISK AND LIFE CYCLE BASED FRAME WORKS FOR SUSTAINABILITY 9

Environmental Risk – Risk assessment, Risk based environmental law, Life cycle – Life cycle assessment, Life cycle based environmental law, Life cycle assessment tools, pollution prevention concepts.

UNIT III SUSTAINABLE MATERIALS 9

Environmental and natural resource use footprints – material extraction and production, material flows in engineered systems, Environmental releases- chemical and physical properties, estimate environmental partitioning, persistence and measures of exposure.

UNIT IV DESIGN FOR SUSTAINABILITY 9

Sustainable engineering design principles, economic performance indicators, environmental performance indicators, social performance indicators, environmental cost analysis

UNIT V CASE STUDIES 9

Sustainable built environments, Biofuels for transportation, electric vehicles, bioplastics,

TOTAL: 45 PERIODS

OUTCOMES

1. Students would be able to quantify sustainability, and resource availability.
2. rationalize the sustainability based on scientific merits
3. Understand and apply sustainability concepts in designs, product developments and processes across various engineering disciplines.
4. To make a decision in applying green engineering concepts.
5. Lifelong advocate of sustainability in society.

REFERENCES

1. Sustainable Engineering concepts, design and case studies, David T. Allen and David R.Shonnard, Prentice hall.
2. Engineering applications in sustainable design and development , Bradley Striebig, Adebayao A.Ogundipe and Maria Papadakis, Cengage Learning; 001 edition (January 1, 2015).

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	1	2	3	1	3	2
2	1	2	2	2	2	1
3	3	1	3	2	3	1
4	2	1	2	2	3	2
5	1	1	3	2	3	1

EV4007 PROJECT FORMULATION AND IMPLEMENTATION L T P C
3 0 0 3

OBJECTIVES:

- To examine the techniques and procedures relevant for project planning and implementation in developing countries, especially infrastructure projects pertaining to environmental sector
- To enable the students to understand about project identification, feasibility analysis, design, financing, implementation, monitoring and evaluation

UNIT I INTRODUCTION TO PROJECT FORMULATION 9

Overview of the project cycle – planning process and project planning – search for project ideas – strategies in capital allocation – key elements in project formulation – methods and tools for project formulation – project identification and selection – preparation of feasibility reports as per government policies (AMRUT / JnNURM)

UNIT II PROJECT ANALYSIS 8

Capital cost estimation – market demand analysis – technical analysis – environmental analysis – financial and economic analysis – cash flow generation

UNIT III PROJECT APPRAISAL 10

Time and value of money – investment criteria – internal rate of return – net present value, cost benefit analysis, and social cost benefit analysis – project risk analysis – appraisal of marketing strategy – pricing and credit worthiness and management capabilities

UNIT IV PROJECT FINACING AND IMPLEMENTATION 10

Funding options for urban and rural development projects – tender procedure – transparency in government tender rules – organizational aspects in project management – network techniques for project management – resource management - risk management

UNIT V PROJECT MONITORING AND EVALUATION 8

Need and techniques for monitoring – service Level benchmark performance and process monitoring – monitoring Schedules – Penalty and Bonus points

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Understand the project cycle, key elements in project formulation, methods and tools for project formulation

CO2 Understand capital cost estimation, market and demand analysis, technical, environmental, financial and economic analysis

CO3 Understand time and value of money, investment criteria, internal rate of return, cost benefit analysis, project risk analysis and appraisal of marketing strategy

CO4 Have knowledge on funding options for urban and rural development projects, tender procedure, transparency, resource management & risk management

CO5 Understand need and techniques for monitoring project performance

REFERENCES:

1. Clifford F Gray, Erik W Larson , "Project Management-The Managerial Process" Tata Mcgraw-Hill Publishing Co Ltd
2. Jack Meredith, Samuel J. Mantel Jr. "Project Management- A Managerial Approach" John Wiley and Sons
3. John M Nicholas "Project Management for Business and Technology" Prentice Hall Of India Pvt Ltd
4. James P Lewis " Project Planning ,Scheduling And Control" Tata McGraw-Hill.
5. Detailed Project Report: Preparation Toolkit (Sub-mission for Urban Infrastructure and Governance), Government of India
6. www.india.gov.in national portal for India

CO-PO MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	3	-	2	3	2	2
2	3	1	3	3	1	1
3	1	1	3	3	1	1
4	1	3	3	3	1	1
5	2	-	3	3	2	1

EV4008 ADVANCED OXIDATION PROCESS L T P C
3 0 0 3

OBJECTIVES:

- To 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
- To understand the fundamentals of advanced oxidation processes (AOPs), photochemistry, ozone chemistry, and its application to AOPs for the detoxification of contaminated water
- To 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 to enhance independent learning and critical thinking skills.

UNIT I INTRODUCTION TO AOPs 8

Introduction to AOPs for water and wastewater treatment – mechanism – photooxidation reactions photocatalytic reactions, photo initiated oxidation – UV- H_2O_2 / ozonation, fenton / photofenton – photocatalysis – light source choice – used in AOPs and their spectral distributions.

UNIT II HOMOGENOUS AOPs 8

Ozone, electro-chemical oxidation, ultrasonication, UV – photolysis, hydrogen peroxide and ultraviolet radiation (H_2O_2 /UV), Fenton and Photo Fenton's oxidation, chemical and non-chemical AOPs, advantages and disadvantages of homogeneous processes.

UNIT III 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 nanomaterials

UNIT IV AOP ENHANCEMENT TECHNIQUES 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 AOPs 10

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

TOTAL: 45 PERIODS

OUTCOME:

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

CO1 Comprehend the basic principles of advanced water treatment processes, capabilities / constraints of their application in water and wastewater treatment
CO2 Apply technical knowledge and skills on the design and operation of AOPs for the water and wastewater treatment
CO3 Design suitable pre-treatment and post treatment schemes, and cleaning protocols for AOPs
CO4 Conduct economic assessment on AOTs for water and wastewater treatment
CO5 Select appropriate AOPs to solve emerging environmental wastewater issues in the society, that are technically sound, economically feasible and socially acceptable

REFERENCES:

1. Cao G., "Nanostructures & Nanomaterials: Synthesis, Properties & Applications", Imperial College Press, 2004.
2. Rose R. M., Shepard L. A.and Wulff J., "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
5. Marta.I.Litter, RobertsJ.Candal,J.Martin Meichtry, "Advanced Oxidation Technologies: Sustainable Solution for Environmental Trearment , CRC,Press, 2014.
6. R.M.Rose, L.A.Shepard and J.Wulff, "The Structure and Properties of Materials", Wiley Eastern Ltd, 1996.

CO-PO MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	1	1	3	3	1	1
2	3	1	3	2	1	1
3	2	3	3	3	1	1
4	1	3	3	1	1	1
5	3	1	3	3	3	3

EV4009 COMPUTING TECHNIQUES IN ENVIRONMENTAL ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- To educate the students to know about the computing techniques used in environmental engineering, and explain the artificial intelligence like ANN, Fuzzy logic and genetic algorithm applications in environmental engineering.

UNIT I SOFT COMPUTING PRINCIPLES 9

Introduction to computing techniques – algorithms and flowcharts, numerical methods - solution to ordinary and partial differential equation using finite difference, finite element and finite volume methods, numerical integration and differentiation.

UNIT II ARTIFICIAL INTELLIGENCE 9

Knowledge based expert system concepts - principle of Artificial Neural Network (ANN) – perceptron learning rule, neural network structure – neural network operations – ANN Algorithm - Application of ANN Model to environmental field – genetic algorithms

UNIT III FUZZY LOGIC 9

Fuzzy logic principles - fuzzy logic and the theory of uncertainty - fuzzy set theory- fuzzy membership function, fuzzy relations, fuzzy rule, and applications of the fuzzy set theory to inference and control, clustering, and image processing.

UNIT IV DIGITAL DATA MANAGEMENT 9

Data base structure - data acquisition - data warehouse - DBMS - RDBMS - data analysis - network data sharing - Statistical Analysis (SYSTAT) - regression - factor analysis - histogram - scatter diagram - goodness of fit – big data analysis.

UNIT V ENVIRONMENTAL MODELING SOFTWARE 9

Introduction to MATLAB Software – MATLAB applications in environmental – pollutants transport, decay and degradation modeling using MIKE 21 – MODFLOW - case studies.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Understand the various computing techniques available for environmental engineering.
CO2 Apply the principles of ANN and GA for solving environmental problems
CO3 Apply the principles of Fuzzy logic and for solving environmental problems.
CO4 Work in the statistical analysis software SYSTAT.
CO5 Employ modern advanced computing tool MATLAB software in environmental studies

REFERENCES:

1. Aliev R. A, and Aliev Rashad, "Soft Computing and its Applications", World Scientific Publications Co. Pte. Ltd. Singapore, 2017.
2. Chepra S. C. and Canele R. P., "Numerical Methods for Engineers", McGraw-Hill, a business unit of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY 10020. 6th Edition 2018.

3. Data-Driven Modeling: Using MATLAB in Water Resources and Environmental Engineering, Springer; 2014 edition.
4. Mathews J. H. and Fink K.D. "Numerical methods using MATLAB", Pearson Education 2018.

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	2	2	3	3	2	2
2	2	2	3	3	2	1
3	1	1	3	3	2	1
4	1	3	3	3	2	2
5	1	2	3	3	1	3

EV4010 GEO-ENVIRONMENTAL ENGINEERING L T P C
3 0 0 3

OBJECTIVES

- To acquires the knowledge on the Geotechnical engineering problems associated with soil contamination.
- To safe disposal of waste and remediate the contaminated soils by different techniques
- To remediate the contaminated ground water thereby protecting environment.

UNIT I INTRODUCTION 8

Emergence of Geo-Environmental engineering, Types of Geo-Environmental problems, inorganic and organic toxic chemicals, composition of soils, soil properties, inorganic and organic geochemistry.

UNIT II CONTAMINANT TRANSPORT AND FATE 10

Transport processes, chemical mass transfer processes, biological processes, contaminant transport and fate modeling, landfill and surface impoundments, in-situ barriers, ground water contamination

UNIT III `SUBSURFACE CONTAMINATION AND WASTE CONTAINMENT 10

Sources and types of contamination, remediation approach, contaminated site characterization, risk assessment and remedial strategy. Vertical and bottom barriers, surface caps, ground water pumping systems, subsurface drains, liner systems.

UNIT IV SOIL REMEDIATION 8

Soil vapour extraction, soil washing, stabilization and solidification, electrokinetic remediation, thermal desorption, vitrification, bioremediation, phytoremediation, soil fracturing.

UNIT V GROUND WATER REMEDIATION 9

Pump and treat, In-situ flushing, permeable reactive barriers, in-situ air sparing monitored natural attenuation, bioremediation.

TOTAL: 45 PERIODS

OUTCOMES

1. Assess the contamination in the soil
2. Understand the current practice of waste disposal
3. To prepare the suitable disposal system for particular waste.
4. Stabilize the waste and utilization of solid waste for soil improvement.
5. Select suitable remediation methods based on contamination

REFERENCES

1. Sharma H.D. and Reddy K.R., "Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies" John Wiley& Sons, Inc., USA, 2004.
2. Yong, R. N., "Geoenvironmental Engineering,Contaminated Soils, Pollutant Fate, and Mitigation" CRC Press, New York, 2001.
3. Reddi L.N. and Inyang, H. I., "Geoenvironmental Engineering, Principles and Applications" Marcel DekkerInc. New York, 2000.

CO-PO MAPPING

CO	PO			PSO		
	1	**2**	**3**	**1**	**2**	**3**
1	2	1	3	2	1	1
2	2	2	3	3	2	2
3	3	1	2	2	1	1
4	3	1	3	3	2	1
5	2	1	2	3	1	1

EV4011 ENVIRONMENTAL MONITORING INSTRUMENTS L T P C
3 0 0 3

OBJECTIVES:

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

UNIT I FUNDAMENTALS 9

Wet chemistry methods and their limitations-instrumental methods, selection of method- precision and accuracy, error in measuring signals- quality control & assurance- sample preservation, sample preparation and analyte isolation.

UNIT II SPECTROSCOPIC METHODS 12

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

UNIT III CHROMATROGRAPHIC METHODS 8

Principles, techniques and applications of GC, GC-MS, high performance liquid chromatography (HPLC) and Ion Chromatography (IC)-hyphenated techniques for environmental contaminant (trace organics) analysis, ICP-MS

UNIT IV ELECTRO AND RADIO ANALYTICAL METHODS 8

Principles, techniques and applications of conductometry, potentiometry, coulometry, AOX Analyzer. amperometry, polarography, electro-capillary analysis, Neutron Activation Analysis (NAA), X-ray Fluorescence (XRF) and X-ray Diffraction (XRD) methods.

UNIT V CONTINUOUS MONITORING INSTRUMENTS 8

Principles, techniques and applications of NDIR analyzer for CO, chemiluminescent analyzer for NOx, fluorescent analyzer for SO_2- particulates analysis- auto analyzer for water quality using flow injection analysis. LIMS.

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Able to select appropriate instrumental method for chemical analysis
CO2: Understand spectroscopic methods of analysis of pollutants
CO3: Select correct method for toxic organics estimation using chromatography methods
CO4: Understand electro and nondestructive methods of analysis
CO5: Familiar with online analyzers

REFERENCES:

1. Willard H. Merritt, L. Dean, D.A. and Settle, F.A. 'Instrumental methods of analysis Edn. Words Worth, New York, 2004.
2. Paul R. Loconto Trace Environmental Quantitative Analysis: Principles, Techniques, and Applications**,** Marcel Dekker; 2nd Edition , 2005,
3. Ewing Instrumental Methods of Chemical Analysis, 5th Edition, McGraw Hill, New York.1985
4. Reeve, R.N., "Introduction to Environmental Analysis", Analytical Techniques in the Sciences, John Wiley & Sons, Chichester, UK, 2002.
5. Barcelo, D.(editor), "Environmental analysis. Techniques, Applications and Quality Assurance", Elsevier, The Netherlands, 1996

CO-PO MAPPING

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	1	**2**	3	**1**	**2**	**3**
1	2	1	3	3	1	1
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3	2	1	2	2	1	1
4	2	1	3	3	2	1
5	3	1	3	3	1	3

EV4012 WATER QUALITY MODELLING L T P C
3 0 0 3

OBJECTIVES:

- To understand the fundamentals of mathematical models and their importance in water quality modelling, and to impart the skills to use water quality modelling software for surface and groundwater quality modelling.

UNIT I MODELLING INSIGHTS 9

Engineers and Mathematical models-Water quality models – historical development - different types of models-- steps in model development - importance of model building.- calibration and verification of models- finite element, finite difference and finite volume methods.

UNIT II POLLUTANT TRANSPORT` 9

Transport phenomena – advection, diffusion, dispersion- contamination transport in surface and subsurface water - Simple transport models –steady state and time variable solutions- conservation of mass, momentum and energy balance, governing equation for contaminant fate and transport

UNIT III SURFACE WATER QUALITY MODELLING 10

Water quality modeling of streams, lakes and estuaries – water quality– model sensitivity – assessing model performance; Models for dissolved oxygen, pathogens and BOD-Streeter Phelp's model for point and distributed sources - modified streeter Phelp's equations. Tropic status assessment.

UNIT IV GROUNDWATER QUALITY MODELLING 9

Groundwater flow and mass transport of solutes – groundwater quality modelling using numerical methods - degradation of organic compounds in sub surface - prediction of contaminant transport and particle tracking -seawater intrusion – basic concepts and modelling.

UNIT V WATER QUALITY MODELLING SOFTWARE 8

Exposure to surface water and groundwater quality modelling software's – MIKE 21, WASP, QUAL2E and MODFLOW – demonstration - case studies.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Know about the principles of water quality modelling.
CO2 Understand the pollutant transport phenomena in surface and groundwater.
CO3 Apply the knowledge of surface water quality modelling to predict the water quality of rivers, lakes and estuary.
CO4 Predict the groundwater contamination transport.
CO5 Predict water quality of surface and sub surface water using numerical solution.

REFERENCES:

1. Steven C. Chapra, "Surface Water Quality Modelling", Tata McGraw-Hill Companies, Inc., New Delhi 2018.
2. "Water Quality Modelling for Rivers and Streams" Authors: Benedini, Marcello, Tsakiris, George, Springer Netherlands 2017.
3. **"**Hydrodynamics and Water Quality**:** Modelling Rivers, Lakes, and Estuaries", Zhen-Gang Ji, John Wiley & Sons, 2018.
4. "Modelling Groundwater Flow and Contaminant Transport By Jacob Bear, A. H.-D. Cheng, Springer Science & Business Media, 2010.
5. "Mathematical Modelling of Groundwater Pollution" Ne-Zheng Sun, Alexander Sun, Springer New York, 2012

CO-PO MAPPING

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EV4013 MARINE POLLUTION AND CONTROL L T P C
3 0 0 3

OBJECTIVES:

- To impart the knowledge about marine and coastal environment, oceanography, and sources, effects and monitoring of marine pollutants.

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 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 – online marine pollution monitoring,

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

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, 2017.
2. Marine Pollution: New Research - Tobias N. Hofer, Nova Publishers, 2018,
3. Laws, E.A., "Aquatic pollution", an introductory text. John Wiley and Sons, Inc., New York, 2000.
4. Practical Handbook of Estuarine and Marine Pollution, Michael J. Kennish, Volume 10 of CRC Marine Science, CRC Press, 1996.

CO-PO MAPPING

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EV4014 **CLIMATE CHANGE AND MODELLING** **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce the emerging concepts of climate modelling 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 - applications in climate change projections

UNIT II IPCC CLIMATE SCENARIOS 9

Intergovernmental PANEL on Climate Change (IPCC) - an overview - key assumptions – Representative Concentration Pathways (RCP 2.6, 4.5, 6.0, 8.5)

UNIT III GLOBAL CLIMATE MODEL AND REGIONAL CLIMATE MODEL 9

Climate model – types of model- General Circulation Models (GCM) - Issues with GCMs - Introduction to RCMs and LAMs - RCMs modellers -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 AND POST PROCESSING 9

Model validation and calibration- evaluating model performance- post processing - introduction to analysis tools - Ferret, R, Grads, IDL, SPSS, ArcGIS - climate change impact - vulnerability assessment-case studies-Adaptation strategies

TOTAL: 45 PERIODS

OUTCOMES

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

CO1: Understand the basics of climate change and variability
CO2: Comprehend the latest IPCC climate scenarios
CO3: Gain in-depth knowledge on climate models
CO4: Downscale of climate scenarios through different modelling techniques, and validate climate models
CO5: Post process the model outputs for climate impact assessment, know about adaptation strategies

REFERENCES:

1. IPCC Fifth Assessment Report, Cambridge University Press, Cambridge, UK, 2013
2. Neelin David J, “Climate Change and Climate Modelling”, Cambridge University Press 2011
3. Kendal McGuffie, Ann Henderson, “A Climate Modelling” Primer 3rd Edition, John Wiley & Sons, Ltd, Chichester, UK 2005
4. Thomas Stocker, “Introduction to Climate Modelling”, Advances in Geophysical and Environmental Mechanics and Mathematics. Springer Publication, 2011
5. David Archer, ‘Global warming-Understanding the forecast’, Blackwell publishing, 2007

CO-PO MAPPING

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EV4015 OPERATION AND MAINTENANCE OF WATER AND WASTEWATER TREATMENT SYSTEMS **L T P C 3 0 0 3**

OBJECTIVE:

- To educate the student on the various operation & maintenance aspects of water treatment systems, sewer systems, sewage treatment plants and effluent treatment plants.

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 incrustation and corrosion - problems in transmission mains- maintenance of pipelines and leakage control- repair method for different types of pipes- preventive and corrective maintenance of water 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 pumping stations- 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 - chemical metering 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 controlling of plant operations – capacity building, case studies of retrofitting- SOP-case studies

TOTAL: 45 PERIODS

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, Central Public Health and Environmental Engineering Organisation, Ministry of Urban Development, Government of India 2013
2. Ministry of Drinking Water and Sanitation, operation and maintenance manual for rural 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

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EV4016 AIR QUALITY MODELLING L T P C
3 0 0 3

OBJECTIVES:

- To introduce the theory of dispersion of air pollution in the atmosphere and major approaches for air pollution modelling and to demonstrate the features of most widely used commercial and freely available air quality models

UNIT I MODELLING AND MODELS 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. Types of air quality models-classification

UNIT II METEOROLOGY AND DISPERSION 11

Chemistry of air Pollutants - atmospheric reactions, sinks for air pollution –transport of air pollutants - meteorological factors for dispersal of air pollutants – meteorological modelling-developing wind rose and pollutant rose diagrams-vertical structure of temperature and stability, mixing height; tall stacks-transport and diffusion of stack emissions –plume segments–flare stack–plume rise equations-Holland's and Brigg's models.

UNIT III EMISSION AND SOURCE DISPERSION MODELS 10

modeling for reactive and nonreactive pollutants, point source-single and multiple sources- area sources, line source models, fixed box models- diffusion models – Gaussian plume derivation-modifications of Gaussian plume equation- Gaussian puff model- emission models-emission factors-long term average-multiple cell model-accuracy and utilization-limitations-air quality mapping

UNIT IV RECEPTOR MODELS AND INDOOR AIR QUALITY MODELS 8

Receptor models- source apportionment studies- CMB model- PMF models; environmental wind tunnel models; indoor air pollutants –mass balance-single compartment-multiple compartments calculation of deposition velocity and Position of Particles-Aerosol-Odours and sick building syndrome-Integrated Models.

UNIT V SOFTWARE PACKAGE APPLICATIONS 8

Commercial air quality models - ADMS, AERMOD, CALINE, CALPUFF, DEGADIS, HYROAD, INDUSTRIAL SOURCE COMPLEX, SCREEN, HYSPLIT, INDEX

TOTAL: 45 PERIODS

OUTCOMES:

- At the end of the course the student will be to

CO1 Concepts and types of models, model development, their applicability and limitations.

CO2 Understand the physicochemical transformation of air pollutants in the atmosphere along with the meteorological influence in dispersion of pollutants.

CO3 Identifies emission source and applies suitable modeling tools to estimate the impact of the pollutants.

CO4 Fetch knowledge on source inventories, model prediction efficiency and potential risk assessment.

CO5 Understand the application of models to predicts the air quality scenarios for different conditions and find suitable mitigation measures.

REFERENCES:

1. Noel de Nevers, "Air Pollution Control Engg"., Mc Graw Hill, New York, 2016.
2. Arthur C.Stern, “Air Pollution (Vol.I – Vol.VIII)”, Academic Press, 2006.
3. Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004
4. John H. Seinfeld and Spyros N. Pandis Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, 2 nd Edition, , 2006,
5. Mark Z. Jacobson Fundamentals of Atmospheric Modeling, 2 nd Edition, 2005,
6. Deaton and Wine Brake, “Dynamic Modeling of Environmental Systems”, Wiley & Sons, 2002.

CO-PO MAPPING

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EV4017 FATE AND REMEDIATION OF EMERGING CONTAMINANTS L T P C

3 0 0 3

OBJECTIVE:

- To impart knowledge on the priority list of emerging contaminants and improve understanding of their sources, occurrence, distribution, existing regulations/policies, analysis and screening techniques, environmental fate, transport, underlying mechanisms, modelling frameworks, ecotoxicity, risk assessment tools and remediation technologies.

UNIT I SOURCES, OCCURRENCE AND REGULATORY REQUIREMENTS 9

Definition - Priority *vs.* emerging contaminants - recent concerns - major groups - examples - properties - sources - occurrence - distribution in soils, groundwater, industrial and municipal wastewaters, aquaculture effluents, freshwater and marine ecosystems, air, food, plants, animals and human blood - existing global regulatory frameworks and policies

UNIT II CHARACTERIZATION AND INSTRUMENTATION 7

Sampling – sample preparation methods – analytical protocols for detection of pharmaceuticals, personal care products, antimicrobials and antibiotics, hormones, phthalate plasticizers and degradation products, surfactants, brominated fire retardants, pesticides and nanoparticles – analytical instruments

UNIT III ENVIRONMENTAL FATE AND TRANSPORT 9

Sorption - leaching - runoff - erosion - volatilization - plant/animal uptake - degradation and transformation - human health and ecological risks - environmental fate modelling frameworks - risk assessment tools - challenges - biomonitoring and biosensors

UNIT IV REMEDIATION TECHNOLOGIES 13

Incineration - sonolysis - multi-phase extraction - permeable reactive barrier - advanced oxidation processes - membrane based separation - nanofiltration - Reverse osmosis - biosorption - bioaugmentation - combined treatment options - remediation endpoints - challenges - opportunities

UNIT V CASE STUDIES 7

Occurrence in different environmental compartments - environmental fate and transport - potential and known risks to human health and the environment - effective technological and policy approaches to prevent, control and remove emerging pollutants in the environment

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Explain about the different kinds of emerging contaminants, their sources, occurrence, distribution in different environmental compartments and existing regulations/policies

CO2 Explain about the analytical techniques for the detection of emerging contaminants in environment

CO3 Explain about the environmental fate, behaviour, underlying mechanisms, human health and ecological risks of emerging contaminants, and will be able to monitor and assess the degree of environmental contamination by emerging pollutants

CO4 Select an appropriate single and/or integrated physical, chemical and/or biological clean-up option for environments contaminated with different classes of emerging pollutants in order to achieve the target remedial endpoints

CO5 Conduct independent research in the future pertinent to emerging contaminant pollution and remediation

REFERENCES:

1. Alok Bhandari, Rao Y. Surampalli, Craig D. Adams, Pascale Champagne, Say Kee Ong, R. D. Tyagi and Tian Zhang, Contaminants of Emerging Environmental Concern, American Society of Civil Engineers, US, 2009.
2. Caitlin H. Bell, Margaret Gentile, Erica Kalve, Ia Ross, John Horst and Suthan Suthersan, Emerging Contaminants Handbook, CRC Press, US, First edition, 2018.
3. Damia Barcelo and Mira Petrovic, Emerging Contaminants from Industrial and Municipal Waste Removal Technologies, Springer, Germany, 2012.
4. Damia Barcelo, Emerging Organic Contaminants and Human Health, Springer, Germany, 2012.
5. Francisco G, Calvo-Flores, Joaquin Isac-Garcia, Jose A. Dobado, Emerging Pollutants: Origin, Structure and Properties, Wiley & Sons, US, 2018.
6. Giusy Lofrano, Emerging Compounds Removal from Wastewater Natural and Solar Based Treatments, Springer, Germany, 2012

CO-PO MAPPING

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EV4018 ENVIRONMENTAL REACTION ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- To gain an understanding of the fundamentals of chemical reaction engineering with a focus on chemical reaction rates and reaction mechanisms. The course will cover mole balances, rate laws, chemical kinetics, and reactor design. These principles can be applied to any environmental system where chemical transformations must be described.

UNIT I PRINCIPLES OF REACTION ENGINEERING 9

Classification of reactions, reaction rate, variables affecting reaction rate, speed of chemical reactions. Reaction engineering principles of chemical treatment – chemical reactions in major treatment technologies, incineration, selective catalytic reduction. Wet- gas scrubbing - H_2S

UNIT II KINETICS OF HOMOGENOUS REACTIONS 9

Simple reactor types, the rate equation, concentration dependent term of rate equation. Molecularity and order of reaction. Rate constant k, representation of an elementary and nonelementary reaction. Kinetic models for nonelementary reactions. Testing kinetic models. Temperature dependent term of rate equations from Arrhenius theory and comparison with collision and transition state theory. Activation energy and temperature dependency.

UNIT III REACTOR ANALYSIS 8

Reactor concepts, ideal reactors, reaction rate measurements, sequencing batch reactor, reactors in series and reactors in recycle. non-ideal reactor behaviour, RTD analysis

UNIT IV MASS TRANSFER AND ITS APPLICATIONS 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-adsorption.

UNIT V BIOLOGICAL REACTION ENGINEERING 10

Kinetics of cell growth and enzymes. cell growth kinetics; substrate uptake and product formation in microbial growth; enzyme kinetics, Michaelis-Menten rate form.-biological kinetics, aerobic processes-anaerobic processes - anaerobic digestion, anaerobic filters, Up flow anaerobic sludge blanket reactor. bio concentration, bioaccumulation, bio magnification, bioassay, bio monitoring. bio scrubbers, bio trickling filters and their applications. vermi technology, methane production, root zone treatment, membrane technology.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1 Successfully apply advanced concepts of reaction engineering to identify, formulate, and solve complex environmental engineering problems
CO2 Understand interaction of pollutants in environment
CO3 Understand reactor behavior and transformation of contaminants
CO4 Conceptualize mass transport phenomina
CO5 Apply reaction engineering concept in biological treatment system

REFERENCES:

1. Weber, W.J and Di Giano, F.A., "Process Dynamics in Environmental systems", John Wiley sons Inc, 1996.
2. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
3. Dunn I.J, Elmar Heinzle, John Ingham, Prenosil J.E, " Biological reaction engineering", Wiley inter science, 2005.
4. The Engineering of Chemical reactions by Lanny.D.Schmidt,Oxford University Press , 1997.

CO-PO MAPPING

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EV4019 MEMBRANE SEPARATION FOR WATER AND WASTEWATER TREATMENT **L T P C**
3 0 0 3

OBJECTIVE

- To introduce the principles and design of different membrane separation technologies including microfiltration, ultrafiltration, nanofiltration, reverse osmosis, electrodialysis and membrane bioreactor processes for water and wastewater treatment.

UNIT I MEMBRANE FILTRATION PROCESSES **10**

Membrane filtration for solid Liquid separation - cross flow filtration - theory of membrane separation – mass transport characteristics - concentration polarisation – membrane flux and trans membrane pressure -types and choice of membranes- porous, nonporous, symmetric and assymmetric – 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 - design and applications of low pressure membrane technology systems-microfiltration and ultrafiltration- design and applications of diffusive membrane technologies- nanofiltration and reverse osmosis - – electro dialysis : Ion exchange membranes, 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- fouling and fouling control- case studies

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- pretreatment by sand and membrane filtration- monitoring of pretreatment –chemical cleaning systems- biofoulant control – post treatment systems

UNIT V CASE STUDIES **9**

Case studies on the design of membrane based water and wastewater treatment systems – zero liquid effluent discharge plants – desalination of brackish water and seawater – project implementation and project economics – environmental issues –reject management -energy recovery systems

TOTAL: 45 PERIODS

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. Anthony Wachinski, Membrane Processes for water reuse, McGraw-Hill, Newyork, 2013
3. Nikolay Voutchkov, Desalination Engineering-Planning and Design, McGraw-Hill, Newyork, 2013
4. Symon Jud, MBR Book – "Principles and application of MBR in water and wastewater treatment", Elservier, 2010.
5. A.F. Ismail, Takeshi Matsuura, Membrane Technology for Water and Wastewater Treatment, Energy and Environment, CRC Press, 2016
6. Kaustubha Mohanty, Mihir K. Purkait, Membrane Technologies and Applications, CRC Press, 2011
7. Baker, R.W., "Membrane technology and applications", 2nd ., John Wiley 2012
8. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse fourth Edition, McGraw-Hill, 2017

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AUDIT COURSES

AX4091 ENGLISH FOR RESEARCH PAPER WRITING L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING 6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first-time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 – Understand that how to improve your writing skills and level of readability
CO2 – Learn about what to write in each section
CO3 – Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

AX4092 DISASTER MANAGEMENT L T P C
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 6

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA 6

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster
CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi,2001.

AX4093 CONSTITUTION OF INDIA L T P C
2 0 0 0

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION
History, Drafting Committee, (Composition & Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION
Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES
Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE
Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION
District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION
Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES
Students will be able to:
- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

SUGGESTED READING
- The Constitution of India,1950(Bare Act),Government Publication.
- Dr.S.N.Busi, Dr.B. R.Ambedkar framing of Indian Constitution,1st Edition, 2015.
- M.P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis,2014.
- D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

AX4094 நற்றமிழ் இலக்கியம் **L T P C**
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UNIT I சங்க இலக்கியம் **6**

1. தமிழின் துவக்க நூல் தொல்காப்பியம்
   – எழுத்து, சொல், பொருள்
2. அகநானூறு (82)
   - இயற்கை இன்னிசை அரங்கம்
3. குறிஞ்சிப் பாட்டின் மலர்க்காட்சி
4. புறநானூறு (95,195)

- போரை நிறுத்திய ஔவையார்

UNIT II **அறநெறித் தமிழ்** **6**

1. அறநெறி வகுத்த திருவள்ளுவர்
   - அறம் வலியுறுத்தல், அன்புடைமை, ஒப்புரவறிதல், ஈகை, புகழ்
2. பிற அறநூல்கள் - இலக்கிய மருந்து
   – ஏலாதி, சிறுபஞ்சமூலம், திரிகடுகம், ஆசாரக்கோவை
   (தூய்மையை வலியுறுத்தும் நூல்)

UNIT III **இரட்டைக் காப்பியங்கள்** **6**

1. கண்ணகியின் புரட்சி
   - சிலப்பதிகார வழக்குரை காதை
   சமூகசேவை இலக்கியம் மணிமேகலை
   - சிறைக்கோட்டம் அறக்கோட்டமாகிய காதை

UNIT IV **அருள்நெறித் தமிழ்** **6**

1. சிறுபாணாற்றுப்படை
   - பாரி முல்லைக்குத் தேர் கொடுத்தது, பேகன் மயிலுக்குப் போர்வை கொடுத்தது, அதியமான் ஔவைக்கு நெல்லிக்கனி கொடுத்தது, அரசர் பண்புகள்
2. நற்றிணை
   - அன்னைக்குரிய புன்னை சிறப்பு
3. திருமந்திரம் (617, 618)
   - இயமம் நியமம் விதிகள்
4. தர்மச்சாலையை நிறுவிய வள்ளலார்
5. புறநானூறு
   - சிறுவனே வள்ளலானான்
6. அகநானூறு (4) - வண்டு
   நற்றிணை (11) - நண்டு
   கலித்தொகை (11) - யானை, புறா
   ஐந்திணை 50 (27) - மான்
   ஆகியவை பற்றிய செய்திகள்

UNIT V **நவீன தமிழ் இலக்கியம்** **6**

1. உரைநடைத் தமிழ்,
   - தமிழின் முதல் புதினம்,
   - தமிழின் முதல் சிறுகதை,
   - கட்டுரை இலக்கியம்,
   - பயண இலக்கியம்,
   - நாடகம்.
2. நாட்டு விடுதலை போராட்டமும் தமிழ் இலக்கியமும்,
3. சமுதாய விடுதலையும் தமிழ் இலக்கியமும்,
4. பெண் விடுதலையும் விளிம்பு நிலையினரின் மேம்பாட்டில் தமிழ் இலக்கியமும்,
5. அறிவியல் தமிழ்,
6. இணையத்தில் தமிழ்,
7. சுற்றுச்சூழல் மேம்பாட்டில் தமிழ் இலக்கியம்.

TOTAL: 30 PERIODS

தமிழ் இலக்கிய வெளியீடுகள் / புத்தகங்கள்

1. தமிழ் இணைய கல்விக்கழகம் (Tamil Virtual University) - www.tamilvu.org
2. தமிழ் விக்கிப்பீடியா (Tamil Wikipedia) -https://ta.wikipedia.org
3. தர்மபுர ஆதீன வெளியீடு
4. வாழ்வியல் களஞ்சியம் - தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்
5. தமிழ்கலைக் களஞ்சியம் - தமிழ் வளர்ச்சித் துறை (thamilvalarchithurai.com)
6. அறிவியல் களஞ்சியம் - தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்