ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M. Sc. ENVIRONMENTAL SCIENCE (2 YEARS)

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOS):

To provide the science graduates with a high level of technical expertise in Environmental Science so that they are able to successfully apply the knowledge to

- recognize the processes that influence the magnitude and routes of exposure to environmental agents, factors, and stressors of chemical, physical, biological and ergonomic origin that pose adverse effects.
- Assess the potential environmental impact of development projects and design mitigation measures
- apply the scientific principles, instrumentation, and techniques to adequately evaluate exposures to environmental agents, factors, or stressors
- organize and interpret environmental data using qualitative and quantitative methods
- recommend, operate and evaluate controls to avoid, reduce or eliminate pollution
- conduct research to identify, abate, and eliminate hazards that affect people, wildlife, and their environments.

PROGRAMME OUTCOMES (POS):

By the time of their graduation, the students are expected to be able to :

- Understand the physical, chemical and biological components of Earth's environment, the ecological concepts, principles, processes including human and natural disturbances that impact the environment
- Assess the potential environmental impact of development projects and design mitigation measures
- design and conduct experiments, as well as to analyze and interpret data through laboratory and field exercises
- Interpret and apply applicable and emerging environmental regulations, standards, and best practices
- apply the scientific knowledge and analytical skills to protect environmental resources effectively
- monitor waste disposal sites, preserve water supplies, and reclaim contaminated land and water to comply with environmental regulations.
- design and conduct experiments, as well as interpret data and communicate effectively
- find professional level employment or pursue higher studies

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CURRICULA AND SYLLABI

SEMESTER – I

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	ES7101	Air Quality Management	PC	3	3	0	0	3
2.	ES7102	Microbiology of Environment	FC	3	3	0	0	3
3.	ES7103	Numerical and Statistical Methods	FC	3	3	0	0	3
4.	ES7104	Principles of Water and Wastewater Treatment	PC	3	3	0	0	3
5.	ES7105	Solid and Hazardous Waste Management	PC	3	3	0	0	3
6.		Elective I	PE	3	3	0	0	3
PRACTICAL								
7.	ES7111	Environmental Microbiology Laboratory	PC	4	0	0	4	2
			TOTAL	**22**	**18**	**0**	**4**	**20**

SEMESTER – II

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	ES7201	Chemistry of Environment	FC	3	3	0	0	3
2.	ES7202	Environmental Biotechnology	PC	3	3	0	0	3
3.	ES7203	Environmental Impact Assessment	PC	3	3	0	0	3
4.	ES7204	Environmental Policies and Legislations	PC	3	3	0	0	3
5.	ES7205	Operation and Maintenance of water and wastewater treatment Plants	FC	3	3	0	0	3
6.		Elective II	PE	3	3	0	0	3
PRACTICAL								
7.	ES7211	Environmental Chemistry Laboratory	PC	4	0	0	4	2
			TOTAL	**22**	**18**	**0**	**4**	**20**

SEMESTER - III

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	ES7301	Environmental Analytical Techniques	PC	3	3	0	0	3
2.	ES7302	Renewable energy	PC	3	3	0	0	3
3.	ES7303	Sustainable Ecosystems	PC	3	3	0	0	3
4.		Elective III	PE	3	3	0	0	3
5.		Elective IV	PE	3	3	0	0	3
PRACTICAL								
6.	ES7311	Industrial Training	EEC	0	0	0	0	1
7.	ES7312	Seminar	EEC	4	0	0	4	2
			TOTAL	**19**	**15**	**0**	**4**	**18**

SEMESTER - IV

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Elective V	PE	3	3	0	0	3
2.		Elective VI	PE	3	3	0	0	3
PRACTICAL								
3.	ES7411	Project Work	EEC	24	0	0	24	12
			TOTAL	**30**	**6**	**0**	**24**	**18**

TOTAL NO. OF CREDITS: 76

FOUNDATION COURSES (FC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Numerical and Statistical Methods	FC	4	4	0	0	4
2.		Microbiology of Environment	FC	3	3	0	0	3
3.		Chemistry of Environment	FC	3	3	0	0	3
4.		Operation and maintenance of treatement plants	FC	3	3	0	0	3

PROFESSIONAL CORE (PC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Principles of water and wastewater treatment systems	PC	3	3	0	0	3
2.		Air Quality management	PC	3	3	0	0	3
3.		Environemental Biotechnology	PC	3	3	0	0	3
4.		Solid and Hazardous Waste Management	PC	3	3	0	0	3
5.		Environmental Chemistry practicals	PC	4	0	0	4	2
6.		Environmental Policies and Legislations	PC	3	3	0	0	3
7.		Environmental Impact Assessment	PC	3	3	0	0	3
8.		Renewable energy	PC	3	3	0	0	3
9.		Environmental Nano science and Technology	PC	3	3	0	0	3
10.		Sustainable Ecosystems	PC	3	3	0	0	3
11.		Environmental Microbiology practicals	PC	4	0	0	4	2

PROFESSIONAL ELECTIVES (PE)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	ES7001	Biodiversity and Conservation	PE	3	3	0	0	3
2.	ES7002	Climate Change Modeling	PE	3	3	0	0	3
3.	ES7003	Disaster Management and Mitigation	PE	3	3	0	0	3
4.	ES7004	Ecological Remediation	PE	3	3	0	0	3
5.	ES7005	Industrial and Environmental Toxicology	PE	3	3	0	0	3

6.	ES7006	Industrial hygiene and safety	PE	3	3	0	0	3
7.	ES7007	Industrial wastewater pollution- prevention and control	PE	3	3	0	0	3
8.	ES7008	Marine Resources Management	PE	3	3	0	0	3
9.	ES7009	Remote sensing and GIS for Environmental Sciences	PE	3	3	0	0	3
10.	ES7010	Tertiary wastewater treatment systems	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Industrial Training	EEC		0	0	0	1
2.		Seminar	EEC	4	0	0	4	2
3.		Project Work	EEC	24	0	0	24	12

ES7101 AIR QUALITY MANAGEMENT L T P C
3 0 0 3

OBJECTIVES

- To impart knowledge on the principles and design of control of indoor/particulate/gaseous air pollutant and its emerging trends
- Control of particulates, NOx, SOx, Hydrocarbons and CO • Air pollutants and global climate.

UNIT I INTRODUCTION 10

Structure and composition of Atmosphere – Definition- Scales of Air Pollution Problems - Sources and classification of air pollutants - Effects of air pollutants on human health, vegetation and animals, Materials and Structures – Effects of air Pollutants on the atmosphere, Soil and Water bodies – Long-term effects on the planet – Global Climate Change - Ozone Holes – Ambient Air Quality and Emission Standards – Air Pollution Indices – Emission Inventories – Ambient and Stack Sampling and Analysis of Particulate and Gaseous Pollutants.

UNIT II MEASUREMENT AND MONITORING OF AIR POLLUTION 5

Ambient air sampling systems for particulate and gaseous pollutants – Analysis and Measurement of Particulate and gaseous pollutants, odours, visibility – Air Pollution Monitoring and Surveillance.

UNIT III AIR POLLUTION MODELLING 10

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

UNIT IV CONTROL OF PARTICULATE AND GASEOUS POLLUTANTS 12

Working principles of various types of particulate control equipment – settling chamber, cyclone separators and scrubbers, fabric filters and electrostatic precipitators - Working principles of various types of gaseous pollutant equipment – incineration, absorption, adsorption, condensation and bio filters – Case Studies for Stationary and Mobile Sources.

UNIT V INDOOR AIR QUALITY MANAGEMENT 8

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

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- Suggest suitable air pollution prevention equipments and techniques for various gaseous and particulate pollutants to Industries.
- Discuss the emission standards.
- Apply control and preventive measures of Indoor air pollutants.

REFERENCES

1. Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, Air Pollution Control Engineering, Tokyo, 2004.
2. Noel de Nevers, Air Pollution Control Engineering, Mc Graw Hill, New York, 1995.
3. David H.F. Liu, Bela G. Liptak „Air Pollution", Lweis Publishers, 2000.
4. Anjaneyulu. Y, "Air Pollution & Control Technologies", Allied Publishers (P) Ltd., India, 2002.
5. Arthur C.Stern, "Air Pollution (Vol.I – Vol.VIII)", Academic Press, 2006.
6. Wayne T.Davis, "Air Pollution Engineering Manual", John Wiley & Sons,Inc.,2000.
7. Daniel Vallero "Fundamentals of Air Pollution", Fourth Edition,2008.
8. Kenneth Wark,Cecil Francis Warner,"Air Pollution:Its Origin and Control" Third edition,1998.

ES7102 MICROBIOLOGY OF ENVIRONMENT L T P C
3 0 0 3

OBJECTIVE

- To educate the students in the area of air, water and soil microbiology and the applications of microorganisms in wastewater treatment and reclamation of pollutants.

UNIT I INTRODUCTION 5

Classification and Culturing of microorganisms, Isolation of microorganisms – Pure culture technique – Enrichment culture –Preservation of microorganisms – Identification – Biochemical and Molecular Biology Techniques - Microbial nutrition – Carbon, nitrogen, sulfur – Effective Microbial Solution.

UNIT II MICROBIAL PHYSIOLOGY 10

Microbial enzymes – Classification, Chracteristics, Nomenclature, nature and metabolism of enzyme action, Regulation of enzymes – Principles of Bioenergetics – Respiration – aerobic, Anaerobic – Energy production by aerobic processes – Biochemical Calculations.

UNIT III MICROBIOLOGY OF ENVIRONMENT 10

Distribution of microorganisms in contaminated sites - soil, air, water – Interaction of Microorganisms - Characteristics – Factors affecting Microbial Population –Algae in water supply systems – Problems and control –– Extremophiles – Adaptation and survival.

UNIT IV MICROBIOLOGY OF WASTEWATER TREATMENT 10

Microbial Growth Kinetics - Pollutants in Wastewater – Organic, inorganic –– ά-oxidation, βoxidation, nitrification, denitrification – Degradation of toxic pollutants.

UNIT V APPLICATION OF MICROORGANISMS FOR RECLAMATION 10

Microorganisms as sources of protein – Biofertilizer – Bacterial, fungal, algal – Biocontrol agents – Enzyme production by microorganisms, chemotherapeutic agents – Redox reactions in Microbial degradation of macromolecules – Soil, water and air.

TOTAL: 45 PERIODS

OUTCOME

On completion of the course, the candidate will be able to:

- Acquire knowledge on the distribution of microorganisms in various environment and the mechanisms involved in remediating the pollutants.

REFERENCES

1. Maier.R.M., Pepper I.L. and Gerba C.P., Environmental Microbiology Academic Press Inc.-1999.
2. Pelczar, Jr.M.J., Chan., E.C.S., Krieg, R.Noel and Pelczar Merna Foss, Microbiology, 5th Edn., Tata Mc Graw Hill Publishing company Ltd., New Delhi 1996.
3. Dubey, R.C. and Maheshwari, D.K. A text book of Microbiology, Chand and Company Ltd., New Delhi – 2002.

ES7103 NUMERICAL AND STATISTICAL METHODS L T P C
3 0 0 3

OBJECTIVE

- To learn about the concept of linear equations, integration, differentiation and statistical techniques.

UNIT I SYSTEM OF LINEAR EQUATIONS AND INTERPOLATION 9

Simultaneous linear equations - Direct method - Gauss elimination,Gauss - Jordan methods - Iterative method - Jacobi and Gauss-eidal methods. Difference table - Newton‟s forward and backward interpolation - Newton‟s divide differences - Lagrangian interpolation**.**

UNIT II NUMERICAL INTEGRATION AND ORDINARY DIFFERENTIAL EQUATIONS 9

Numerical integration - Trapezoidal and Simpson‟s 1/3 rules. Taylor series and Euler methods - Runge - Kutta method of fourth order - Miline‟s Predictor - Corrector method.

UNIT III EMPIRICAL STATISTICS 9

Description of discrete and continuous data - Measures of Central tendency and dispersion for grouped and ungrouped data - Skewness and Kurtosis.

UNIT IV ESTIMATION THEORY 9

Unbiased Estimators - Maximum Likelihood Estimation - Method of Moments - Curve fitting by Principle of least squares - Linear Correlation and Regression.

UNIT V TESTING OF HYPOTHESES 9

Statistical hypotheses - Type I and Type II errors - Tests based on Normal, t, χ^2 and F distributions for testing mean, variance and proportions - Tests for Independence of attributes and Goodness of fit.

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- Understand graphical methods of describing data sets and be able to calculate and interpret numerical descriptive statistical measures.
- Understand the concept of sampling distribution of a statistic and be able to calculate the sampling distribution for simple sampling situations.

REFERENCES

1. Grewal ,B.S. and Grewal ,J.S. ,"Numerical methods in Engineering and Science", 6th Edition, Khanna Publishers , New Delhi ,2002.
2. Gupta, S. C. and Kapoor, V. K., "Fundamentals of Mathematical Statistics", 11th Edition Sultan Chand & Sons, New Delhi, 2002.
3. Balagurusamy ,E," Numerical Methods ", Tata Mc Graw Hill Pub.Co. Ltd, New Delhi, 1999.
4. Seymour Lioschutz and John Schiller, "Introduction to Probability and Statistics", Schaum‟s outlines, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2005.
5. Walpole,R.E. and Myers R.H, Myers ,S.L. and Ye, K," Probability and Statistics for Engineers and Scientists ", Pearson Education, Asia, 8th Edition, 2007.

ES7104 PRINCIPLES OF WATER AND WASTEWATER TREATMENT L T P C
3 0 0 3

OBJECTIVES

- To educate the students on the principles and process designs of various treatment systems for water and wastewater.
- Introduce unit operations and processes employed in the treatment of water and wastewater.
- Develop an understanding of the characteristics of water and wastewater that must be considered during design of a treatment plant.

UNIT I INTRODUCTION 5

Pollutants in water and wastewater – characteristics, standards for performance – Selection criteria-types of reactors - Significance and need for treatment- unit operations and unit processes Legislation.

UNIT II PRINCIPLES OF TREATMENT 10

Physical treatment principles - screening, skimming, floatation – mixing, equalization, sedimentation, filtration – gas transfer – adsorption – Isotherms –membrane separation – stripping - coagulation flocculation –– disinfection, Ion exchange –– principles of biological treatment – aerobic and anaerobic treatment - kinetics of biological growth – attached and suspended growth.

UNIT III DESIGN OF WATER TREATMENT PLANTS 10

Design of treatment plant units – selection of process - upgrading existing plants – ultimate residue disposal - aerators – chemical feeding – Clari-flocculator – filters – rapid sand filters, pressure filter, dual media filters – disinfectors- design of softeners – demineralisers –reverse osmosis plants – process flow chart Layout for treatment plants.

UNIT IV DESIGN OF WASTEWATER TREATMENT PLANTS 12

Design of treatment units - screens- grit chamber - settling tanks - design of aerobic treatment systems - activated sludge process and variations, sequencing batch reactors, membrane biological reactors-trickling filters-Bio Tower - aerated lagoons – natural treatment systems, waste stabilization ponds, constructed wet land – Disinfection – reclamation and reuse – recent trends – Design of anaerobic treatment system - UASB, up flow filters, septic tanks – Nutrient removal systems - process flow chart Layout for treatment plants.

UNIT V RESIDUAL MANAGEMENT 8

Design of sludge management facilities, sludge thickening, sludge digestion, biogas generation, sludge dewatering -mechanical and gravity - sludge drying beds - Sludge disposal.

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- Design the water and wastewater treatment plant with various capacity.
- Know the concept of residue management.

REFERENCES

1. Metcalf and Eddy, Wastewater Engineering, Treatment and Reuse, Tata McGraw Hill, New Delhi, 2003.
2. Qasim, S.R., Motley, E.M. and Zhu.G. Water works Engineering – Planning, Design and Operation, Prentice Hall, New Delhi, 2002.
3. Manual on “Sewerage and Sewage Treatment” CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1993.
4. Qasim, S.R. Wastewater Treatment Plant, Planning, Design & Operation, Technomic Publications, New York, 1994.
5. Manual on Water Supply and Treatment, CPHEEO, Govt. of India, New Delhi (2003).

ES7105 SOLID AND HAZARDOUS WASTE MANAGEMENT L T P C

3 0 0 3

OBJECTIVE

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

UNIT I SOURCES, CLASSIFICATION AND REGULATORY FRAMEWORK 9

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

UNIT II WASTE CHARACTERIZATION AND SOURCE REDUCTION 8

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

UNIT III STORAGE, COLLECTION AND TRANSPORT OF WASTES 9

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

UNIT IV WASTE PROCESSING TECHNOLOGIES 10

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

UNIT V WASTE DISPOSAL 9

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

TOTAL: 45 PERIODS

OUTCOME

On completion of the course, the candidate will be able to:

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

REFERENCES

1. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, "Integrated Solid Waste Management, Mc-Graw Hill International edition, New York, 1993.
2. Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans and Environmental Resources Management, Hazardous waste Management, Mc-Graw Hill International edition, New York, 2001.
3. CPHEEO, "Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organisation , Government of India, New Delhi, 2000.
4. Vesilind P.A., Worrell W and Reinhart, Solid waste Engineering, Thomson Learning Inc. Singapore, 2002.
5. Paul T Williams, Waste Treatment and Disposal, Wiley, 2005.

ES7111 ENVIRONMENTAL MICROBIOLOGY LABORATORY L T P C
0 0 4 2

OBJECTIVE

- To educate and train the students in experiments related to microbiological analysis of air, water, soil and wastewater.

Sl.No	List of experiments	Name of the Equipment
1.	Study of instruments and equipments used in the Microbiology Laboratory.	-
2.	Preparation of culture media	Autoclave
3.	Isolation and enumeration of microorganisms from air.	Autoclave, Incubator
4.	Isolation and Enumeration of microorganisms from water	Autoclave, Incubator, Laminar air flow chamber
5.	Isolation and Enumeration of microorganisms from soil	Autoclave, Incubator, Laminar Air flow Chamber
6.	Determination of growth curve of bacteria	Calorimeter
7.	Identification of bacteria by staining techniques	Microscope
8.	Effect of Heavy metals on microbial growth.	-
9.	Effect of temperature and pH on growth of microorganisms	Autoclave, Calorimeter
10.	Enumeration of Total coliforms and Faecal Coliforms by MPN technique.	Autoclave, Incubator, laminar Air flow Chamber
11.	Enumeration of coliforms by Membrane Filter Technique	Membrane Filter Assembly, Incubator
12.	Enumeration of Streptococcus faecalis.	Incubator
13.	Detection of Anaerobic bacteria	-
14.	Estimation of DNA by spectrophotometer.	Gel Electrophoresis Unit

TOTAL: 60 PERIODS

OUTCOME

On completion of the course, the candidate will be able to:

- Know the various techniques for the analysis of samples for microorganisms from different environments and also to identify the various microorganisms.

REFERENCES

1. Sukyta, B. Techniques in Applied Microbiology, Elsevier Science Publication, New York, USA 1995.
2. Standard methods for the examination of water and wastewater, American Public Health Association (21st edition) 2005.
3. Charles P. Gerba, Environmental Microbiology: A laboratory manual, Elsevier Publications, 2012.
4. Dubey, R.C. and Maheshwari, D.K., Practical Microbiology, S. Chand and Company Ltd., New Delhi, 2002.

ES7201 **CHEMISTRY OF ENVIRONMENT** **L T P C**
3 0 0 3

OBJECTIVE

- To educate the students in the area of water, air and soil chemistry.

UNIT I GENERAL **10**

Stoichiometry – First and Second law of Thermodynamics – Gibb‟s free energy – Chemical potential – Oxidation and Reduction, Nernt equation pH-pE diagrams, Chemical Equillibria, Acid – Base reactions – Solubility product ,Application in heavy metals removal– Solubility of gases in water — Chemical kinetics – Colloids charge- Coagulation, water treatment-nuclear reactions associated with atomic change – nuclear fusion and fission – use of radioactive materials as tracers – radioactive waste management.

UNIT II AQUATIC CHEMISTRY **10**

Transport and transformation of chemicals – Phase Interactions- Sorption- Degradation of food stuffs(carbohydrates, proteins), Detergents, Pesticides, hydrocarbons(aliphatic and aromatic) – Photolysis – Volatility – Classification of elements — Complex formation — Hydrophobic interactions –Chemical speciation.

UNIT III ATMOSPHERIC CHEMISTRY **9**

Photochemical reactions in the atmosphere- Degradation of VOCs– Chemical process for the formation of inorganic and organic particulate matter – Ozone formation and depletion chemistry Photochemical smog and sulphurus smog.

UNIT IV SOIL CHEMISTRY **8**

Soil classification– Inorganic and organic components of soil –physical and chemical properties of soil- Acid -base and ion exchange reactions-Cation exchange capacity-Salt affected soil-types and remediation.

UNIT V GREEN CHEMISTRY **8**

Principles of green chemistry – Clean synthesis, – Atom economy – Environmental factor “E‟ and Quotient “Q‟,mass Index, Nano materials synthesis, properties and application CNTs, T_iO_2.

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- Communicate effectively with the chemistry and environmental science communities.
- Outline fundamental and applied aspects of environmental analytical chemistry.

REFERENCES

1. Sawyer,C.N.,MacCarty,P.L.and Parkin,G.F.,"Chemistry for Environmental Engineering and Science", Tata McGraw–Hill,Fifthedition,NewDelhi 2003.
2. Colin Baird „EnvironmentalChemistry‟,Freemanand company, NewYork,1997.
3. Manahan,S.E., "Environmental Chemistry",Eighth Edition,CRC press,2005.
4. Ronbald A.Hites,"ElementsofEnvironmental Chemistry",Wiley,2007.

ES7202 **ENVIRONMENTAL BIOTECHNOLOGY** **L T P C**
3 0 0 3

OBJECTIVE

- The course provides a basic understanding on biotechnological principles and concepts. Biodegradation of pollutants and the mechanism of biodegradation are outlined. The basics of bioremediation and the methods of bioremediation are also provided.An exposure to cleaner technologies and recombinant technology concepts are also covered.

UNIT I BASIC CONCEPTS AND RECOMBINANT DNA TECHNOLOGY 5

General principles - Environmental Pollution; Types of Pollution; Principles of Recombination and Plasmids DNA Transformation - Recombinant DNA Technology - Polymerase Chain Reactions - Isolating and Cloning Fragments - Concept of Gene Probes - Fundamentals of Cloning - Insertion and Expression of Foreign Genes - Recombinant DNA Techniques in Biotechnology - Applications in Environmental Engineering - Environmental Issues.

UNIT II BIODEGRADATION OF POLLUTANTS 8

Xenobiotic compounds and recalcitrance – Biodegradation of Xenobiotics – adaptation of microorganisms for nutrients removal – microbial systems – degradation of toxic pollutants – hydrocarbons: non halogenated and halogenated – industrial application and concerns - Biological treatment of Waste water – Biotechnology for Solid waste management.

UNIT III MECHANISM OF DETOXIFICATION 8

Environmental fate of organic pollutants – mechanisms of detoxification – oxidation, reduction, and dehydrogenation – Microbial system for Heavy metal accumulation - Biotransformation of metals – Biosorption - Microbial leaching of metals – role of extracellular polymers to detect pollutants.

UNIT IV BIO-REMEDIATION 12

Biotechnological remedies for environmental pollution – soil, water and air remediation – reclamation concepts bioremediation – Ecological Restoration - Air Pollution and Deordorization process in Industry – Applications - Case study success stories.

UNIT V CLEANER TECHNOLOGIES 12

Biotechnology in biodiversity conservation – microalgal biotechnology and applications in agriculture - biogas biofuel production using microorganisms - Biomining of Resources – Integrated Waste Management - Biosensors in Environmental Monitoring and Analysis – Biofertillizers - Biopesticides – *Bacillus thuringiensis* and Integrated Pest Management

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- Have a grasp of the basics of the recombinant DNA technology and its environmental applications.
- Understand on the mechanisms behind the biodegradation of environmental pollutants in wastewater and solid waste
- Have a sound understanding on the bioremediation techniques applied to field and the application of microorganisms on waste and wastewater for useful by products and their use in monitoring pollutants in the environment

REFERENCES

1. Bruce E. Rittmann and Perry L. Mc Carty., Environmental Biotechnology: Principles and Application, McGraw –Hill International Edition, 2001.
2. Purchit, S.S., Biotechnology – Fundamentals and Applications, Student Edition, India, 2004.
3. Manahan, S.E., Environmental Science and Technology, Lewis Publ., New York, 1997.
4. Gabriel Briton, Wastewater Microbiololgy, Fourth Ed., Wiley and Blackwell, 2011.
5. Jogdand S. N., Environmental Biotechnology ,3rd Edition,Himalaya Publisher, 2006.
6. S.C Bhatia., Hand Book of Environmental Biotechnology, vol. 1,2 & 3, Atlantic Publishers and Distributers Ltd.,2008.

ES7203 ENVIRONMENTAL IMPACT ASSESSMENT L T P C
3 0 0 3

OBJECTIVE

- To expose the students to the need, methodology, documentation and usefulness of environmental impact assessment and to develop the skill to prepare environmental management plan.

UNIT I INTRODUCTION 7

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

UNIT II COMPONENTS AND METHODS FOR EA 10

Matrices – Networks – Checklists – Connections and combinations of processes - Cost benefit analysis – Analysis of alternatives – Software packages for EIA – Expert systems in EIA. Prediction tools for EIA – Mathematical modeling for impact prediction – Assessment of impacts – air – water – soil – noise – biological –– Cumulative Impact Assessment – Documentation of EIA findings – planning – organization of information and visual display materials – Report preparation. EIA methods in other countries.

UNIT III SOCIO-ECONOMIC IMPACT ASSESSMENT 8

Definition of social impact assessment. Social impact assessment model and the planning process. Rationale and measurement for SIA variables. Relationship between social impacts and change in community and institutional arrangements. Individual and family level impacts. Communities in transition - neighborhood and community impacts. Selecting, testing and understanding significant social impacts. Mitigation and enhancement in social assessment. Environmental costing of projects.

UNIT IV ENVIRONMENTAL MANAGEMENT PLAN 10

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

UNIT V SECTORAL EIA 10

EIA related to the following sectors - Infrastructure –construction and housing Mining – Industrial - Thermal Power - River valley and Hydroelectric – coastal projects-Nuclear Power. EIA for coastal projects.

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- Understand the legal requirement for getting environmental clearance for new projects.
- Know the requirements to become EIA consultant.
- To be a part of EIA team to conduct EIA study for various Projects.

REFERENCES

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

ES7204 ENVIRONMENTAL POLICIES AND LEGISLATIONS L T P C
3 0 0 3

OBJECTIVE

- This course will study National and International concerns, the bases for them and policy responses to them both within India and Internationally. The Third World dilemma between Environment and Development with special reference to economic approaches and human rights concerns will be considered. The course will analyse the legislative and judicial responses to environmental problems and the administrative system of environment related laws such as air, water, land, and hazardous substances etc. Environment advocacy and approaches for using litigation in environment protection will receive special attention.

UNITI INTRODUCTION TO ENVIRONMENTAL LEGISLATIONS INTERNATIONMAL SCANERIO 9

Significance of Environmental Law,International Environmental Law,Development of International Environmental Law,Source and General principals of International Environmental Law ,General rights and obligations of States ,General Issues of the international law related to environmental protection ,Stockholm Declaration,Rio Declaration on Environment and Development,Basel Convention on the Control of Trans boundary Movement of Hazardous Wasters and their disposal,Convention of Biological Diversity,U.N Frame Work Convention on Climate Change,Montreal Protocol on Substances that deplete Ozone Layer,Kyoto Protocol

UNIT II POLLUTION CONTROL - INDIAN SCENARIO 9

Indian Constitution and Environmental protection Constitutional provisions concerning Environment Articles 14,15,(2) (b) 19 (e),21,31,32,38,39,42,47, 48-A,49,51,51-A: Indian Environmental Policy2006Administrative machinery for pollution control Common Law & Criminal Law Nuisance, Negligence, strict liability and absolute liability, Provisions of IPC relating to environmental problems (public nuisance u/s 268 and others (Sections 269,270,277,284,285,286,425 to 440) Section 133 of Cr.P.C.

UNIT III REMEDIES FOR ENVIRONMENTAL POLLUTION 9

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

UNIT IV MAJOR INDIAN LEGISLATIONS 9

Water Act (1974) Air Act (1981) Environmental Protection Act (1986) Major Notifications The Municipal solid Wastes (Management and Handling) Rules 2000-Bio Medical Wastes (Management and Handling) Rules 1998- Hazardous Wastes (Management and Handling Rules 1989- Environment Impact Assessment Notifications- Coastal Regulation Zone Notification- Public Hearing Notifications

UNIT V ENVIRONMENT AND DEVELOPMENT 9

Meaning and concept of development - Its impact on environment; conflict between environment and development, Concept of Sustainable Development., Polluter Pay Principle, Precautionary Principle, Public Trust Doctrine. Landmark Judgments,Olium gas leakage case,Rural Litigation and Entitlement Kendra, Dehradun, (1985) Supp SCC 487),Vellore Citizen Welfare Forum v. Union of India, (1996) 5SCC 647) ,Ganga Pollution case (1988) I SCC) ,S. Jagannath v. UOI (1997) SCC867) Vellore Citizens welfare forum case,M.C.Mehta V. Kamalnath (1997) I SCC 388)

TOTAL: 45 PERIODS

OUTCOMES

- To know the origins and sources of environmental laws, and understand how and by whom environmental laws are made and interpreted.
- To understand the key principles of, and actors within, environmental laws

- To critically analyse environmental laws within various contexts and to evaluate laws against procedural and substantive criteria.
- On completion of the course, Student will have through legal knowledge and the Legal system operating in India and will be in a position to prepare compliance reports for getting environmental clearance.

REFERENCES

- Statutory Materials
- Bare Act/s
- Hand Book of International Environmental Law UNEP Publication
- Alan Boyle and Patricia Bernie, International Law and Environment, Oxford
- Philippe Sands, Principles of International Environmental Law, Cambridge
- Elli Louka, International Environmental Law, Cambridge

Books Prescribed:

- P. Leelakrishnan, Environmental Law in India, Butterworths
- P. Leelakrishnan, Environmental Case Book, Lexis Nexis
- S. Shanthakumar, Environmental Law – An Introduction, Butterworths
- ShyamDiwan and Armin Rosencranz, Enviromental Law and Policy in India, Oxford .

ES7205	OPERATION AND MAINTENANCE OF WATER AND WASTEWATER TREATMENT PLANTS	L T P C 3 0 0 3

OBJECTIVE

- To educate the student on the various Operation & Maintenance aspects of Common Effluent Treatment Plants.

UNIT I ELEMENTS OF OPERATION AND MAINTENANCE 10

Introduction - Plant operation roles - Plant Maintenance program- Knowledge of process and equipment - Proper and adequate tools - Spare units and parts - Laboratory control- Records and Reports- Housekeeping - Safety measures - Corrosion prevention and control – Industrial effluent management units – Effluents - Effluent management - Waste minimization - Process modification - Clean technology developments - Effluent treatment scheme - Sampling procedure-Analytical techniques- Code of practice for analytical laboratories.

UNIT II COMMON EFFLUENT TREATMENT PLANTS (CETPS) 8

Operation - disposal of effluent and residues - Constraints - Number and type of contributing units - Plant capacity – Location - Ownership and management - Influent and effluent characteristics - Collection and conveyance system- -Effluent treatment plant - Treatment process at CETPs – Case Studies.

UNIT III COLLECTION AND CONVEYANCE SYSTEMS 10

Operation and Maintenance of wastewater collection and conveyance systems - Functions of collection system – Components of collection system – Conduits or pipes – Manholes – Ventilating shaft – Maintenance of collection system – Problems generally faced – Clogging of pipes – Hazards – Precautions – Precautions against gas hazards – Precautions against infections – Devices for cleaning the conduits – Preventive maintenance – Corrective maintenance – Case Studies.

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

Operation and maintenance in screen chamber, Grit Chamber and clarifiers- - Operation guidelines for clarifier - Equalization basins –Neutralization unit - Chemical storage and mixing equipment - Chemical metering equipment - Flash mixer – Clarifiers - Operation and maintenance - Start-up and maintenance inspection - Motors and Pumps - Chemical feed systems

UNIT IV OPERATION AND MAINTENANCE OF BIOLOGICAL TREATMENT UNITS 8

Construction, Operation and Maintenance aspects – Operation and maintenance in activated sludge process, trickling filters, anaerobic digester- Trouble shooting – Planning, Organising and Controlling of plant operations – capacity building, case studies of Retrofitting.

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- Follow safe practices in the laboratory and in plant operations.
- Apply chemical, microbiological, and mechanical knowledge and skills to maintain proper water and wastewaterplant operations.
- Apply math and hydraulics skills in proper waterand wastewater plant, collection system, and distribution system operations.
- Understand regulations and operate the plant accordingly.

REFERENCES

1. Ghose D.N. (1991) “Operation and Maintenance of Sewage treatment plants CBS publishers and distributors, Delhi.
2. Kenneth D. Kerri, Bill B. Dendy, John Brady and Willam Crooks (1996) “Industrial Waste Treatment – A field study training program” Third edition, prepared by California sate University in Cooperation with the California water pollution on control association for the USEPA.
3. Metcalf and Eddy (1996) “Wastewater Engineering – Treatment – Disposal –Reuse” Tata McGraw Hill. 3rd Edition.
4. Sawyer C.N. Mccarty P.L. and Parkin G.F. (1994) “Chemistry for Environmental Engineering” McGraw Hill publishers.
5. UNIDO (1999) “Manual on Design, Operation and Maintenance of Tannery Effluent Treatment Plant” UNIDO, regional workshop, 13 – 14 October.

ES7211 ENVIRONMENTAL CHEMISTRY LABORATORY L T P C
0 0 4 2

OBJECTIVE

- To train the students in the laboratory in the determination of pollutants present in air, water, wastewater and soil.

LIST OF EXPERIMENTS

Sl.No	List of Experiments	Name of Equipment
1	Calibration of Pipette	Weighing balance
2	Measurement of pH of water & sludge soil sample using pH meter	pH Meter

3	Measurement of Electrical Conductivity of aqueous solution using conductivity meter	Electrical Conductivity Meter
4	Measurement of turbidity of water sample – Nephelometry	Nephlometer
5	Determination of alkalinity of water sample by titrimetry	Titration Method
6	Determination of hardness of water sample by titrations (EDTA)	Titration Method
7	Determination of chloride of water sample by titrations (Mohr‟s method)	Titration Method
8	Determination of sulphate of water sample using colorimeter	Spectrophotometer/Colorimeter
9	Determination of phosphate of water sample using colorimeter	Spectrophotometer/Colorimeter
10	Determination of nitrite of water sample by azo dye method	Spectrophotometer/Colorimeter
11	Determination of ammonia in waste water sample	Spectrophotometer/Ammonia Distillation Unit
12	Determination of DO by Winkler‟s method	DO Meter
13	Determination of BOD of wastewater sample	BOD Incubator
14	Determination of COD of wastewater sample	COD Digester
15	Determination of SO_2 in air by Spectrophotometric method	Spectrophotometer
16	Determination of SPM using High volume sampler	High Volume Sampler
17	Determination of potassium in soil.	Flame Photometer
18	Determination of surface area of activated carbon by acetic acid method	Mechanical Shaker
19	Determination of partition co-efficient of acetic acid between water & CCl_4	Titration Method
20	Determination of rate constant of a wastewater treatment method	Titration Method

TOTAL: 60 PERIODS

OUTCOME

On completion of the course, the candidate will be able to:

- Perform Environmental Quality Measurements.

REFERENCES

1. APHA, Standard methods for the Examination of Water and Wastewater, 20thEdition, Washington, 1998.
2. Rump, H.H., and H. Krist, Laboratory Manual for the Examination of water, wastewater and soil – Second Edition, VCH, Germany, 1992.
3. WHO, Selected Methods of Measuring Air Pollutants, Geneva, 1996.
4. Warren, J.Lyman, Willian F. Reehi and D.H. Rosen Blaff, „Handbook of Chemical property Estimation Methods‟, ACS, 1990.

ES7301 ENVIRONMENTAL ANALYTICAL TECHNIQUES L T P C
3 0 0 3

OBJECTIVE

- To educate the students on the analytical techniques of environmental disturbances with reference to air, water and soil.

UNIT I INTRODUCTION 7

Objectives of monitoring-Monitoring net work, Planning ,system design- Sampling devices, preservation , Sample preparation-Classification of analytical methods– Selection of a suitable method - Reliability of analytical data-Statistical analysis- Quality control and assurance.

UNIT II ELECTROANALYTICAL METHODS 8

Principle, instrumentation and environmental applications of conductometry, potentiometry, coulometry, Capillary electrophoresis and polarography – Field Instruments.

UNIT III SPECTROSCOPIC METHODS 12

Principle, instrumentation and environmental applications of atomic emission, absorption and fluorescence spectroscopy – Molecular UV, visible, IR spectroscopy and scattering methods.

UNIT IV CHROMATOGRAPHIC METHODS 7

General Theory-Column, Paper and thin layer chromatography (TLC) separation- Principle, instrumentation and environmental applications of GC, HPLC , Ion chromatographyand size exclusion chromatography.

UNIT V OTHER METHODS 11

Principle, instrumentation and environmental applications of NAA, XRF, XRD, SEM,TGA and Mass spectrometry, Continuous monitoring analysis – fluorescent analyzer for SO_2, chemiluminescent analyzer for NOx, NDIR for CO, Flow injection analyzer.

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- Identify, formulate, analyse and solve environmental analytical chemistry problems.
- Design and carry out a method of environmental chemical analysis, including instrumental analysis.

REFERENCES

1. Willard. H., Merritt, L., Dean, D.A. and Settle F.A., „Instrumental Methods of Analysis", 7th edition, Wordsworth, New York, 1998.
2. Galen. W. Ewing, „Instrumental Methods of Chemical Analysis 5th edition, McGraw Hill, New York., 1995.
3. Roger Reeve,Introduction to Environmental Analysis, John Wiley & Sons Ltd,2002
4. Fundamentals of Analytical chemistry, D.A. Skoog, D.M. West and F.J.Holler, Harcourt Asia PTE. Ltd., 7th edition, New Delhi,2001.

ES7302 RENEWABLE ENERGY L T P C
3 0 0 3

OBJECTIVE

- To impart knowledge on principles, technologies and economics of Bio-energy for Energy and environmental conservation.

UNIT I INTRODUCTION 9

Energy fundamentals- Biomass: Types – Advantages & Drawbacks – Indian Scenario - Potentials of solid and liquid wastes - agriculture - industrial - human origin (municipal and kitchen wastes) - quantities and characteristics- Bio Conversion Mechanisms- Fuel cells.

UNIT II BIOMETHANATION 9

Microbial Systems – Phases in Biogas production – Parameters affecting gas production Physical, chemical and engineering aspects of biogas - pressure, volume, temperature interaction. Anaerobic digestion - Biodegradation and Biodegradability of Substrateand layer stratification - distribution - pH, C/N ratio, retention period - Methoanl, Ethanol Production - Fermention - Anaerobic Digestion - Hydrogen and diesel Generation from Algae- Effect of additives on Biogas yield - alternate feedstock materials.

UNIT III COMBUSTION & GASIFICATION 9

Strategies for bio-products production- Perfect, Complete & Incomplete combustion – Equivalence ratio – Fixed Bed, Fluid Bed – Fuel & Ash handling –Briquetting– Feed requirements & Preprocessing – Advantages – Drawbacks Types of Gasification – Comparison – Application – Performance Evaluation – Dual fuel engines – 100 % Gas Engines – Engine characteristics on gas mode – Gas cooling & cleaning train- Wood Gasifier- Operation and Maintenance.

UNIT IV PYROLYSIS & CARBONISATION 9

Types – process governing parameters – Thermo gravimetric analysis – Differential thermal analysis – Differential scanning calorimetry – Typical yield rates and Liquefaction.

UNIT V ECONOMICS OF BIOENERGY 9

Computational Tools for bioenergy (modeling, simulation, GIS) Commercialization of bioenergy technologies -Industrial Application - Viability of Energy Production - Environmental Aspects of Bioenergy Conversion -Socio-economic aspects - cost- benefit analysis.

TOTAL: 45 PERIODS

OUTCOME

On completion of the course, the candidate will be able to,

- Understand the necessity to go for alternative energy and potential for bioenergy and methods to explore the energy in biological mode.

REFERENCES

1. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood, ichester, 1984
2. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986
3. Mahaeswari, R.C.Bio Energy for Rural Energisation, Concepts Publication, 1997
4. Tom B Reed, Biomass Gasification – Principles & Technology, Noyce DataCorporation, 1981
5. Best Practices Manual for Biomass Briquetting, I R E D A, 1997.
6. Eriksson. S & M. Prior, The Briquetting of Agricultural Wastes for Fuel, FAO Energy & Environment Paper, 1990.
7. G D Rai, Non Conventional Energy Sources, Khanna Publishers, New Delhi.

ES7303 SUSTAINABLE ECOSYSTEMS L T P C
3 0 0 3

OBJECTIVE

- To educate the students to acquire knowledge on different ecosystems and their values and the need for the conservation of ecosystems.

UNIT I INTRODUCTION 9

Ecosystem - Concepts of ecology, Structural and Functional Analysis of ecosystems, Community Structure – Energy flow through ecosystems, Ecological succession and disturbance – Biological Invasions.

UNIT II ECOLOGY AND ECOSYSTEM SERVICES 9

Ecosystems- Aquatic, Terrestrial – Supporting services– Provisioning services – Regulating Services – Cultural ServicesResources – Ecosystem health – Ecological indicators.

UNIT III BIODIVERSITY AND BIOLOGICAL CONSERVATION 9

Hot spots- Species loss – Threats – Habitat destruction, genetic pollution, human population, over exploitation, climate change – Global Change

UNIT IV ECOSYSTEM CONSERVATION 9

Ecosystem Manipulation and Disruption – Ecosystem degradation – Natural, Anthropogenic – Conservation – Need - Concepts and foundations- Approaches- Ethics and Values – Conservation Methods - Ecological Modeling

UNIT V ECOSYSTEM SUSTAINABILITY 9

Ecological knowledge - Ecological Sustainability – Importance of Sustainability – Types of sustainability – Recycling sustainability, Green Sustainability - Natural Resource sustainability, living sustainability, Water movement sustainability, Sustainability Agroforestry – Environmental Policy

TOTAL: 45 PERIODS

OUTCOME

On completion of the course, the candidate will be able to,

- Know the importance of ecosystems and the various approaches for the sustainability of the ecosystems.

REFERENCES

1. Smith, R.L. and Smith, T.M. Elements of Ecology Benjamin Cummings, 2003.
2. Odum, E.P. Fundamentals of Ecology, 1991, Indian EWdition – Nataraj Publishers.
3. Roger Perman, Yu Ma and James McGilvray, 1997, Natural Resources and Environmental Economics, Second Edition, Addison Wesley Longman Ltd., Singapore.
4. Jorgensen, SE, 1986, Fundamentals of Ecological Modelling.

ES7001 BIODIVERSITY AND CONSERVATION L T P C

3 0 0 3

OBJECTIVE

- To provide Knowledge about the importance of conserving biodiversity and approaches followed for mitigating threats through conservation.

UNIT I CONCEPTS OF BIODIVERSITY 9

Life on Earth - Evolution of cellular diversity - Species Diversity - Genetic Diversity - Ecological Diversity - Measuring Biodiversity Species - Abundance - Adaptation - Evolution of Biodiversity - Natural Selection - Species Interaction - Genetic Variability - Importance of Biodiversity.

UNIT II SPECIATION 9

Species Formation and Evolution - Types- Mechanism of Speciation- Sympatric- Allopatric Speciation - Species losses- Endemism - Its types, Neo endemism, Paleo endemism - Rare and threatened species.

UNIT III LOSS OF BIODIVERSITY 9

Habitat Loss and Fragmentation – Over exploitation – Alien species invasions – Co extinction - Loss of Genetic Diversity – Loss of Species Diversity – Loss of Agro-biodiversity – Extinction – Causes of Extinction - Protection species – Polymophism – Balanced and Transient polymorphism - Geographical diversity.

UNIT IV CONSERVATION BIOLOGY 9

Fragmentation of Habitats –Overharvesting -Invasive species - Extinctions and the practice of preventing them - Reintroduction of Species - Ecosystem Health Checks – Bio indicators – Indicator species - Organisms of conservation concern – Rare – Endangered species – Conservation strategies - Management strategies.

UNIT V CONSERVATION OF ECOLOGY 9

Approaches to Conservation – Principles of conservation - *Insitu* and *Exsitu* Conservation Plant Biodiversity – Biosphere reserves and National Parks - Animal sanctuaries – Conservation of wild life – Organization associated with Biodiversity Conservation - Management of forest and forest resources – Biomes – Grassland - Desert – Tundra – Auto rotation and deforestation.

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- Perform biodiversity analysis in a given habitat.
- To understand and frame conservation measures on new or endangered species in a given habitat.

REFERENCES

1. Sharad . Singh. Negi, " Biodiversity and its conservation in India" 2nd edition, Indus Publishing Company,2008.
2. K.V. Krishnamurthy, "Text Book of Biodiversity" Science Publisher Inc. 2003.
3. Micheal J. Jeffris, "Biodiversity and Conservation" 2nd Edition, Routledge, 2006.
4. P.C. Trivedi, "Global Biodiversity: Status and Conservation" Pointer Publishers, 2007.
5. Primack, R. Essentials of Conservation Biology, 3rd Edition, Sinauer Associates Inc.

ES7002 CLIMATE CHANGE AND MODELING L T P C

3 0 0 3

OBJECTIVE

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

UNIT I CLIMATE CHANGE AND CLIMATE VARIABILITY 9

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

UNIT II IPCC SRES SCENARIOS 9

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

UNIT III GLOBAL CLIMATE MODEL (GCM) AND REGIONAL CLIMATE MODEL (RCM) 9

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

UNIT IV DOWNSCALING GLOBAL CLIMATE MODEL - AN OVERVIEW 9

Need for downscaling - Selection of GCMs for regional climate change studies - Ensemble theory – Selection of - Ensembles, Model Domain (Spatial domain and temporal domain), Resolution and climate variables - Lateral boundary conditions - Methods of downscaling (Statistical and Dynamical) - examples from each and their limitations.

UNIT V ANALYSIS /POST PROCESSING 9

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

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- Understand the earth climate systems and global warming.
- Understand the impact of climate change on society and the adaptation and mitigation measures of climate change impacts.
- Know the concept of modeling techniques.

REFERENCES

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

ES7003 DISASTER MANAGEMENT AND MITIGATION L T P C

3 0 0 3

OBJECTIVE

- To impart knowledge on various natural and manmade disasters and the mitigation measures to be followed.

UNIT I NATURAL DISASTERS 9

Basic concepts – Global problem – Time and space in disaster – Geological hazards Earth Quake and Landslides – hydrological hazards – Cyclone – Flood – Epidemics – Sea level rise – Tsunami - Forest fire

UNIT II MAN MADE DISASTERS 9

Industrial hazards – Air, water, noise and vibration pollution – Dam failures – Oil Spillage – Sea water intrusion – ground water pollution – Mining excavation – Ground subsidence – Biotechnological disasters.

UNIT III MITIGATION **9**

Principles of mitigation measures – Need of preparedness – Hazard zoning – Warming – Building code provisions – Planning and regulation for functional changes – Risk assessment – Vulnerability analysis – Ground water monitoring and artificial recharge integrated coastal zone management.

UNIT IV RESPONSE AND RELIEF **9**

Characteristics, operations and logistics for response and recovery – Medical emergencies – Post disaster review – Disaster Legislation – Resources and Utilization – Cost reduction and effective analysis.

UNIT V ENVIRONMENTAL ISSUES **9**

Environmental impacts by various disasters – Health Hazards – Public awareness – Training – Sociology and economics – Remote Sensing and GIS applications.

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- Define and describe disaster management, hazard, emergency, disaster, vulnerability, and risk.
- Identify and describe the types of natural and non-natural disasters and the implications of disasters on environment.
- List and describe the main hazards to which our region is, or may be, Vulnerable.
- Describe briefly how the effects of disasters can be reduced on vulnerable groups.

REFERENCES

1. Mitigating Natural Disasters, United Nations Publication, New York, 1991.
2. Nick Carter, W., Disaster Management – A Disaster Manager‟s Hand book, Asian Development Bank, Phillippines, 1991.
3. David Alexander, Natural Disasters, UCL Press, London, Research press, New Delhi, 1993.
4. Stanely E. Manahan, Environmental Science& Technology, Lewis Publishers, New York, 1997.
5. Bell, F.G., Geological Hazards : Their assessment, avoidance and mitigation, E & FN SpON, Routledge, London, 1999.
6. Manual on Disaster Management, National Disaster Management Authority, ,Government of India ,2010.

ES7004 ECOLOGICAL REMEDIATION **L T P C**
3 0 0 3

OBJECTIVE

- The course provides an insight on the principles of restoration of an ecosystem and the techniques and monitoring methods for the restoration.

UNIT I INTRODUCTION TO RESTORATION ECOLOGY **9**

Environmental Restoration- Restoration Ecology – Need for Restoration - Basic Elements of Restoration Planning -Ecological Principles in Restoration Ecology - Ecosystem Management Models - Species interaction.

UNIT II THREATS OF ECOLOGY **9**

Toxicology and Ecotoxicology- Extinction – Threats of Biological Diversity - Habitat Fragmentation- Pollution- Natural Drivers- Overexploitation- Habitat Conversion- Climate Change- Hybridization.

UNIT III RESTORATION APPROACH AND RESTORATION PLANNING 9

Limitation to Restoration – Biological, Physical, Chemical, Hydrological - Ecological Degradation – Invasive species Biology and control – Assessment tools in Ecosystem restoration - Landscape Management Technique.

UNIT IV RESTORATION OF ECOSYSTEM 9

Wetlands - Lake- Rivers and Flood Plains - Coral reefs – Forest- Mined land – Land spoiled by Industrial activities--Restoration of Species Diversity - Restoration Case Studies.

UNIT V MANAGEMENT OF RESTORATION PROJECTS 9

Setting Goals- Planning - Action Plan - Adaptive Management – Monitoring – After care and Final Assessment - Biological Markers.

TOTAL: 45 PERIODS

OUTCOME

On completion of the course, the candidate will be able to:

- Plan the activities for restoration of a degraded ecosystem with the best available techniques.

REFERENCES

1. Sigurdur Greipsson, “Restoration Ecology “Jones & Bartlett Learning, LLC; 2011.
2. Susan M. Galatowitsch,” Ecological Restoration, Sinauer Associates, Inc. Publishers 2012.
3. Andre F.Clewell, James Aronson; “Ecological Restoration” Island Press., 2007.
4. S.C. Bhatia, “Ecology and Sustainable Development” Volume 2, Atlantic Publisher., 2008.

ES7005 INDUSTRIAL AND ENVIRONMENTAL TOXICOLOGY L T P C
3 0 0 3

OBJECTIVE

- To impart knowledge on toxicology, risk assessment and remediation.

UNIT I BIOCHEMICAL TOXICOLOGY 12

Toxicants, Distribution, Metabolism of toxicants, sites of action, classification of toxicity – acute and sub-acute toxicity bioassay, Factors influencing toxicity, Elimination of toxicants, Methods of toxicity testing – Evaluation - statistical assessment, sediment toxicity, Bio- chemical markers/indicators, Toxicokinetics, Bioconcentration, Bio-accumulation and Bio magnification in the environment.

UNIT II GENETIC TOXICOLOGY 12

Xenobiotics – Chemical carcinogenesis – Genotoxicity assays – Neurotoxicity, Skin toxicity, Immunotoxicity. Renal toxicity, Endocrine disruptors, hormones, receptors.

UNIT III NDUSTRIAL TOXICOLOGY 8

Toxicity of monomers, solvents, intermediates, products – toxic substrates – Metals and other inorganic Chemicals, Organic Compounds – Persistent chemicals.

UNIT IV RISK ASSESSMENT AND REMEDIATION 8

Procedures for assessing the risk – Risk measurement and Mitigation of environmental disorders – Factors in risk assessment.

UNIT V CASE STUDIES IN RISK ASSESSMENT 5

Pharmaceutical, Petroleum, Carbide industry, Textile and Leather Industry Case study.

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- Demonstrate knowledge of main groups of toxins and contaminants
- Understand the basic physical, chemical and biological aspects of environmental toxicology.
- Apply in-depth environmental toxicology knowledge under a range of representative real case studies.
- Choose the tools most suitable to analyze concrete environmental toxicology problems.

REFERENCES

1. Crosby, D.G.1998. Environmental Toxicology and Chemistry, Oxford University Press, New york
2. Hodgson, A. 2004, A text book of Modern Toxicology, John Wiley and Sons, Inc.NJ.
3. Walker, C. H. et al., 1996. Principles of Ecotoxicology, Taylor and Francis, Inc, ISBN 074803557.
4. Ballantyne, B. Marrs, T. M and Syversen, T. 1999. General and Applied Toxicology 2nd ed. Mac Millan Reference Ltd.
5. Hodson, E. and R.C. Smart, 2001, Introduction to Bio-chemical toxicology, Wiley Interscience, New York.

ES7006 INDUSTRIAL HYGIENE AND SAFETY L T P C
3 0 0 3

OBJECTIVES

- To educate about the health hazards and the safety measures to be followed in the industrial environment.
- Describe industrial legislations (Factories Acts, Workmen's Compensation and other laws) enacted for the protection of employees health at work settings
- Describe methods of prevention and control of Occupational Health diseases, accidents/emergencies and other hazards

UNIT I INTRODUCTION 9

Need for developing Environment, Health and Safety systems in work places - Accident Case Studies - Status and relationship of Acts - Regulations and Codes of Practice - Role of trade union safety representatives. International initiatives - Ergonomics and work place.

UNIT II OCCUPATIONAL HEALTH AND HYGIENE 11

Definition of the term occupational health and hygiene - Categories of health hazards - Exposure pathways and human responses to hazardous and toxic substances - Advantages and limitations of environmental monitoring and occupational exposure limits - Hierarchy of control measures for occupational health risks - Role of personal protective equipment and the selection criteria - Effects on humans - control methods and reduction strategies for noise, radiation and excessive stress.

UNIT III WORKPLACE SAFETY AND SAFETY SYSTEMS 11

Features of Satisfactory and Safe design of work premises – good housekeeping - lighting and colour, Ventilation and Heat Control – Electrical Safety – Fire Safety – Safe Systems of work for manual handling operations – Machine guarding – Working at different levels – Process and System Safety.

UNIT IV HAZARDS AND RISK MANAGEMENT 7

Safety appraisal - analysis and control techniques – plant safety inspection – Accident investigation - Analysis and Reporting – Hazard and Risk Management Techniques – major accident hazard control – Onsite and Offsite emergency Plans.

UNIT V ENVIRONMENTAL HEALTH AND SAFETY MANAGEMENT 7

Concept of Environmental Health and Safety Management – Elements of Environmental Health and Safety Management Policy and methods of its effective implementation and review – Elements of Management Principles – Education and Training – Employee Participation.

TOTAL: 45 PERIODS

OUTCOMES

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

- Describe, with example, the common work-related diseases and accidents in occupational setting.
- Name essential members of the Occupational Health team.
- What roles can a community health practitioners play in an Occupational setting to ensure the protection, promotion and maintenance of the health of the employee.

REFERENCES

1. Fundamentals of Industrial Safety and Health by Dr.K.U.Mistry, Siddharth Prakashan, 2012
2. Environmental and Health and Safety Management by by Nicholas P.Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995
3. The Facility Manager's Guide to Environmental Health And Safety by Brian Gallant, Government Inst Publ., 2007.
4. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, Culinary and Hospitality Industry Publications Services,2005.
5. William F.Martin, and Steven P.Levine, " Protecting Personnel at Hazardous waste Sites", Second Edition, Buttorworth. Heinemann, 1994.

ES7007 INDUSTRIAL WASTEWATER POLLUTION- PREVENTION AND CONTROL L T P C

3 0 0 3

OBJECTIVES

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

UNITI INTRODUCTION 8

Industrials cenario in India–Industrial activity and Environment-Uses of Water by industry–Sources and types of industrial wastewater–Nature and Origin of Pollutants-Industrial waste water 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

UNITII INDUSTRIAL POLLUTION PREVENTION &WASTE MINIMISATION 8

Prevention visav is 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.

UNITIII INDUSTRIAL WASTEWATER TREATMENT 10

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

UNITIV WASTEWATER REUSEAND 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.

UNITV CASE STUDIES 10

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

TOTAL: 45 PERIODS

OUTCOMES

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

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

REFERENCES

1. "Industrial wastewater management, treatment &disposal, Water Environment" Federation Alexandria Virginia, Third Edition, 2008.
2. LawranceK.Wang,Yung.TseHung,HowardH.LoandConstantineYapijakis,“handlook of Industrial and HazardouswasteTreatment”,Second Edition,2004.
3. Metcalf & Eddy/AECOM, "water reuse Issues, Technologies and Applications", The Mc Graw-Hill companies,2007.
4. Nelson Leonard Nemerow, “industrial waste Treatment”, Elsevier, 2007.
5. W.Wesley Eckenfelder, “ Industrial Water Pollution Control”, SecondEdition,McGrawHill,1989.
6. PaulL.Bishop, Pollution Prevention:- Fundamentals and Practice", Mc-Graw Hill International, Boston, 2000.

ES7008 MARINE RESOURCES AND MANAGEMENT L T P C

3 0 0 3

OBJECTIVES

- To educate the Coastal and Marine environment.
- To educate the marine resources
- Students will gain competency in the field of ocean study

UNIT I MARINE ENVIRONMENT AND COASTAL PROCESS 9

Seas and oceans, Continental area, Coastal zone, Properties of sea water, Coastal eco system, Communities of the marine environment, Marine Bio-diversity, Importance of Coastal Environment – food, transportation, recreation, Coastal hydrodynamics, Interaction between water and coastal sediments

UNIT II MARINE RESOURCES 10

Food web and energy fluxes, Nutrient enrichment, Biomass, Economic Importance of marine biota – Microbes, Benthos., Algae, Seaweeds Seagrass, Coral reef , Mangroves – importance, interaction of mangroves with other allied and nearby coastal ecosystems – estuaries, lagoons, salt marshes etc.

UNIT III ENERGY RESOURCES 8

Non living resources of the sea for human welfare, Energy resources – Tides, Waves, and Thermal, Exploration of minerals – Hydrocarbons, Manganese nodules, Heavy mineral deposition, Desalination of sea water.

UNIT IV ENVIRONMENTAL AND SOCIO-ECONOMIC ISSUES 9

Human intervention on marine resources, Marine pollution sources and effects, Need for conservation, Resource allocation conflicts, Coastal threats – Indian scenario, Coastal economic concepts, Issues in ecological security of coast - Protecting livelihood of coastal communities, stake holders.

UNIT V COASTAL ZONE MANAGEMENT 9

Ocean policy and legal issues – acts- Issues on EIA of coastal zone development, Need for conservation, Applications of Remote Sensing and GIS techniques in monitoring marine resources – Integrated coastal zone management, Exclusive Economic Zone, Marine bio reserves.

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- Know about marine environment.
- Have knowledge on physical concepts lying behind the oceanic currents and natural processes of various activities happening over the marine environment.
- Acquire knowledge on the marine pollution and the effect of the same on the ecology.

REFERENCES

1. Newman, M.C., Roberts Jr. M. H., Male, R.C., (2002), „Coastal and Estuarine Risk Assessment", Lewis Publishers. Washington , D.C
2. Maarten Bavinck, „Marine Resources Management", Sage Publications India Private Limited, 1 edition (Mar 5 2001), M-32, Market , Greater kailash part 1,New Delhi -48.

ES7009 REMOTE SENSING AND GIS FOR ENVIRONMENTAL SCIENCES L T P C

3 0 0 3

OBJECTIVES

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

UNIT I INTRODUCTION TO REMOTE SENSING 8

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

UNIT II REMOTE SENSING TECHNIQUES 10

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

UNIT III SATELLITE REMOTE SENSING AND DATA PROCESSING 10

Satellites and their sensors , ISRO satellites, LANDSAT, TERRA, SPOT, ERS satellites, Characteristics of Remote Sensing data, Satellite data analysis , Photogrammetry, Visual image interpretation, Digital image processing – Image rectification, enhancement, transformation, Classification, Data merging

UNIT IV GEOGRAPHICAL INFORMATION SYSTEM 8

Introduction to GIS, GIS concepts – Spatial and non spatial data, Vector and raster data structures, Data analysis, Database management – Overview of GIS software"s, RS – GIS Integration, Image processing software

UNIT V REMOTE SENSING AND GIS APPLICATIONS 9

Monitoring and management of environment, Conservation of resources, sustainable land use, Agriculture, Coastal zone management

TOTAL: 45 PERIODS

OUTCOMES

On completion of the course, the candidate will be able to:

- I identify the environmental problems using Remote sensing.
- Apply the principle of RS and GIS for solving Environmental problems.
- Assess the Environmental Impacts using RS and GIS.
- Employ modern engineering tools in environmental studies.
- Function on a multi-disciplinary team.

REFERENCES

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

ES7010 TERTIARY WASTEWATER TREATMENT SYSTEMS L T P C

3 0 0 3

OBJECTIVES

- To educate the students on the principles and process designs of various tertiary treatment systems for wastewater.
- Develop an understanding of the characteristics of wastewater that must be considered during design of a treatment plant.
- Students will gain competency in the iterative process employed in design of treatment systems and the components comprising such systems, leading to the selection of specific process equipment items.

UNIT I INTRODUCTION TO TERTIARY TREATMENT 9

Objectives of tertiary treatment of sewage and industrial effluents -Flow sheets- unit operations and unit processes. Quality requirements for Wastewater reuse – Sodium hazards-Legislation

UNIT II FILTRATION AND DISINFECTION 9

Theory of Filtration, size, shape and characteristics of granular media, preparation of filter sand.Filtration through homogeneous and stratified bed, Estimation of loss of head, development of negative head. Hydraulics of filters- Design of rapid and pressure filters. Theory of disinfection, factors affecting disinfection - Chlorination – types of Chlorination, residual chlorine, Disinfection using other disinfectants.

UNIT III NURTIENT REOVAL SYSTEMS 9

Removal of Nitrogen by biological nitrification / denitrification, Removal of phosphorus by Chemical and biological methods. Application of MBR in nutrient removal – Conversion of ammonia by biological nitrification, Removal of toxic compounds – Adsorption and Ion exchange process-Removal of dissolved inorganic substances.

UNIT IV MEMBRANE SYSTEMS 9

Microfiltration principles and applications – Ultrafiltration principles and applications - Nanofiltration principles and applications – Reverse Osmosis: Theory and design of modules, assembly, plant process control and applications -Membrane System components – Design of Membrane systems - pump types and Pump selection – Plant operations – Economics of Membrane systems

UNIT V WASTEWATER REUSE AND RESIDUE MANAGEMENT 9

Sewage Treatment Plants (STPs) and Common Effluent Treatment Plants (CETPs) – Joint treatment of industrial and domestic wastewater - Zero effluent discharge systems - Industrial reuse , Present status and issues – Residuals of tertiary treatment – Management of RO rejects.

TOTAL: 45 PERIODS

OUTCOMES

- Develop conceptual schematics required for tertiary treatment of wastewater.
- Ability to identify and formulate engineering problems.

REFERENCES

1. Water Environment Federation (WEF), Membrane Systems for Wastewater Treatment, McGraw-Hill, USA, 2005.
2. Symon Jud, MBR Book – Principles and application of MBR in water and wastewater treatment, Elservier, 2006.
3. Metcalf and Eddy, Wastewater Engineering, Treatment and Reuse, Tata McGraw Hill, New Delhi, 2012.
4. Manual on “Sewerage and Sewage Treatment Systems Part A, Part B &Part C” CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
5. Qasim, S.R. Wastewater Treatment Plant, Planning, Design & Operation, Technomic Publications, New York, 1994.