

M. Sc - ENVIRONMENTAL SCIENCE & TECHNOLOGY
COURSE STRUCTURE
I YEAR

I SEMESTER

SUBJECT CODE	SUBJECT TITLE	L	P	CREDITS
EST-1.1	Environmental Ecology	4	0	4
EST-1.2	Environmental Chemistry	4	0	4
EST-1.3	Environmental Microbiology& Bio-Chemistry	4	0	4
EST-1.4	Natural Resources	4	0	4
EST-1.5	Computer Programming & Statistics	4	0	4
ESTL-1.6	Water, Wastewater & Air Pollution Analysis Lab	-	8	8
ESTL-1.7	Computer Programming Lab	-	8	8
Total Credits (5 Theory + 2 Lab)				36

II SEMESTER

SUBJECT CODE	SUBJECT TITLE	L	P	CREDITS
EST-2.1	Air Pollution and Control Technologies	4	0	4
EST-2.2	Water Pollution and Treatment Techniques	4	0	4
EST-2.3	Environmental Biotechnology	4	0	4
EST-2.4	Remote Sensing and GIS	4	0	4
EST-2.5	Instrumental methods of Analysis	4	0	4
ESTL-2.6	Environmental Micro Biology and Biotechnology Lab	-	8	8
ESTL-2.7	Solid Waste Characterization And Instrumental Methods Analysis Lab	-	8	8
Total Credits (5 Theory + 2 Lab)				36

II YEAR**III SEMESTER**

SUBJECT CODE	SUBJECT TITLE	L	P	CREDITS
EST-3.1	Global Environmental Issues	4	0	4
EST-3.2	Environmental Modeling	4	0	4
EST-3.3	Solid and Hazardous Waste Management	4	0	4
EST-3.4	Environmental Impact Assessment	4	0	4
EST-3.5	Occupational Health and Safety	4	0	4
ESTL-3.6	Water and Waste Water Treatment Methods Lab	-	8	8
ESTL-3.7	RS & GIS Lab	-	8	8
Total Credits (5 Theory + 2 Lab)				36

IV SEMESTER

SUBJECT CODE	SUBJECT TITLE	L	P	CREDITS
ESTP-4.1	Project Work	-	-	36
Total Credits				36

L- No. of Lectures per week; P- No. of Practical's per week.

EST-1.1 ENVIRONMENTAL ECOLOGY

UNIT I DEFINITION AND SCOPE OF ECOLOGY:

Physical, chemical, environmental factors and their relation to organisms. Climatic Factors: Environmental complex-Interaction of ecological factors-Light factor-Temperature factor-Precipitation (rain fall) -Humidity of Air-Atmosphere-Gases and Wind-Atmospheric gases- Wind factor-Fire factor. Topographic (Physiographic) Factors: Height of mountain chains-Direction of mountains and valleys-Steepness of slope- Exposure of slope.

UNIT II EDAPHIC FACTORS (Soil Science):

Importance of soil- Definition and composition of soil-Formation (origin) of soil-Factors affecting soil formation-soil profile-Some processes in soil formation-Characteristic to the climate type-Soil classification- Soil complex-components and properties-Soil erosion- Soil conservation.

UNIT III BIODIVERSITY AND ITS CONSERVATION:

Current levels of biodiversity – alpha and beta diversity- extinction and endangered species – steps to preserve biodiversity- insitu and ex-situ conservation – gene banks –biodiversity conservation and agenda –21 – hotspots of biodiversity – national parks and sanctuaries – gene pools. Biodiversity Act 2002 of India.-

UNIT IV POPULATION AND COMMUNITY ECOLOGY:

Relation within species, population growth, population dynamics positive and negative growth, bio potential, age structure, equilibrium position, oscillation and fluctuation- Restriction of Urbanization. Different communities and their occupation in different ranges in the environment and their relationship for the maintenance of eco-balance in the environment- Niche ecological succession.

UNIT V BIO-GEO CHEMICAL CYCLES:

Carbon dioxide cycle, oxygen cycle, Nitrogen cycle, Phosphorus cycle and Potassium cycle.

UNIT VI ECOSYSTEM ECOLOGY:

Structure and functions of an Ecosystem- Ecological energetic-Energy flow in ecosystem Food chain, role of producers and consumers, Methods of calculating energies in the ecosystems-Nutrient cycles in ecosystem- Atmospheric cycles- Edaphic cycles. Elements of ecosystem modeling- Pond ecosystem-Marine ecosystem-Grassland ecosystem-Forest ecosystem-Desert ecosystem -Cropland ecosystem-Productivity of different ecosystems-Primary production in terrestrial ecosystems-Secondary ecosystem.

UNIT VII SUSTAINABLE DEVELOPMENT:

Ecological sustainability- goals of sustainable development-symptoms and causes of unsustainability- Organic farming- Biofertilizers- Biopesticides. current environmental issues in India – Narmada dam- tehri dam – almetti dam

UNIT VIII ECOSYSTEM MODELING:

Introduction, wetland mapping, spatial models, ecological systems and process.

Text Books:

1. **Concepts of Ecology**, E.J.Kormondey, 1984. Indian reprint 1991 Prentice-Hall of India.
2. **Basic Ecology**, E.P. Odum, 1983, Holt-Saunders International Edition.
3. **Ecology & Environment**, P.D.Sharma, Ashish publications,1994.

Reference Books:

1. **Introduction to Ecology**, Paul Colinvaux, 1973. Wiley International Edition.
2. **Advanced Ecological Theory- Principles and Applications**, Bleakwell Science Ltd., Oxford (1999).
3. **Environment Conservation**, Raymond F Dasmann, John Wiley & Sons (1984).

EST-1.2 ENVIRONMENTAL CHEMISTRY

UNIT I FUNDAMENTALS OF ENVIRONMENTAL CHEMISTRY:

Stoichiometry, chemical equilibria, acid base reactions, solubility product, solubility of gases in water, the carbonate system, unsaturated and saturated hydro carbons, radio-nuclides.

UNIT II ATMOSPHERIC CHEMISTRY:

Structure and composition of atmosphere- chemical reactions in the atmosphere- ozone chemistry- CFC's- Acid rain- photochemical smog- aerosols types- production and distribution- aerosols and radiation- temperature inversion- green house gases- global warming.

UNIT II WATER CHEMISTRY:

Water resources, hydrological cycle, physical and chemical properties of water, complexation in natural and waste water, role of microorganisms – Water pollutants- Types – Sources – Heavy metals – Metalloids –Organic- Inorganic - Biological and Radioactive – Types of reactions in various water bodies including marine environment- Eutrophication- Groundwater – Potable water.

UNIT III SOIL CHEMISTRY & SOIL COMPOSITION:

Organic & Inorganic – soil, physical and chemical properties- cation exchange capacity- soil pH- environmental properties of soils, leaching and erosion – reactions with acids and bases- geochemical reactions that neutralize acidity- biological process that neutralize acidity – salt affected soils- trace metals in soils.

UNIT IV TOXICOLOGICAL CHEMISTRY:

Introduction to toxicology and toxicants- Toxicants - -Dose response relationship- Evaluation methods-LD₅₀, LC₅₀ , impact of Toxic chemicals on Enzymes - Biochemical effects of arsenic, lead, mercury, carbon monoxide, Nitrogen oxides - sulphur dioxide - ozone and PAN - cyanide - pesticides and Carcinogens.

UNIT V GREEN CHEMISTRY:

Principles- tools of green chemistry- alternative feed stocks starting materials, alternative reagents, alternative solvents, alternative products and alternative catalysis.

UNIT VII GREEN ENVIRONMENTAL ISSUES:

Introduction- ecological and carbon foot prints- carbon credits- carbon sequestration- clean development mechanism (CDM)- polluters pay- consumerism- sustainable mining- urban forestry- green buildings- green building practices- approaches to green computing- nanotechnology and environment.

UNIT VIII CHEMISTRY APPLICATIONS IN WASTE WATER TREATMENT METHODS:

Coagulation- oxidation- H₂O₂, fenton, ozonation, sonication- ion exchange- adsorption- membrane filtration.

Textbooks:

1. **Environmental chemistry**, a global perspective by Gary W. Vanloon & tephem J. Duffy- Oxford university press.
2. **Chemistry for environmental engineering and science**- fifth edition by Clair N. Sawyer, Perry L. Me Carty. Gene F. Parkin, Tata Megrahill edition.
3. **Environmental Chemistry**, by A. K. de, 4th ed. New age internati9onal (P) Ltd., New Delhi, 2000.
4. **Chemistry and the Environment**, Johnson, D. O. Netterville, J. T., Wood, J. C., and James, M., 1973, W.B. Saunders company Philadelphia.
5. **Toxic Chemistry, health and the Environment**, Lave, L. B and Upton , A.C. 1987, The Hopkins Press Ltd., London.
6. **Green Chemistry**, Rashmi sanghi and Srivastava M. M, Narosa (2006).
7. **Environmental Chemistry** by Manhan, 7th ed., CRC press, Bo Co Raton, F. L., 2000.
8. **Waste water engineering, treatment and reuse** by Metcalf and eddy, fifth edition, Tata Mc Graw Hill.

EST-1.3 ENVIRONMENTAL MICROBIOLOGY AND BIO-CHEMISTRY

UNIT I INTRODUCTION TO ENVIRONMENTAL MICROBIOLOGY :

Origin, scope and importance. Diversity of microorganisms: Three domains of life- Prokaryotes versus eukaryotes- Eukaryotic and prokaryotic cell General characters, important uses and harmful effects of (a) protozoa (b) algae, (c) fungi (d) bacteria and (e) Virus.

UNIT II GROWTH OF MICROORGANISMS:

Isolation cultivation (aerobic & anaerobic) and preservation of microbes; Nutritional types of microbes, nutrient media (selective, differential, enriched and enrichment) and growth conditions. Physiology of growth, bacterial growth curve, methods for determining bacterial numbers, mass and cell constituents. Exponential growth and generation time. Bacterial growth in batch and continuous culture (chemostat and turbidostat)

UNIT III MICROORGNISMS AND THEIR ENVIRONMENT:

Effect of environmental conditions on survival and growth of microorganisms and adaptations. Temperature, oxygen, desiccation, extreme cold, ionic effect, osmotic pressures, radiant energy, hydrostatic pressures, and surface forces.

UNIT IV CONTROL OF MICROORGANISMS :

Inhibition of growth and killing, sterilization and disinfection, physical (moist and dry heat, radiation and filtration), chemical agents (disinfectants, antiseptics, antibiotics and other chemotherapeutic agents). Characteristics of an antimicrobial agent ; mode of action of antimicrobial agent. Classes of disinfectants - phenol and phenolics alcohol, halogens (Cl₂, Chloramines, Br₂, I₂, tinctures of iodine, iodophores), surfactants (soaps and detergents) alkylating agents (formaldehyde, glutaraldehyde, β-propiolactone) Heavy metals (Hg, Silver and copper containing compounds). Factors affecting sterilization and disinfection, (moisture, organic matter, temperature pH) Evaluation of disinfectants

UNIT V BASIC MECHANISM OF MICROBIAL METABOLISM AND ENERGY CONVERSION:

I Glycolysis, TCA cycle, EDP and HMP pathways, oxidative and photophosphorylations, anaerobic respiration and fermentation.

UNIT VI BACTERIAL PHOTOSYNTHESIS:

Bacterial photosynthesis -oxygenic and anoxygenic, bacterial pigments, photophosphorylation, CO₂ fixation.

UNIT VII MICROBIAL DEGRADATIONS AND BIOTRANSFORMATIONS :

Degradation of biopolymers : cellulose, xylan, starch , pectin, lignin and chitin, protein, nucleic acids, lipids and fats - Microbial degradation of hydrocarbons : Methane, ethane, propane, butane and other long chain alkanes, and aromatic compounds - Biodegradation of pesticides.

UNIT VIII BIO- INDICATORS:

Plankton community as indicators of water pollution, use of diversity index in evaluation of water quality, lichens as indicators of air pollution, determination of microbiology quality of potable and recreational waters.

Text Books:

1. **The microbial world** 1990. Stanier, P.R., Ingraham., Wheelis, M.L and Painter, P.R. Prentice-Hall of India Private Limited, New Delhi.
2. **Microbiology**-Pelzar, Reid and Chan. Tata-Mc Graw-Hill Publishing Company Limited.,1996
3. **Brock Biology of Microorganisms** 2010, (Twelfth Edition) Michael T. Madigan, John M. Martinko and Jack Parker Prentice Hall publication.
4. **Microbiology** 2008 (Seventh edition) Lansing M Prescott, John P.Harley and Donald A. Klein Mc Graw Hill publication.
5. **General Microbiology** (Seventh Edition) Schlegel. Cambridge University Press publisher.

Reference Books:

1. Microbiology Davis, B.D., Dulbecco, R., Eisen, H.N and Ginsberg, H.S. Harper and Row Publishers, Singapore, 1

EST -1.4 NATURAL RESOURCES

UNIT I INTRODUCTION :

Definition - Importance – Classification - Human physiological socio-economic and cultural development – Human population Explosion – Natural Resource Degradation -- Concept of conservation - Value system -- Equitable resource use for sustainable life system .

UNIT II FOREST RESOURCES:

Use and over exploitation, timber extraction, mining, dams and their effects on forest and tribal people, Forest cover in India and the World -- Importance -- Desertification – Forest Wealth – Afforestation -- Agro forestry – Social Forestry – Joint Forest Management Strategy for Forest Conservation,.

UNIT III WATER RESOURCE:

Rivers and Lakes In India – Water Conservation and ground water levels increase – Watershed Programme -Use and over utilization of surface and ground water, floods, drought, conflicts over water, dams- benefits and problems-Case Studies.

UNIT IV MINERAL RESOURCES:

Use and exploitation -- Environmental effects of extracting and using mineral resources – Restoration of mining lands – Expansion of supplies by substitution and conservation- Case Studies

UNIT V FOOD RESOURCES:

World food problems, changes caused by agriculture and over grazing, effects of modern agriculture, fertilizer- pesticide problem, water logging, salinity, case studies.

UNIT VI ENERGY RESOURCES:

Growing energy needs, renewable and non- renewable energy sources, use of alternate energy sources, case studies.

UNIT VII LAND RESOURCES :

Land as a resource, land degradation, man induced landslides, The nature of soils – soil conservation and sustainable agriculture, Land use planning – Soil Erosion – Loss of soil Nutrients -Restoration of soil Fertility – Soil Conservation Methods and Strategies in India, Wet Land conservation and Management -- Ecological Importance of wet lands in India – Conservation Strategy and ecological Importance- Case Studies

UNIT VIII BIO-DIVERSITY AND ITS CONSERVATION:

Introduction- definition: genetic, species and ecosystem diversity, Bio-geographical classification of India, India as mega diversity nation, Hot-spots of bio-diversity, threats to bio-diversity: habitat loss, poaching of wildlife, man-wildlife conflicts, Endangered and endemic species of India and conservation of biodiversity.

References:

1. Haue R and Freed V.H., Environmental Dynamics of pesticides, Menum press, London (1975).
2. Singh B, Social Forestry for Rural Development, Anmol Publishers, New Delhi (1992).
3. Shafi.R.,Forest Eco system of the World,(1992)
4. Trivedi R.K., Environment and Natural Resources Conservation , (1994)
5. Murthy J.V.S., Watershed Management in India, (1994).
6. Raymond F Dasmann, Environmental Conservation, John Wiley (1984).
7. Nalini K.S., Environmental Resources and Management, Anmol Publishers, New Delhi (1993).

EST-1.5 COMPUTER PROGRAMMING & STATISTICS

UNIT I COMPUTER BASICS :

Problem solving using computers- flowcharts-algorithms-CPU-Input and output units-.computer memory.

UNIT I STRUCTURE OF C++:

Basic concepts of Object oriented Languages - Basic structure of C++ programming- tokens-keywords- data types: basic data types-derived data types-user defined data types- constants-variables-arrays-one, two and multi dimensional arrays-structure-union-enumerated data types.

UNIT III ARITHMETIC OPERATORS:

Relational operators-increment and decrement operators-bit wise operators-arithmetic expression- precedence of operators-Evaluation of expression- type compatibility-expression and implicit conversion-manipulators-control structures: decision making and branching-decision making and looping-Function declaration and definition- argument passing-return values.

UNIT IV CLASS & OBJECTS:

Member functions- array of objects-object as a argument- function overloading- friend function- operator overloading-this pointer-static data member-static member function.

UNIT V CONSTRUCTORS:

Constructors: default constructor-parameterized-copy constructor-dynamic constructor-destructors- Inheritance-single inheritance-multiple inheritance-multilevel inheritance-pointers virtual functions and polymorphism

UNIT VI INTRODUCTION TO STATISTICS:

population-sample –primary data and secondary data - graphical and diagrammatic representation of data- Measure of central tendency-Mean, median and mode-measure of dispersion-range-standard deviation -raw and central moments-skewness and kurtosis(definition only)-Concept of probability –classical and relative frequency definition of probability-addition and multiplication laws of probability(without proofs) and examples.

UNIT VII CONCEPT OF RANDOM VARIABLES:

Probability mass function-probability density function-probability distribution function(definitions only)- Binomial ,Poisson and Normal distribution(definitions and statements of properties and examples).Principles of least square-fitting of straight line-parsons coefficient of correlation and concept of linear regression.

UNIT VIII

Concept of testing of hypothesis critical region-two type errors-level of significance of large sample tests for single mean and difference of means. single proposition and difference proportion- chi square test for goodness of fit and chi square test of means and f-test for equality of variances- arithmetic, Geometric and harmonic mean.

Text book :

1. Fundamentals of Computers by V Raja Raman
2. Object Oriented Programming with C++ by E. Balagurusawmy
3. Statistical methods S.P.Gupta. S Chand Publications

ESTL-1.6 WATER, WASTE WATER AND AIR POLLUTION ANALYSIS LAB

1. pH and Electrical Conductivity
2. Turbidity
3. Color and odour
4. Hardness
5. Alkalinity
6. Nitrate-Nitrogen
7. Ammonical-Nitrogen
8. Nitrite-Nitrogen
9. Phosphates
10. Sulfate
11. Residual chlorine
12. Chlorine demand
13. Dissolved oxygen
14. Biological oxygen demand
15. Chemical oxygen demand
16. Fluorides
17. Heavy metals by AAS
18. Estimation of NO_x
19. Estimation of SO_x
20. Estimation of Particulate matter

ESTL-1.7 COMPUTER PROGRAMMING LAB

Computer programmes with reference to environmental problems. Each student should develop and execute a minimum of 15 Programmes both in C and C++ and submit in the form a record.

1. Write a C program to evaluate the following expression
 - a. $(a + b) - (b \times c) \% a$
 - b. $(a + b) + (b \times d) / \sqrt{a}$
 - c. $(b \times a) \times (d + c) / (a + b) \% (b / d)$
 - d. $(a \% b) \times (b \% c)$
2. Write a C program to calculate the marks of 3 subjects for one student and generate a marks list.
3. Modify the above program to calculate and generate marks list for n number of students using while loop.
4. Using for loop calculate the alkalinity of 10 water samples.
5. Using do while loop write a C program to convert Centigrade to Fahrenheit.
6. Write a program to calculate the area of a triangle, square and trepezoid asking stwich – case syntax.
7. Calculate the hardness of a given water sample using C program.
8. Using While –statement write a C program to find the sum of $1 + 2 + 3 + 4 + \dots n$.
9. Repeat problem (8) using DO-WHILE statement.
10. Write a C program that prints the given 3 integers in ascending order using IF-ELSE.
11. Write a C program to convert SO_x data in $\mu\text{g}/\text{m}^3$ to ppm for 1 sample.
12. Modify the (11) program using do-while loop to calculate for 20 samples.
13. Create a class with private and public variable and declared constructors with and without parameter to the class.
14. Write a C program to find a pH of 10 water samples (use if, else and while).
15. Modify (14) program using for – loops.

EST-2.1 AIR POLLUTION AND CONTROL TECHNOLOGIES

UNIT I CLASSIFICATION AND PROPERTIES OF AIR POLLUTANTS:

Emission sources -major emissions from Global sources -importance of anthropogenic sources-behaviour and fate of air pollutants- photochemical smog-effects of air pollution-health, vegetation and materials damage in India-air pollution standards - Isolation and heat balance of the atmosphere – different types of terrain – effects of terrain features on atmosphere – mechanical and thermal turbulence- Indoor air pollution.

UNIT II METEOROLOGICAL ASPECTS OF AIR POLLUTION DISPERSIONS I:

Temperature lapse Rates and Stability-wind velocity and turbulence-Plume behavior dispersion of air pollutants- solutions to the atmospheric dispersion equation - the Gaussian Plume Model..

UNIT III METEOROLOGICAL ASPECTS OF AIR POLLUTION DISPERSIONS- II:

Air pollution sampling and measurement-types of pollutant sampling and measurement-Ambient air sampling-collection of gaseous air pollutants-collection of particulate pollutants- stock sampling, analysis of air pollutants-sulfur dioxide- nitrogen dioxide, carbon monoxide, oxidants and ozone-hydrocarbons-particulate matter.

UNIT IV CONTROL METHODS:

Sources- correction methods- -particulate emission control- gravitational settling chambers-cyclone separators- fabric filters-electrostatic precipitators-wet scrubbers- -control of gaseous emissions-adsorption by solids-absorption by liquids-combustion, condensation – control of SO₂ emission – desulphurization of flue gases – dry methods – wet scrubbing methods. Control of sulphur dioxide emission-desulphurization of flue gases-dry methods-wet scrubbing methods-control of nitrogen oxides-modification of operating conditions- modification of design conditions-effluent gas treatment methods-carbon monoxide control-control of hydrocarbons-mobile sources.

UNIT V AIR POLLUTION FROM SPECIFIC INDUSTRIES:

Portland cement plants – steel mills – petroleum refineries

UNIT VI VEHICULAR AIR POLLUTION I:

Genesis of Vehicular emissions-Natural Pollution- Gasification of Vehicles- Point sources of Air Pollution from automobiles-Fuel tank, carburettor, crank case- Exhaust emissions-Mechanism of Origin of air pollution from automobiles.

UNIT VII VEHICULAR AIR POLLUTION II:

Automobile air pollution – Indian Scenario- Population and pollution loads of vehicles- Automobile Pollution Control-Control at sources-Exhaust gas treatment devices-Alternate fuels comparison-Thermal Reactor-Catalytic Converter- Automobile Emission Control- Legal measures.

UNIT VIII NOISE POLLUTION:

Sources of noise pollution – measurement of noise and indices – effect of meteorological parameters on noise propagation- noise exposure levels and standards – noise control and abatement measures – impact of noise on human health.

Textbooks:

1. Air Pollution, H.C.V.Rao, 1990, McGraw Hill Co.
2. Environmental Pollution Control, C.S.Rao, Wiley Eastern Ltd.,1993
3. Air Pollution , M.N.Rao McGraw Hill 1993.

Reference Books:

1. Fundamentals of Air Pollution, Samuel, J.W., 1971, Addison Wesley Publishing Co.
2. Air Pollution, Kudesia, V.P. International Student Edition McGraw-Hill-Kosakusha Ltd.,Tokyo.
3. Fundamentals of Environmental Pollution, Krishnan Khannan S.Chand & Company Ltd.,1994
4. Environmental Air Analysis, Trivedi & Kudesia, Akashdeep Pub.1992
5. Air Pollution Control and Engineering, De Nevers, Mc Graw- Hills, 1993
6. Energy Technology and the Environment Atilio Bisio, Sharan Boots, Wiley Encyclopaedia Series in Environmental Science
7. Noise Pollution -Vandana Pandey, Meerut Publishers,1995
8. Air Pollution by T.Shivaji Rao,Lavanya lata Pub. 1988.

EST-2.2 WATER POLLUTION AND TREATMENT TECHNIQUES

UNIT I WATER POLLUTANTS:

Types and Sources, Heavy metals- metalloids- organic- inorganic- biological - radioactive pollutants, Eutrophication, potable water and carrying capacity of rivers.

UNIT II WATER TREATMENT:

Methods of water purification, primary treatment- sedimentation- flotation, secondary (biological) treatment- design and principles in biological treatment facilities- activated sludge process- trickling filters – low cost waste treatment systems and their design, tertiary treatment.

UNIT III INDUSTRIAL WASTEWATER TREATMENT:

Sources, Characteristics, methodology and process for the treatment of industrial wastes of sugar industry- beverage industry- tannery industry- textile mill waste industry- fertilizer plant- steel plant- oil refinery- pharmaceutical [plant- paper and pulp mill.

UNIT IV ADVANCED WASTE WATER TREATMENT:

Introduction, removal suspended solids- removal of dissolved solids- Ammonia removal- phosphorus removal- chemical oxidation- recovery of materials from process effluents.

UNIT V BIO-REACTORS FOR WASTE WATER TREATMENT:

Up Flow Anaerobic Sludge Blanket (UASB), Two-stage, Aerobic UNI Tank System (TSU-System, Route Zone Treatment, Submerged Aerobic Fixed Film (SAFF) Reactor, Fluidized Aerobic Bio – Reactor (FAB).

UNIT VI SEWAGE TREATMENT AND DISPOSAL:

Self purification of streams- BOD and its important- treatment methods- primary, secondary and tertiary levels- disinfections of treated sewage effluent- septic tank design- effluent disposal methods- disposal on land, sewage sickness- disposal by dilution- design of biological treatment units- sludge characteristics, unit operations in sludge disposal, conventional and high rate digesters- disposal of sludge- gas utilization.

UNIT VII PHYTOREMEDIATION TREATMENT:

Introduction, current trends in role of phytoremediation- examples of species potential in absorbing heavy metals and pollutants in waste water- root zone treatment technology- microbial remediation- role of bacteria and the microbes in cleaning of sewage waters- oil spilled waters- domestic waste waters- polluted agricultural run off- bio medical waste retaining waters.

UNIT VIII RECYCLING OF WASTE:

Waste types- sources- waste generation per capita- composition of waste- recycling of waste for industrial, agriculture and domestic purpose- recycling of metal products- reuse, recovery- reduction of paper, plastics- recycling of food manufacturing, beverages, apparel, leather, paper, pulp, chemical from industries- fly ash utilization.

Text Books:

1. **Water Supply and Sanitary Engineering** G.S.Bridie & J.S.Brides, Dhanpat Rai & Sons 1993.
2. **A treatise on Rural, Municipal, and industrial water management** KVSG Murali Krishna
3. **Environmental sanitation (Social and Preventive medicine)** Dr.P.V. Rama Raju & KVSG Murali Krishna.
4. **Waste water engineering, treatment and reuse** by Metcalf and eddy, fifth edition, Tata Mc Graw Hill.

Reference Books:

1. **Municipal and Rural Sanitation**-Ehlers,V.M.&Steel,E.W.McGRAW-HILLBook Company,IncV.edition. 1987.
2. **Environmental Sanitation**, Ehlers, V.M., add Steel, E.W., McGraw-Hill Book Co., Inc.
3. **Environmental pollution and Toxicology**, Meera Asthana and Asthana D.K, Alka Printers (1994)

EST-2.3 ENVIRONMENTAL BIOTECHNOLOGY

UNIT I INTRODUCTION TO ENVIRONMENTAL BIOTECHNOLOGY:

scope and Importance - Microorganisms and energy requirements of mankind - Production of nonconventional fuels-methane (biogas), hydrogen, alcohols and algal hydrocarbons and microbial fuel cells.

UNIT II BIOREMEDIATION:

Bioremediation, constraints, advantages and application, types of bio remediation (natural and engineered), bio-attenuation, ex-situ & In-situ, bio-augmentation and bio-stimulation, application, specific advantages and disadvantages of specific bioremediation technologies. Land farming, prepared beds, biopiles, composting, bioventing, pump and treatment method, phytoremediation.

UNIT III MINING AND METAL BIOTECHNOLOGY:

Microbial transformation, accumulation and concentration of metals, metal leaching, extraction and future prospects.

UNIT IV MICRO-ORGANISMS AS FOOD:

Microbial production of food (SCP), essential prerequisites for organisms to be used as SCP & as food and feed supplements. Microbial production of flavors and food colorants probiotics & prebiotics.

UNIT V BIOLOGICAL CONTROL:

Microbial control of plants, plant pests,(Bacteria, viruses, fungi and protozoa), pathogens and insects. Micro-organisms and microbial products.

UNIT VI INDUSTRIAL MICROBIOLOGY GENERAL ACCOUNT:

Maintenance of stock cultures, culture collection centers/microbial gene banks, inoculum build-up, industrial substrates, design of a bioreactor, batch and continuous fermentation and solid-substrate fermentations, Immobilization technologies.

UNIT VII MICROBIAL BIOSENSORS:

Definition, advantages and limitations, different components of a biosensor. Types of biosensors, various transducer principles (conductometric, potentiometric, amperometric and optical detector)-specific biosensors- glucose, ammonia, BOD, methane and mutagen sensors.

UNIT VIII BIOTECHNOLOGY AND INTELLECTUAL PROPERTIES:

Intellectual property rights (IPR) and protection (IPP), patents, trade secrets, copyrights, trade marks, GATT and TRIPS. Elements of preparation of TKDL (Traditional Knowledge Digital Library, convention on biodiversity).

Text Books:

1. **Elements of biotechnology**, 1995. P.K.Gupta Rastogi Co.
2. **Industrial Microbiology** - Casida, Wiley Eastern publishers,1994.
3. **Industrial Microbiology**- Prescott and Dunn.
4. **Biodegradation & Bioremediation**- Martin Alexander.

Reference Books:

1. **Biotechnology-A new industrial revolution** Prentis S. Orbis Publishing Ltd., London.
2. Microbiology Davis, B>D., Dulbecco, R., Eisen, H.N and Ginsberg, H.S. Harper and Row Publishers, Singapore., 1992.
3. Environmental Microbiology, 2000, Maier, R.M. Pepper, I.L and Gerba, C.P. Academic press.
4. Review articles published in current opinion in microbiology, microbiological reviews, Advances in Microbial physiology, Bacteriological reviews etc.

EST-2.4 REMOTE SENSING AND GIS

UNIT I INTRODUCTION

Definition of a map, types of maps, map reading, map scale, Basics of map projections. Definition, History of Remote Sensing.

UNIT II FUNDAMENTALS OF REMOTE SENSING

Components of Remote sensing, Electromagnetic Remote sensing process- Electromagnetic Spectrum and its characteristics. Laws governing energy interaction

UNIT III EMR ENERGY INTERACTION WITH ATMOSPHERE AND EARTH SURFACE

Atmospheric Scattering- Rayleigh's & Mie's theories and Atmospheric Windows.
EMR Interaction With Earth Surface Materials -Spectral signature concepts -Typical spectral reflectance of water – vegetation- soil

UNIT IV OVERVIEW OF IMAGE ANALYSIS

Basics of Visual and Digital image Interpretation-Interpretation of Satellite Imagery- Key elements in Visual Image Interpretation- Converging Evidence- Basic character of digital image- Preprocessing, Image registration, Image Enhancements, Image classification.

UNIT V GEOGRAPHIC INFORMATION SYSTEM (GIS)

Introduction, definition and terminology, GIS categories, Components of GIS Fundamental Operations of GIS, A theoretical framework for GIS. The Essential Elements of a GIS: An overview,

UNIT VI DATA STRUCTURES

Functional Elements - Data in GIS. Data Structure Raster Data Structures, Vector Data Structures, Comparisons between Data Structures.

UNIT VII DATA INPUT, DATA EDITING AND DATA QUALITY

Data input methods: Keyboard entry, Manual digitizing, Scanning and automatic digitizing. Quality - Components of data quality. Accuracy, Precision and resolution, Consistency, Completeness, Sources of error in GIS

UNIT VIII GIS DATA MANAGEMENT

GIS data file management: Simple list, ordered sequential files, Indexed files. , Database models: Hierarchical database models Relational database models.

Textbooks:

1. **Textbook of Remote Sensing and GIS** by M. Anji Reddy
2. **Remote Sensing and Image Interpretation** by T. M. Lillesand and R.W.Kiefer.
3. **Remote Sensing in Hydrology** by E. T. Engman and R. J. Curney
4. **Geographic information Systems - A Management Perspective** by Stan Aronoff
5. **Geographic Information Systems** - David Martin.
6. **Fundamentals of GIS** by Michael N. Demers

EST-2.5 INSTRUMENTAL METHODS OF ANALYSIS

UNIT I INTRODUCTION:

Type of Analytical methods – Instruments for Analysis – Uncertainties in Instrumental measurements – Sensitivity and detection limit for instruments.

UNIT II UV- VISIBLE SPECTROSCOPY :

Introduction, the absorption laws, measurement of spectrum, chromophores, units of frequency and wavenumbers– Absorptivity – Apparent deviations from Beer's law – Double beam spectrophotometer - Instrumentation – Sources of radiation – Detectors – Photometric accuracy – Chemical applications – Qualitative analysis – photometric titrations.

UNIT III INFRARED SPECTROSCOPY:

Infrared spectroscopy – Theory, Instrumentation & applications.

UNIT IV ATOMIC ABSORPTION SPECTROSCOPY:

AAA: Principle – Instrumentation – operation – Interference – applications.

UNIT V ATOMIC EMISSION SPECTROSCOPY:

Atomic Emission Spectroscopy – Theory, Instrumentation & applications. ICP: Flame Photometer Principle – Instrumentation – Interference – applications of Flame Photometry.

UNIT VI NMR SPECTROSCOPY AND XRD:

NMR theory, instrumentation, chemical shift, spin-spin couplings, applications, XRD- Bragg's equation- instrumentation and applications.

UNIT VII CHROMATOGRAPHY:

Classification, Principle and instrumentation of the thinlayer Chromatography (TLC), Gas Chromatography (GC) and High performance liquid Chromatography.

UNIT VIII POTENTIOMETRY / CONDUCTOMETRY:

Measurement of pH, Ion selective electrode – applications, Conductance measurements.

Textbook:

1. **R.A. Day** & A.L. Underwood, Quantitative analysis, Prentice-Hall of India Pvt. Ltd., 1985.
2. Skoog & West, Fundamentals of Analytical Chemistry, 1982.
3. Hobert H. Willard, D.L. Merrit & J.R.J.A. Dean, Instrumental methods of analysis, C.B.S Publishers and Distributors, 1992.

Reference books:

1. Vogel, Textbook of quantitative inorganic analysis, 1990.
2. Ewing, Instrumental Methods of Chemical Analysis, 1992, Mc Graw Hill
3. Instrumental Methodology of Analysis by Chatwal Anand, Himalaya Publishing House.

ESTL-2.6 ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY LAB

I. General techniques of microbiology

Enrichment, isolation and enumeration of Microorganisms from the environment

1. Isolation and enumeration of green algae
2. Isolation and enumeration of fungi,
3. Enrichment of purple non-sulfur bacteria

Characterization of microorganisms

1. Cultural characteristic
2. Staining
3. Biochemical tests
4. Macromolecular composition
5. Whole cell absorption spectrum

Studies on the bacterial growth patterns and cellular contents

1. Bacterial growth curve
2. Estimation of cellular contents of photosynthetic pigments

Evaluation of antimicrobial chemical agents

Evaluation of microbiological quality of water

Photo production of hydrogen

Production of violacein by ssf

Methods of microbial immobilisation

Demonstration of phosphate solubilisation activity of microbes.

Microbial fuel cells

Photobiological production of hydrogen from industrial effluents.

ESTL-2.7 SOLID WASTE CHARACTERIZATION AND INSTRUMENTAL METHODS ANALYSIS LAB

A. SOIL ANALYSIS: Estimation of following parameters:

Physical & Chemical parameters:

1)Moisture content 2)Electrical conductivity 3)Bulk density 4)Specific gravity 5)Water holding capacity 6)pH 7)potassium 8)Nitrogen (Kjeldahl) 9)Organic matter 10)Nitrate 11)Chlorides 12)Total phosphorous 13) Sulphate 14) Phosphate 15)Alkalinity 16) Calcium 17) Heavy metal 18) Magnesium 19) Sodium

B. SOLID WASTE CHARACTERISATION (INDUSTRIAL AND MUNICIPAL)

Physical & Chemical parameters:

1)Moisture content 2) Electrical conductivity 3)Bulk density 4) Specific gravity 5) Water holding capacity 6)pH 7) potassium 8)Nitrogen (Kjeldahl) 9) Organic matter 10)Nitrate 11)Chlorides 12) Total phosphorous 13) Sulphate 14) Phosphate 15) Alkalinity 16) Calcium 17)Volatile Organic Matter 18)Magnesium 19) COD 20) Sodium 21)Calorific value 22) Estimation of aromatic compounds 23) Heavy metals

C. INSTRUMENTAL ANALYSIS

- a) Ion analyzer
- b) AAS
- c) HPLC
- d) GC
- e) GCMS
- f) UV-VIS

EST-3.1 GLOBAL ENVIRONMENTAL ISSUES

UNIT I INTRODUCTION:

Human environmental Interactions- Global Environmental Agreements & Movements - Stockholm and Beyond – Evolution of International Environmental Laws- making international , national environmental agreements.

UNIT II ENVIRONMENTAL MOVEMENTS:

Global and national movements of Significance impact: RAMSAR Convention- Green Belt movement- Green Peace – Chipko movement- Narmada Bachao Andolan – Silent valley- Doon valley and related issues / case studies

UNIT III CLIMATE CHANGE:

Sea level Change – primary and secondary impacts- Adapting to Sea level changes. Global Warming- Fossil fuels- Green house gases- Global and national scenario. National Action Plan on Climate Change. (NAPCC). Climate Change and Biodiversity loss.

UNIT IV ENERGY CRISIS:

Energy requirements- Developed- Developing- Under Developed nations. Cases studies of International and National importance.

UNIT V LAND DEGRADATION :

Land pollution • Desertification - Soil — Soil conservation • Soil erosion • Soil contamination • Soil salination. Mining- reclamation of mined area. Desertification-case studies

UNIT VI NUCLEAR ISSUES:

Nuclear issues —Nuclear power • Nuclear weapons • Nuclear and radiation accidents • Nuclear safety • High-level radioactive waste management.

UNIT VII NATURAL DISASTERS AND ANTHROPOGENIC:

Natural Disaster : Volcanoes- Landslides- Tsunami- Forest Fires – Case studies
Anthropogenic : Oil spills

UNIT VIII CONTEMPORARY ISSUES:

Green Buildings- Genetic pollution- Genetically modified food controversies. Intensive farming Monoculture. Health and Diseases- Epidemics and Famines.

Textbooks:

1. Global environmental issues: a climatological approach by David D. Kemp, Taylor and Francis.

EST-3.2 ENVIRONMENTAL MODELLING

UNIT I AIR POLLUTION MODELING:

Aermod's software, ISCST models, theoretical applications, LAGA systems.

UNIT II WATER QUALITY MAPPING AND MODELING:

Introduction, role of remote sensing and GIS, case study of Hyderabad city, GIS data analysis, correlation between water quality and ground water level, correlation between water quality index and land use, ground water quality studies using SPANS, evaluation of impact of land use/land cover changes on ground water quality and spatial database creation.

UNIT III WATERSHED MANAGEMENT AND MODELING:

Philosophy and concept of watershed, technology vectors and social dynamics, role of remote sensing and GIS, GIS data base for watershed management, research approach, model watershed, soil mapping, hydro-geo-morphological mapping, groundwater prospects map, drainage mapping.

UNIT IV NATURAL DISASTER MANAGEMENT: LANDSLIDES:

Introduction, major types of landslides, common features of landslides, causes of landslides and related phenomena, landslide analysis, human causes of landslides, remote sensing for landslide mapping, landslide analysis in GIS, hazard mapping of landslide, case study: Kohima area.

UNIT V GIS AND ENVIRONMENTAL MODELING:

Overview of GIS for environmental problem solving, software's in integrating GIS and environmental modeling, ARC/INFO, ARC/VIEW and spans GIS.

UNIT VI SALT WATER INTRUSION MODELING:

Introduction, saline water intrusion (SWI), applications of Geo-informatics, case study: Pennar basin, GIS database, spatial database, attribute data base creation, generation spatial distribution maps of water quality, SWI model development.

UNIT VII

GIS in hazardous waste site investigations, GIS in natural hazard assessment, GIS for environmental planning, GIS for ecological systems, GIS in risk management.

UNIT VIII

AVHRR land data sets for environmental monitoring and modeling, ocean color monitoring by OCEANSAT, remote sensing and GIS for EIA of pipeline alignments, GIS for urban and transportation planning, remote sensing and GIS for terrain evaluation analysis.

Reference books:

1. Environmental modeling with GIS by Michael F. Good Child, Bradley O.Parks, Louis T. Steyaert.
2. Geo-informatics for Environmental management by Dr. M. Anji Reddy, B Publications.

EST – 3.3 SOLID & HAZARDOUS WASTE MANAGEMENT

UNIT I SOLID WASTE:

Definition of solid wastes – types of solid wastes – Sources - Industrial, mining, agricultural and domestic – Characteristics. Solid waste Problems - impact on environmental health – Concepts of waste reduction, recycling and reuse.

UNIT II COLLECTION, SEGREGATION AND TRANSPORT OF MUNICIPAL SOLID WASTES:

Handling and segregation of wastes at source. Collection and storage of municipal solid wastes; analysis of Collection systems. Transfer stations .

UNIT III MUNICIPAL SOLID WASTE MANAGEMENT:

Solid waste processing technologies. Mechanical and thermal volume reduction. Biological and chemical techniques for energy and other resource recovery: composting, vermicomposting, termigradation, fermentation. Incineration of solid wastes. Disposal in landfills: site selection, design, and operation of sanitary landfills; Leachate and landfill gas management; landfill closure and post-closure environmental monitoring; landfill remediation. Regulatory aspects of municipal solid waste management.

UNIT IV HAZARDOUS WASTES:

Hazardous waste definition. Physical and biological routes of transport of hazardous substances – sources and characterization categories and control. Sampling and analysis of hazardous wastes – analytical approach for hazardous waste characterization – proximate analysis – survey analysis – directed analysis – analytical methods.

UNIT V HAZARDOUS WASTES MANAGEMENT:

Sources and characteristics: handling, collection, storage and transport, TSDF concept. Hazardous waste treatment technologies - Physical, chemical and thermal treatment of hazardous waste: solidification, chemical fixation, encapsulation, pyrolysis and incineration. Hazardous waste landfills - Site selections, design and operation. Hazardous waste reduction and Recycling-Regulatory aspects of HWM.

UNIT VI BIOMEDICAL WASTE MANAGEMENT:

Biomedical waste: Definition, sources, classification, collection, segregation Treatment and disposal.

UNIT VII RADIOACTIVE WASTE MANAGEMENT:

Radioactive waste: Definition, Sources, Low level and high level radioactive wastes and their management, Radiation standard by ICRP and AERB

UNIT VIII E-WASTE MANAGEMENT:

Waste characteristics, generation, collection, transport and disposal.

Book Recommended

1. Hazardous waste management by Prof. Y. Anjaneyulu.
2. Hazardous waste management Charles A. Wentz. Second edition 1995. McGraw Hill International.
3. Integrated solid waste management George Tchobanoglous, Hilary Theisen & Samuel A. Vigil.
4. Criteria for hazardous waste landfills – CPCB guidelines 2000.
5. Environmental Science by Daniel B. Botkin and Edward A. Keller, Wiley student, 6th edition- 2009.

EST-3.4 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

UNIT I CONCEPTUAL FACTS OF EIA:

Introduction, Definition and Scope of EIA, Objectives in EIA, Basic EIA Principles, Classification of EIA: Strategic EIA (SEIA), Regional EIA, Sectoral EIA, Project Level EIA and Life Cycle Assessment, Project Cycle, Grouping of Environmental Impacts: Direct Impacts, Indirect Impacts, Cumulative Impacts and Induced Impacts. Significance of Impacts: Criteria/Methodology to Determine the Significance of the Identified Impacts.

UNIT II BASELINE DATA ACQUISITION:

Environmental Inventory, Data Products and Sources: thematic data, topographical data, collateral data and field data. Environmental Baseline Monitoring (EBM), Preliminary Study to determine impact significance, Environmental Monitoring network Design, Monitoring Stations, Air quality data acquisition, Water Quality data acquisition, soil data, socioeconomic data and biological data acquisition. Impact on Environmental Components: Significance of Impacts, Criteria to determine the significance of the identified Impacts.

UNIT III PLANNING AND MANAGEMENT OF IMPACT STUDIES:

Conceptual Approach for Environmental Impact Studies, Proposal Development, Interdisciplinary Team Formations, Team Leader Selection and Duties, General Study Management, Fiscal Control.

UNIT IV OPERATIONAL ASPECTS OF EIA:

Screening: Application for Prior Screening for Environmental Clearance, Screening Criteria; Category A Projects, Category B Projects, Criteria for Classification of Category B1 and B2 Projects, Consistency with other Requirements and Siting Guidelines. Scoping: Identification of Appropriate Valued Environmental Components(VEC), Identification of Impacts, Information in Form 1, Structure of a Pre-feasibility Report. Public consultation: Appraisal, Decision Making, Post-clearance Monitoring Protocol.

UNIT V METHODS FOR IMPACT IDENTIFICATION:

Background Information, Interaction-Matrix Methodologies: simple matrices, stepped matrices, development of a simple matrix, other types of matrices, summary observations on matrices, Network Methodologies: Checklist methodologies, simple checklists, descriptive Checklists, summary observations on simple and descriptive Checklists.

UNIT VI PREDICTION OF IMPACTS (AIR AND WATER):

Air Environment: Basic information on air quality, Sources of Pollutants, effects of pollutions, Conceptual approach for addressing air environment impacts, Air quality standards, Impact Prediction, Impact significance. Water Environment: Basic Information on surface-Water Quantity and Quality, Conceptual Approach for Addressing Surface-Water-Environment Impacts, Identification of Surface-Water Quantity or Quality Impacts, Procurement of Relevant Surface-Water Quantity-Quality Standards, Impact Predictions, Assessment of Impact Significance.

UNIT VII PREDICTION OF IMPACTS (NOISE, SOIL, BIOLOGICAL AND SCIO-ECONOMIC):

Basic Information on Noise Key Federal Legislation and Guidelines, Conceptual Approach for Addressing Noise-Environment Impacts, Identification of Noise Impacts, Procurement of Relevant Noise Standards and/or Guidelines, Impact Prediction, Assessment of Impact Significance. Soil Environment: Human Health and Society, Biological Environment: Basic Information on Biological Systems, Conceptual Approach for Addressing Biological Impacts, Identification of Biological Impacts, Description of Existing Biological Environment Conditions, Procurement of Relevant Legislation and Regulations, Impact Prediction, Assessment of Impact Significance.

UNIT VIII ENVIRONMENTAL MANAGEMENT PLAN (EMP):

Case Study, identification of Impacts, EMP for Air Environment: Dust Control Plan, Procedural Changes, Diesel Generator Set Emission Control Measures, Vehicle Emission Controls and Alternatives, Greenbelt Development. EMP for Noise Environment, EMP for Water Environment: Water Source Development, Minimizing Water Consumption, Domestic and Commercial Usage, Horticulture, Storm Water Management. EMP for land Environment: Construction Debris, hazardous Waste, Waste from temporary Labour settlements.

Text Books:

1. Textbook of Environmental Science & Technology by M.Anji Reddy, BS Publications, 2010
2. Technological guidance manuals of EIA. MoEF.
3. EIA by Canter

EST-3.5 OCCUPATIONAL HEALTH AND SAFETY

UNIT 1 INTRODUCTION TO SAFETY PHILOSOPHY:

Sequence of Accident Occurrence, Occupational Injuries-Effects of Industrial Accidents, Analysis of Accidents, Injury Data, Accident Investigations & Reporting, Accident Costing

UNIT II SAFETY & HEALTH MANAGEMENT:

Employer & Employee Responsibilities, Record-keeping & Reporting Requirements, Safety Organization, Responsibilities of Safety Officer, Supervisors, Safety committees.

UNIT III RISK MANAGEMENT:

Definitions of Hazards, Risks, Evolution of Methodical Analysis, System safety Analysis techniques, Performance measurement, Operational Reviews - Internal & External.

UNIT IV WORK PRACTICES IN INDUSTRIES:

Hazards in Chemical Operations, Material Handling Hazards, Lifting Machinery & Pressure Vessels, Material Safety Data Sheets, Classification of Chemicals, Hazardous Chemicals, Storage Practices, Radiation Safety, Petroleum Storage Requirements, Pesticide Safety.

UNIT V INDIAN STATUTES:

Central Acts, Factory's Act, AP Factory Rules, Construction Safety Regulations, Petroleum Rules 2002, Electrical Act & Rules.

UNIT VI FIRE SAFETY:

Basic Elements, Causes, Industrial Fires, Explosions, Effect On Environment, Property & Human Loss, Prevention Techniques, Building Design, Fire Protection Systems, Contingency Plan, Emergency Preparedness, Evacuation.

UNIT VII INDUSTRIAL BEST PRACTICES:

In Electrical, Mechanical, Fire, Machine Guarding, Personal Protective Equipment, Occupational Health, Ergonomics Ambulance, Noise Abatement Methods, Management Of Contractors.

UNIT VIII OCCUPATIONAL SAFETY & MANAGEMENT STANDARDS:

Indian Standards, OHSAS 18001 Standard and its Elements, CE Certificate, Social Accountability Standards, System Implementation, Benefits.

Text Books:

1. Industrial safety and health, David L. Goetsch, Macmillan Publishing Company, 1993.
2. Handbook of environmental health and safety, Vol I & II, Herman Kooren, Michael Bisesi, Jaico Publishing House, 1999.

ESTL-3.6 WATER AND WASTEWATER TREATMENT METHODS LAB

Unit operations for water treatment

1. Coagulation
2. Softening
3. Mixing and Flocculation
4. Chlorinating and Disinfection
5. Defluoridation
6. Hardness removal by lime soda process
7. Reverse Osmosis

Unit operations for wastewater treatment

1. Sedimentation
2. Filtration
3. Trickling filter
4. Activated Sludge
5. Rotating biological contractor
6. Anaerobic digester
7. UASB
8. Adsorption
9. Ion exchange

ESTL-3.7 RS and GIS LAB

1. Study of toposheet and base map preparation
2. Visual interpretation and digital analysis of satellite data for extraction of thematic information
 - ◆ **Road network**
 - ◆ **Drainage**
 - ◆ **Watershed**
 - ◆ **Slope**
 - ◆ **Land use/land cover**
 - ◆ **Geomorphology**
3. Scanning / digitization of maps using Autocad
4. Demonstration of GIS software and its application
5. Data entry, manipulations and analysis using PC ARC/INFO and Arc View
6. Digital image processing using ERDAS