

**UNIVERSITY OF MUMBAI**

**Syllabus for the M.Sc. Part - II  
[Sem III and IV]**

**Program: M.Sc.**

**Course: Life Sciences**

**Specialisation:**

**Environmental biotechnology**

(Credit Based Semester and Grading System with  
effect from the academic year 2017-2018)

**Restructured for Credit Based and Grading System**  
**To be implemented from the Academic year 2017-2018**

**SEMESTER III**

Course Code	UNIT	TOPIC HEADINGS	Credits	L / Week
<b>PSLSCEBTT301</b> <b>(Biomathematics and Environmental science)</b>	<b>I</b>	<b>Biomathematics</b>	<b>4</b>	
	<b>II</b>	<b>Foundations of environment</b>		
	<b>III</b>	<b>Natural resources</b>		
	<b>IV</b>	<b>Approach in environmental science</b>		

<b>PSLSCEBTT302</b> <b>(Pollution)</b>	<b>I</b>	<b>Air pollution</b>	<b>4</b>	
	<b>II</b>	<b>Water pollution</b>		
	<b>III</b>	<b>Land and noise pollution</b>		
	<b>IV</b>	<b>Radiation, thermal pollution and Electronic waste(E-waste)</b>		

<b>PSLSCEBTT303</b> <b>(Environmental microbiology, toxicology and laws)</b>	<b>I</b>	<b>Environmental microbiology</b>	<b>4</b>	
	<b>II</b>	<b>Bioremediation and biodegradation</b>		
	<b>III</b>	<b>Environmental toxicology</b>		
	<b>IV</b>	<b>Environmental issues and laws</b>		

<b>PSLSCEBTT304</b> <b>(Research Methodology and Quality Control)</b>	<b>I</b>	<b>Research Methodology</b>	<b>4</b>	
	<b>II</b>	<b>Scientific Writing</b>		
	<b>III</b>	<b>ISO</b>		
	<b>IV</b>	<b>GMP / GLP</b>		
<b>PSLSCEBTP301</b>	<b>Biomathematics, Research Methodology and environmental science</b>		<b>2</b>	

<b>PSLSCEBTP302</b>	Pollution	<b>2</b>	
<b>PSLSCEBTP303</b>	Environmental microbiology, toxicology and laws	<b>2</b>	
<b>PSLSCEBTP304</b>	Dissertation on Literature Review	<b>2</b>	

**SEMESTER IV**

<b>PSLSCEBTT401 (Applied environmental biotechnology)</b>	<b>I</b>	<b>Fermentation technology I</b>	<b>4</b>	
	<b>II</b>	<b>Fermentation technology II</b>		
	<b>III</b>	<b>Environmental monitoring</b>		
	<b>IV</b>	<b>Agricultural biotechnology</b>		

<b>PSLSCEBTT402 (Waste management)</b>	<b>I</b>	<b>Industrial and municipal waste</b>	<b>4</b>	
	<b>II</b>	<b>Liquid waste management</b>		
	<b>III</b>	<b>Solid waste management</b>		
	<b>IV</b>	<b>Biological degradation of hazardous waste</b>		

<b>PSLSCEBTT403 (Industrial environmental biotechnology)</b>	<b>I</b>	<b>Sustainable technology</b>	<b>4</b>	
	<b>II</b>	<b>Biofuels</b>		
	<b>III</b>	<b>Natural resource recovery</b>		
	<b>IV</b>	<b>Biotechnology of marine environment</b>		

<b>PSLSCEBTT404 (Genetic Engineering and Food Technology)</b>	<b>I</b>	<b>Microbial Cell Factories and their modification</b>	<b>4</b>	
	<b>II</b>	<b>Applications of Genetic Engineering</b>		
	<b>III</b>	<b>Food Constituents and Nutrition</b>		
	<b>IV</b>	<b>Food Technology</b>		

<b>PSLSCEBTP401</b>	Applied environmental biotechnology	<b>2</b>	
<b>PSLSCEBTP402</b>	Waste management	<b>2</b>	
<b>PSLSCEBTP403</b>	Industrial environmental biotechnology	<b>2</b>	
<b>PSLSCEBTP404</b>	Dissertation of Research Project	<b>2</b>	

**M.Sc. Part – II Life Sciences Syllabus**  
**Restructured for Credit Based and Grading System**  
**To be implemented from the Academic year 2017-2018**  
**Semester III Detailed Syllabus**

<b>Course Code</b>	<b>Title</b>	<b>Credits</b>
<b>PSLSCEBTT301</b>	<b>Biomathematics and environmental science (60L)</b>	<b>4</b>
<b>Unit I : Biomathematics</b> <ul style="list-style-type: none"> <li>• Matrices, Rank of Matrices by Diagonalisation method Limit and derivatives, Differentiation (including differentiability), Successive Differentiation and their application in biological research.</li> <li>• Integration – Definite and Indefinite; Application of integration to find area and application in biological research.</li> <li>• Differential equations --homogeneous and Linear ODE's and its simple applications to biological problems.</li> </ul>		
<b>Unit II : Foundations of Environment (15L)</b> <ul style="list-style-type: none"> <li>• <b>Environment:</b> Definition, principle and scope of environmental science.</li> <li>• <b>Man Environment relationship and impact of technology:</b> Agriculture revolution and its impact on the environment.</li> <li>• <b>Geographical classification:</b> Different biomes in different region, distribution of biomes, tropical rain forests, temperate forests, coniferous forests, arctic</li> </ul>		

<p>tundra, grasslands and deserts .Island biogeography: Zones of India. Biosphere reserves.</p> <ul style="list-style-type: none"> <li>• <b>Aquatic ecosystems</b> –coastal zones, coral reefs and their importance, mangroves, coastal wetlands</li> <li>• <b>Geological Hazards Catastrophic geological hazards.</b> Study of floods, landslides, earthquakes, volcanism and avalanche. Prediction and perception of the hazards and adjustments to hazardous activities.</li> </ul>	
<p><b>Unit III : Natural resources (15L)</b></p> <ul style="list-style-type: none"> <li>• <b>Natural resources:</b> renewable and non-renewable natural resources, destruction and conservation of resources; Mineral resources</li> <li>• <b>Water resources:</b> Availability of water resources, water needs, annual supply of water, water-shortage (reasons and its impact), Water scarcity and its management. Water use – irrigation, domestic, industrial, and miscellaneous; Methods of water conservation</li> <li>• <b>Forest resources:</b> classification of forests, forest resources, destruction of forests – natural and manmade, International initiatives in forest conservation, State of forests in India, Local communities and forest conservation in India;</li> <li>• <b>Energy resources:</b> Source of our energy, Pattern of global energy use, non-renewable fossil fuels (coal reserves, natural gas, nuclear power), Concerns regarding depletion of oil resources, renewable sources (solar, wind, hydropower, biofuel, fuel cells), Conserving and using energy efficiently.</li> </ul>	
<p><b>Unit IV : Approach in environmental science(15L)</b></p> <ul style="list-style-type: none"> <li>• Role of environmental biotechnology; Scope for use, Market for environmental biotechnology, modalities and local influences,</li> <li>• Integrated approach in environmental biotechnology</li> <li>• Immobilisation, Degradation or monitoring of pollutants from a biological origin.</li> <li>• Metabolic Pathways of Particular Relevance to Environmental Biotechnology</li> </ul>	

**Practicals:**

<b>PSLSCEBTP301</b>	<p><b>Biomathematics, Research methodology and environmental science.</b></p> <ol style="list-style-type: none"> <li>1. Solve sums on derivation and integration related biological data.</li> <li>2. Determination of total organic matter in soil.</li> <li>3. Determine the total phosphorus in given soil sample.</li> <li>4. Determination of pH value of different types of soil</li> <li>5. Determination of water holding capacity of soil.</li> <li>6. Determination of Specific gravity of soil.</li> <li>7. Case Study- Project Tiger</li> <li>8. Case study – impact of agriculture on environment</li> </ol>	<b>2</b>	<b>04</b>
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Course Code	Title	Credit
<b>PSLSCEBTT302</b>	<b>Pollution (60L)</b>	<b>4</b>
<p><b>Unit I : Air pollution (15L)</b></p> <ul style="list-style-type: none"> <li>• Natural and anthropogenic sources of pollution,</li> <li>• Primary and secondary pollutants transport and diffusion of pollutants, Effect of air pollution, control measures for air pollution;</li> <li>• Methods of monitoring and control of air pollution - SO<sub>x</sub>, NO<sub>x</sub>, CO,</li> </ul>		

<p>SPM, PAN; Level of air pollution in India.</p> <ul style="list-style-type: none"> <li>• Ambient air quality in India; The Air (Prevention and Control of Pollution) Act, 1981; Acid rains</li> </ul>	
<p><b>Unit II : Water pollution (15L)</b></p> <ul style="list-style-type: none"> <li>• <b>Types and sources of water pollution:</b> marine, fresh and ground water; consequences of water pollution;</li> <li>• Analysis of water quality, Water quality and standards,</li> <li>• <b>Marine pollution:</b> Oil pollution and marine ecology, sources of oil pollution, factors affecting fate of oil after spillage movement, spreading, evaporation, emulsification, dispersion, Remote sensing in water quality monitoring.</li> <li>• Coastal pollution, international initiatives to control marine pollution Eutrophication and monitoring eutrophication; algal blooms .</li> <li>• The Water (Prevention and Control of Pollution) Act, 1974</li> </ul>	
<p><b>Unit III : Land and Noise pollution (15L)</b></p> <ul style="list-style-type: none"> <li>• <b>Soil pollution:</b> Sources of pollution – water logging, soil salinity, desertification, mining, pollution by plastic, dumping of hazardous and toxic waste.</li> <li>• Recycling solid waste and restoring soil condition</li> <li>• Industrial waste effluents and heavy metal; managing of urban waste in India; Chemical and bacteriological analysis of soil sample, soil sampling methods and procedures</li> <li>• <b>Noise pollution:</b> Basic properties of sound waves; loudness and intensity levels, decibel; Sources of Noise Pollution–Measurement and analysis of sound, Measures to control noise pollution</li> </ul>	
<p><b>Unit IV : Radiation, Thermal pollution and Electronic waste (E-waste) (15L)</b></p> <ul style="list-style-type: none"> <li>• <b>Radiation pollution:</b> Radioactive decay; Interaction of radiation with m</li> </ul>	

<p>Biological impact and health hazards associated with radiation; radioactive waste disposal.</p> <ul style="list-style-type: none"> <li>• <b>Thermal pollution:</b> Definition and sources, Chemical and biological effects of thermal pollution; Effect on marine life, bacteria and water quality and other aquatic biota; Methods for minimization and control of thermal pollution.</li> <li>• <b>Electronic waste (E-waste):</b> Sources and types and constituents of E-wastes and its environmental consequences.</li> </ul>	
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**Practicals:**

<b>PSLSCEBTP302</b>	<p><b>Pollution</b></p> <ol style="list-style-type: none"> <li>1. Determination of mechanical composition of soil.</li> <li>2. To study the soil profiles for their height, color, texture and electrical conductivity.</li> <li>3. Determination of Nitrate, phosphate and sulphate from soil / water</li> <li>4. Isolation of Microorganisms from polluted environment/Soil /Water resources /Air</li> <li>5. Case study – Supersonic jets / Concorde</li> <li>6. Case study – Bhopal Gas tragedy</li> <li>7. Case study – APHA, AWWA</li> <li>8. Case study- Acid Rain</li> </ol>	<b>2</b>	<b>04</b>
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Course Code	Title	Credit
PSLSCEBTT303	<b>Environmental microbiology, toxicology and laws (60L)</b>	<b>4</b>
<p><b>Unit I: Environmental microbiology</b></p> <ul style="list-style-type: none"> <li>• <b>Microbiome:</b> Microorganisms in nature and their importance, sampling, culture and cultivation of microorganisms; Microorganisms involved and used in service of nature and humans;</li> <li>• Microbiology of water, air and soil .</li> <li>• Microbes and Environment Role of microorganisms in natural system and artificial system; Influence of Microbes on the Earth’s Environment and Inhabitants; Ecological impacts of microbes; Symbiosis (Nitrogen fixation and ruminant symbiosis); Microbes and Nutrient cycles; Microbial communication system; Quorum sensing; Microbial fuel cells; Prebiotics and Probiotics.</li> <li>• <b>Microbial diversity:</b> Molecular methods of identification of microorganisms – DGGE, TGGE, ARDA, T-RFLP, 16S rDNA sequencing , Database project, Metagenomics and RNA sequencing</li> </ul>		
<p><b>Unit II: Bioremediation and biodegradation(15)</b></p> <ul style="list-style-type: none"> <li>• Bioremediation, insitu and exsitu bioremediation techniques, Bioaugmentation and biostimulation. Evaluating Bioremediation.</li> <li>• Phytoremediation, Metals bioremediation,</li> <li>• Gaseous bioremediation.</li> <li>• Methods in determining biodegradability, Contaminants available for biodegradation.</li> <li>• Microbial degradation of biopolymers:Cellulose,xylan.starch,pectins,lignin and chitinand polyhydroxy alkanoates.</li> </ul>		
<p><b>Unit III : Environmental toxicology (15L)</b></p> <ul style="list-style-type: none"> <li>• Toxic chemicals in the environment (air and water) – their effects and biochemical interactions;</li> </ul>		

<ul style="list-style-type: none"> <li>• Biochemical aspects of arsenic, cadmium, lead, mercury, carbon monoxide, ozone and PAN pesticide; Mode of entry of toxic substance, its breakdown and detoxification; biotransformation of xenobiotics; Insecticides / Pesticides in environment, MIC effects</li> <li>• Carcinogens in environment, chemical carcinogenicity, mechanism of carcinogenicity, environmental carcinogenicity testing.</li> <li>• Epidemiological issues of toxic compounds and metal poisoning</li> </ul>	
<p><b>Unit IV : Environmental issues and environmental laws (15L)</b></p> <ul style="list-style-type: none"> <li>• Ozone layer depletion (Montreal protocol), El Nino, Acid rain - causes and effects, Green House Effect global climate change – GHG and green house effect, global warming – effect on oceans, coastline and marine ecosystem, impact of global warming on India. Response to global warming – Kyoto protocol and its outcome</li> <li>• International Environmental Policies: Nature of Environmental Policies; Stockholm Conference(1972); Rio Conference (UNCED)(1992); Merits of the Conference (Agenda 21); Failures of the Conference.</li> <li>• National Environmental Policy: National Policy on EIA and Regulatory Framework.</li> <li>• International Agreements and Treaties: Concept of agreement and treaty; Need of international agreements and treaties; Johannesburg treaty; GAAT and Environment; CTES.</li> <li>• The Biodiversity Rules, 2004; The Biological diversity act 2002; The Wildlife Preservation Act, 1982; The Wildlife (Protection) Act, 1972; Forest (Conservation) Act, 1980.</li> </ul>	

**Practicals:**

<b>PSLSCEBTP203</b>	<b>Environmental microbiology, toxicology and laws(60L</b> <b>1 Characterisation of Microorganisms :</b> a. Cultural Characteristics b. Staining <b>2 Biochemical Tests</b> <b>3 Effects of Environment on Microorganisms :</b> Oligodynamic effect <b>4 Determination of thermal death point and thermal death time of microorganisms.</b> <b>5. Toxicity Testing: The Effect of Chemicals on Seeds</b> <b>6. Case Study : El Nino</b> <b>7. Case Study : Mercury pollution</b> <b>8. Case Study: EIA</b>	<b>2</b>	<b>04</b>
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<b>Course Code</b>	<b>Title</b>	<b>Credit</b>
<b>PSLSCEBTT304</b>	<b>Research Methodology and Quality Control (60L)</b>	<b>4</b>
<b>Unit I : Research Methodology (15L)</b> <ul style="list-style-type: none"> <li>• Meaning of Research;</li> <li>• Objectives of research, motivation in research;</li> <li>• Types of research – Descriptive, Analytical, Applied, Fundamental, Quantitative, Qualitative, Conceptual, Empirical and Other Types of Research;</li> <li>• Research Approaches; Research Methods vs. Methodology;</li> <li>• Research and Scientific Method;</li> <li>• Research Process: Steps of research process; Criteria of Good Research;</li> <li>• Sampling, Sample size determination, Plan for data collection,</li> <li>• Methods of data collection, Plan for data processing and analysis;</li> <li>• Ethical considerations during research</li> </ul>		

<p><b>Unit II : Scientific writing (15L)</b></p> <ul style="list-style-type: none"> <li>• Meaning of Scientific and non scientific writings; Structures of Research proposals, Synopsis, Dissertations, Thesis, Research paper writings (Abstract, Introduction, Review literature, methodology, Results, Discussions, Summary, Conclusion, Bibliography etc);</li> <li>• Presentations: Graphical, Tabular, Animation, Power point etc</li> </ul>	
<p><b>Unit III: ISO (15L)</b></p> <ul style="list-style-type: none"> <li>• <b>Introduction:</b> Over View of standards in ISO9000 Family</li> <li>• <b>Key principles:</b> Key principles of ISO 9000- Quality Management System</li> <li>• <b>ISO 9001:</b> Detailed study on ISO 9001:2015 standard, based on a seven principles of quality management, including a strong customer focus, the motivation and implication of top management, the process approach and continual improvement</li> <li>• <b>Application:</b> Sector specific Application of ISO 9001- Quality Management System adapted by various industries</li> </ul>	
<p><b>Unit IV: GMP/ GLP (15L)</b></p> <ul style="list-style-type: none"> <li>• <b>Introduction:</b> Good Manufacturing Practices (GMO) and Good Laboratory Practices (GLP) in Pharmaceutical Industries.</li> <li>• Overview of GMPs is enforcement by the U.S. Food Drug Administration (US FDA) under Title 21 CFR</li> <li>• <b>Documentation requirement</b> for GMP and GLP</li> <li>• <b>Case studies for Documentation</b> related to SOP preparation and CAPA (Corrective action Preventive Action).</li> </ul>	

**Practicals:**

<p><b>PSLSCEBTP304</b></p>	<p><b>Dissertation in Literature Review (60L)</b> 1. Project dissertation of literature review</p>	<p align="center"><b>2</b></p>	<p align="center"><b>04</b></p>
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### Semester IV Detail Syllabus

Course Code	Title	Credit
<b>PSLSCENBT401</b>	<b>Applied environmental biotechnology (60L)</b>	<b>4</b>
<b>Unit I: Fermentation technology I (15L)</b> <ul style="list-style-type: none"> <li>• Basic principles in bioprocess technology; Media Formulation; Sterilization; Thermal death kinetics; Primary and secondary metabolites; Extracellular enzymes; Biotechnologically important intracellular products; exopolymers</li> <li>• Strain improvement: Methods of strain improvement in fermentation. Use of molecular biology for development of strain to be utilized for fermentation examples with respect to environmental biotechnology</li> <li>• Bioprocess control and monitoring variables such as temperature, agitation, pressure, pH Microbial processes-production, optimization, screening, strain improvement, factors affecting down stream processing and recovery; Representative examples of ethanol, organic acids, antibiotics etc.</li> </ul>		
<b>Unit II: Fermentation Technology II (15L)</b> <ul style="list-style-type: none"> <li>• Types of bioreactor, design of bioreactor.</li> <li>• Types of fermentation: Batch, Continuous and Fed-batch system.</li> <li>• Comparison of batch and continuous culture.</li> <li>• Monod kinetics.</li> <li>• Fed-batch culture – types and applications</li> <li>• Enzyme Technology-production, recovery, stability and formulation of bacterial and fungal enzymes-amylase, protease, penicillin acylase, glucose isomerase; Immobilised Enzyme and Cell based biotransformationssteroids, antibiotics, alkaloids, enzyme/cell electrodes</li> </ul>		
<b>Unit III : Environmental monitoring (15L)</b> <ul style="list-style-type: none"> <li>• Definition and environmental monitoring process; Sampling – land (site) sampling, water sampling, air sampling,</li> </ul>		

<ul style="list-style-type: none"> <li>• Analysis – physical, chemical and biological analysis methods and process</li> <li>• Monitoring pollution- Bioindicators , Biomarkers.</li> <li>• Toxicity testing using biological material</li> <li>• Biosensors – mechanism, principle and working</li> <li>• Environment Impact Assessment: EIA complete process, Importance of EIA</li> <li>• Principles of environmental mitigation and monitoring.</li> <li>• Principles of Remote sensing, its applications in Environmental Monitoring</li> <li>• <b>Geographical Information System (GIS)</b> Concept of GIS; Types of Geographical Data. Importance of Geographical Information System in environmental studies.</li> </ul>	
<p><b>Unit IV : Agricultural biotechnology (15L)</b></p> <ul style="list-style-type: none"> <li>• Application of biotechnology in agriculture – Detection and diagnostics, Micropropagation;</li> <li>• Somatic cell genetics – production of callus and suspension cultures, production of protoplasts, somaclonal variation, protoplast fusion, haploid production</li> <li>• Transgenic plants: Production of transgenic plants – complete process, vectors used, transformation methods used; Types of GM Plants and Products obtained from GM Plants, Biopharming, Safety of transgenic crops</li> <li>• Transgenic animals: Production – process, disease control, germplasm and biodiversity .</li> <li>• Biofertilisers, biopesticides, bioinsecticides and bioherbicides.</li> </ul>	

**Practicals:**

<b>PSLSCEBTP401</b>	<b>Environmental Monitoring</b> 1. Estimation of total solids 2. Estimation of volatile solids 3. Estimation of cellulose 4. Estimation of starch 5. Estimation of organic carbon – Walkely and Black’s method 6. Estimation of phosphate 7. Carry out fermentation using <i>Saccharomyces spp.</i> to produce ethanol 8. Case study on EIA	<b>2</b>	<b>04</b>
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<b>Course Code</b>	<b>Title</b>	<b>Credit</b>
<b>PSLSCEBTT402</b>	<b>Waste management (60L)</b>	<b>4</b>
<b>Unit I: Industrial and municipal wastes (15L)</b> <ul style="list-style-type: none"> <li>• Waste classification and characterisation, Waste material suitable for Biological treatment,</li> <li>• Wastewater Treatment, BOD Removal, Types of Biological Processes,</li> <li>• Activated Sludge Process, Sludge, Tapered Aeration, Step Feed Aeration, Contact Stabilization, Complete Mix, Extended Aeration, Oxidation Ditch, Anaerobic Digestion</li> <li>• <b>Sludges</b>, Desulfurization, Nitrification/ Denitrification, Nitrification, Suspended Growth Systems, Attached Growth Systems, Aquatics</li> </ul>		
<b>Unit II: Liquid waste management (15L)</b>		

<ul style="list-style-type: none"> <li>• Waste-treatment system, Sewage-treatment methods;</li> <li>• Design of bioreactors for liquid waste management – activated sludge process, trickling filters, rotating biological contactors, anaerobic treatment of waste water;</li> <li>• Modification of existing processes, removal of nitrogen and phosphorus, sludge removal and disposal, agricultural waste treatment.</li> </ul>	
<p><b>Unit III : Solid waste management organisms (15L)</b></p> <ul style="list-style-type: none"> <li>• Solid waste management – Introduction, Treatment processes for solid wastes, thermal conversion process, biological conversion process,</li> <li>• Landfill and landfill bioreactor for solid waste treatment</li> <li>• Biological Control Methods: Land Treatment, Composting, Liquids/Solids Treatment Systems (LSTS) , Soil Biofilters, Trickling Over Process, Stabilization,</li> </ul>	
<p><b>Unit : IV Biological Degradation Of Hazardous Wastes (15L)</b></p> <ul style="list-style-type: none"> <li>• Introduction; Abiotic Treatment Techniques: Wastewater Treatment, Liquids-Solids Separation, Chemical Treatment, Physical Methods, Incineration, Wet Air Oxidation, Solidification Techniques,</li> <li>• Degradability: Basis for Biodegradation, Genetics, Testing for Recalcitrance, Aerobic Tiered Testing, Anaerobic Tiered Testing; Testing for Recalcitrance;</li> <li>• Biochemical pathways of hazardous waste remediation: PCB Biodegradation, Landfill Leachate; TCE Degradation, Any Example of biodegradation (Aromatic Hydrocarbon, Chlorinated Wastes, p-Nitrophenol Degradation, Dioxin, Selenium)</li> </ul>	



**Practicals:**

<b>PSLSCEBTP402</b>	<p><b>Waste management (60L)</b></p> <ol style="list-style-type: none"> <li>1. Waste water analysis - pH, COD, BOD, Hardness, halides, Total solids, alkalinity and chloride.</li> <li>2. Assessment of point of use water purifiers for removal of bacteria and the Bacteriological examination of Water.</li> <li>3. Detection and isolation of industrially important microorganisms – lipase producers, oil degraders, antibiotic producers.</li> <li>4. ETP: Primary, chemical and biological treatment.</li> <li>5. Microbial degradation of textile/dyes/pesticides Hydrocarbon and oils.</li> <li>6. Case study – biotransformation</li> <li>7. Case study – bioremediation</li> <li>8. Case study – phytoremediation</li> </ol>	<b>2</b>	<b>04</b>
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<b>Course Code</b>	<b>Title</b>	<b>Credit</b>
<b>PSLSCEBTT403</b>	<b>Industrial Environmental biotechnology (60L)</b>	<b>4</b>
<p><b>Unit I: Sustainable technology (15L)</b></p> <ul style="list-style-type: none"> <li>• Introduction; Provision of bulk and fine chemicals – plants as a source, microbial production of chemicals, their production process (any example: acetic acid, citric acid, ethanol, glycerol, isopropanol, lactic acid, acrylamide)</li> <li>• Microbial polymers and plastics – process, production and organisms involved;</li> <li>• Industrial process and clean technology: extraction and supply of raw materials; processing of raw material (eg. Enzymes, extremophiles), use and</li> </ul>		

disposal of product.	
<p><b>Unit II: Biofuels (15L)</b></p> <ul style="list-style-type: none"> <li>• Finite supply of fossil fuels, emissions from fossil fuels, Greenhouse gases – CO<sub>2</sub>, Ozone, Sulphur dioxide, their interactions with environment; remediation of the emissions from fossil fuels</li> <li>• Alternative energy sources; Biological energy sources, Bio-diesel from microbial sources. Microbial fuel cells.</li> <li>• Biofuels – generations of biofuels; Combustion of biomass, Biogas, Biodiesel, Ethanol, hydrogen</li> <li>• Biofuels from waste: Methods and processes for utilization of waste for production of fuels, economical and social aspects of waste treatment, Community biogas plant, biogas scheme – scope of rural development,</li> </ul>	
<p><b>Unit : III Natural resource recovery (15L)</b></p> <ul style="list-style-type: none"> <li>• Introduction to natural resource recovery</li> <li>• Oil recovery: Introduction, Enhanced oil recovery (EOR),</li> <li>• Microbially enhanced oil recovery (MEOR), Microbial biopolymers used in recovery</li> <li>• Recovery of metals: Bioleaching – direct and indirect, bioleaching microorganisms, recovery of metals from mining waste; Extraction of – Copper, uranium, gold, etc; Recent developments in natural resource recovery</li> </ul>	

<p><b>Unit : IV Biotechnology of marine environment (15L)</b></p> <ul style="list-style-type: none"> <li>• Introduction, Extreme environmental conditions, Marine life forms, Role of microorganisms in ocean processes; Biomimetic materials</li> <li>• Compounds obtained from marine environment – industrial products and processes, sea and land based cultivation of these pharmaceutical products, Molecular biology products eg. <i>Thermus aquaticus</i>, Polymers – eg Polysaccharides, emulsans, polyhydroxyalkanoates, adhesives and melanins</li> <li>• Microalgae – products obtained from microalgae; Marine Genomics and Proteomics.</li> </ul>	
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**Practicals:**

<p><b>PSLSCEBTP403</b></p>	<p><b>Industrial environmental biotechnology</b></p> <ol style="list-style-type: none"> <li>1. Field visit to waste water treatment plants.</li> <li>2. Estimation of heavy metals in various samples by AAS</li> <li>3. Estimation of <math>Co^{2+}</math> and <math>Ni^{2+}</math> by colorimetry/spectrophotometry.</li> <li>4. Chlorophyll estimation from seaweeds.</li> <li>5. Case Study: Sustainable development</li> <li>6. Determine the particulate matter in atmosphere.</li> <li>7. Cytotoxicity assay (onion root tip/pollen germination) to estimate water contamination.</li> <li>8. Case Study: Biogas plant</li> </ol>	<p>2</p>	<p>04</p>
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Course Code	Title	Credit
<b>PSLSCEBTT404</b>	<b>Genetic engineering and Food Technology (60L)</b>	<b>4</b>
<p><b>Unit I: Microbial Cell Factories and their modification (15L)</b></p> <ul style="list-style-type: none"> <li>• <b>Strain Improvement:</b> Physical, Chemical and Biological Methods (Site-directed Mutagenesis Methods, Molecular Evolution/Random mutagenesis, <i>de novo</i> Sequence design, Expression- Display technologies, , Analysis and detection, applications.</li> <li>• <b>Technologies:</b> Genome editing, RNAi technologies, Metabolic Engineering and modelling, Systems Biology and Synthetic Biology for strain improvement.</li> <li>• <b>Model Expression Systems:</b> Prokaryotic:<i>E. coli</i>: Expression systems,Expression of Foreign Genes in Bacteria – Problems, optimization of expression: host, transcriptional, translational, post translational compatibility, solubility and purification, transport and localization, Modification of gene – codon optimization, host strain modification Expression of Native Proteins, , Detecting Expression of Foreign Genes</li> <li>• <b>Lower eukaryotes:</b> Yeasts: Yeast Selectable Markers and Vector Systems, commercially used yeast strains (<i>S. cerevisiae</i> and <i>Pichia</i>) and their expressionsystems</li> <li>• Heterologous Protein Production - Design parameters: Source of DNA, Heterologous mRNA and protein levels and downstream applications, humanization of yeast for post translational compatibility.</li> </ul>		
<p><b>Unit II: Applications of Genetic Engineering (15L)</b></p> <ul style="list-style-type: none"> <li>• <b>Applications-</b> modifying activity, substrate specificity, cofactor requirement, increasing stability, pH and temperature optima, Construction of deregulated mutants resistant to feed back inhibition and repression.</li> <li>• <b>Uses of Industrial Enzymes:</b> Food and Feed biotechnology: Nutraceuticals,Biopreservation, Biotransformations and other industries.</li> <li>• <b>Uses in Medical Research:</b>Analysis of Genes, Genomes and</li> </ul>		

Protein-Protein Interactions - YACTechnology, Constructing Gene Knockouts and Novel Reporter Systems, synthesis of commercially compounds. Therapeutic proteins, vaccines and alternate therapies.	
<b>Unit III: Food Constituents and Nutrition</b> (15 L)	
<ul style="list-style-type: none"> <li>Food constituents, sources and function: Carbohydrate, lipids, proteins, vitamins, minerals and water; RDA and ICMR recommendations for calorie requirement of food for men, women and children; Food spoilage (chemical, biochemical and microbial); Methods of food preservation (dehydration, chemical, freezing, canning); Food additives – classes and safety; Food poisoning – chemical and microbial</li> </ul>	
<b>Unit IV: Food Technology</b> (15 L)	
<ul style="list-style-type: none"> <li>Cereals and pulses; Milling process, Nutritive loss; Indian cereal products; Bakery and Pasta products; Types of Milk and milk products; Fruits – products and confectionaries; Food beverages; Food analysis and nutritional labeling; Food processing – history, objectives and quality control ; Food packaging – types and functions; Health foods - Functional foods, Prebiotics, Probiotics, Nutraceuticals, organic foods, GM foods</li> </ul>	

**Practicals:**

<b>PSLSCEBTP304</b>	<b>Dissertation of Research Project (60L)</b>	<b>2</b>	<b>04</b>
	1. Project studies: presentation and preparation of report of observations and results		

## References :

### PSLSCEBTT301

1. Kothari, C.R., 1985, Research Methodology- Methods and Techniques, New Delhi, Wiley Eastern Limited.
2. Das, S.K., 1986, an Introduction to Research, Kolkata, Mukherjee and Company Pvt. Ltd.
3. Misra R.P., 1989, Research Methodology: A Handbook, New Delhi, Concept Publishing Company
4. Kumar, R., 2005, Research Methodology-A Step-by-Step Guide for for Beginners, (2nd.ed.), Singapore, Pearson Education.
5. Bhattachraya, D.K., 2006, Research Methodology,(2nd.ed.),New Delhi, Excel Books.
6. Panneerselvam R., 2012, Research Methodology, New Delhi, PHI Learning Pvt. Ltd.
7. Wetland ecology: principles and conservation by Paul A.Keddy
8. Encyclopedia of natural resources: Yeqiao wang.

### PSLSCEBTT 302

1. A textbook of environmental pollution and control. S S. Dara
2. Environmental pollution control engineering. C. S. Rao. New Age International Publishers.
3. APHA 1998. Standard Methods for the examination of water and wastewater, 20th Ed
4. Environment and ecology by S.N.Pandey and S.P Mishra
5. Biotechnology of Odour nd Air pollution.Springer
6. Soil analysis Volume 2 Handbook of methods in environmental studies.s.K.Mai

### PSLSCEBTT 303

1. R. M. Atlas and R. Bartha - 1998 - Microbial Ecology - Fundamentals and applications. AddisonWesley Longman, Inc.
2. R.MMaier,I.L.Pepper and C.P.Gerba 2010,Environmental Microbiology Academic Press
3. Rastogi & Sani,Microbes and Microbial Technology, 2011, pp 29-57, Molecular Techniques to Assess Microbial Community Structure, Function, and Dynamics in the Environment.

4. Brock Biology of microorganisms 12th edition
5. Environmental law: Stuart bell
6. An Introduction to environmental toxicology: Michael H. Dong

#### **PSLSCEBTT304**

1. The Oxford Book of Modern Science Writing (Oxford Landmark Science) 2009 by Richard Dawkins (Author, Editor)
2. Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded (2012) by Joshua Schimel (Author)
3. The Best of the Best of American Science Writing (The Best American Science Writing) 2010 by Jesse Cohen (Author)
4. From Research to Manuscript A Guide to Scientific Writing (Second Edition) By Katz, Michael J. (Springer Publication)
5. Science Research Writing for Non-Native Speakers of English by Hilary Glasman-Deal (Author), Imperial College Press, London, UK
6. Scientific Writing and Communication by Angellka Hofmann, Oxford University Press (2014)
7. ISO 9000 quality systems handbook fourth edition by David Hoyle
8. International standard iso9001 : quality management systems — requirements fifth edition 2015-09-15.
9. Pharmaceutical quality assurance for students of pharmacy, 2nd edition Dec.2007. by Mr. manohar a. Potdar. NiraliPrakashan.
10. How to Practice GMPs 7th ed. by P.P. Sharma ,Seventh edition 2015.
11. Hand Book, Good Laboratory Practices: Quality practices for regulated non-clinical research and development, 2<sup>nd</sup> Edition, 2009.

#### **PSLSCEBTT 401**

1. Environmental biotechnology: Theory and applications by Gareth Evans and Judith Furlong.
2. Industrial microbiology by Casida.
3. Environmental biotechnology: Alan Scragg
4. Environmental sciences: Odum

5. Environmental biotechnology: Bimal Bhattacharya and Ritu Banerjee.
6. Plant tissue culture: An introductory text by Sant Saran Bhojwani and PRem kumar Dantu
7. Remote Sensing and GIS: Basudev Bhatta

#### **PSLSCEBTT402**

1. Wastewater engineering: Treatment and reuse. Metcalf and Eddy, Tata McGraw Hill Publishing Co. Ltd. 4th Ed.
2. Environmental pollution control engineering. C. S. Rao. New Age International Publishers.
3. APHA 1998. Standard Methods for the examination of water and wastewater, 20th Ed.
4. Water and Wastewater analysis Volume 1. Handbook of methods in environmental studies. S. K. Maiti. ABD Publishers 2004
5. Environmental biotechnology: Bimal Bhattacharya and Ritu Banerjee
6. Solid Waste Management CPCB. New Delhi.
7. Ecotechnology for pollution control & environmental management - By R.K. Trivedi & Arvind Kr.
8. Basic Environmental Technology – J.A. Nathanson

#### **PSLSCEBTT 403**

1. Environmental biotechnology: Alan Scragg
2. Environmental sciences: Odum
3. Industrial microbiology: G.REED

#### **PSLSCEBTT 404**

1. Molecular Biology and Biotechnology, 5<sup>th</sup> and 4<sup>th</sup> edition by J. M. Walker and R. Rapley
2. Biotechnology, Concepts and Applications by R. R. Vittal and R. Bhat
3. Biotechnology, Principles and Applications by S. C. Rastogi
4. More Gene Manipulations in Fungi by J. W. Bennette and Linda L. Lasure
5. Microbial Metabolism and biotechnology, e-book by Horst Doelle
6. The Metabolic Pathway Engineering Handbook- Fundamenals Christina D Somlke



7. Systems Biotechnology for strain improvement. Trends in Biotechnology. Volume 3 (7),2006.
8. Sumati R Mudambi , Rajagopal M V. Fundamentals of Food and Nutrition. New Age International Publishers
9. 2. Potter NN , Hotchkiss JH. Food Science. CBS publishers and distributors
10. 3. S. Manany, N S. Swamy Food Facts and Principles. New Age International Publishers
11. 4. Pomrenz Y& Meloan CE 1996 Food Analysis Theory and Practice CBS
12. 5. Jay JM, Loessner MJ & Golden D A 2005. Modern Food Microbiology .Springer Verlag