SRM Institute of Science and Technology
(Deemed to be University u/s 3 of UGC Act, 1956)
College of Engineering and Technology
School of Bio Engineering
Department of Chemical Engineering

Minor Certification Program in Biosustainability

Foundation Courses (F)					
Course Code	Foundation Courses- Title	Hours/ Week			C
		L	T	P	
21MCH111F	Introduction to Sustainability	3	0	0	3
21MCH112F	Biorefinery Technology	3	0	0	3
21MCH113F	Industrial Bioprocess Technology	3	0	0	3
21MCH114F	Bio Entrepreneurship	3	0	0	3
	Total Learning Credits				**12**
Elective Courses (E)					
Course Code	Elective Courses-Title (Any 2)	Hours/ Week			C
		L	T	P	
21MCH211E	Sustainable Fertilizers and Pharmaceuticals	3	0	0	3
21MCH212E[3]	Sustainable Environmental Engineering	3	0	0	3
21MCH213E	Sustainable Agriculture and Food systems	3	0	0	3
	Total Learning Credits				**6**

[3] – Blended mode (online)

Course Code	21MCH111F	Course Name	INTRODUCTION TO SUSTAINABILITY	Course Category	F	Foundation	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Identify the basic concept of Sustainable Development
CLR-2 :	Apply sustainability and resilience at an individual level and in a community
CLR-3 :	Develop an encompassing understanding of sustainability issues
CLR-4 :	Address sustainability issues in environmental, societal, and economic systems
CLR-5 :	Assess the current sustainable development policies of countries

Course Outcomes (CO):	*At the end of this course, learners will be able to:*
CO-1 :	Identify stainability considerations to be incorporated in individuals and community activities
CO-2 :	Utilize metrics to assess the impact of sustainable development activities of communities
CO-3 :	Formulate tools and methods for fine-tuning sustainable developmental activities of communities
CO-4 :	Design feedback methods for assessing effectiveness of sustainable developmental initiatives
CO-5 :	Set pragmatic sustainability targets for communities for communities

Program Outcomes (PO)											
1	2	3	4	5	6	7	8	9	10	11	12
Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
						1					*3*
	3					*1*					
	2							*3*			
		3				*1*					
					3	*1*					

Module 1: Introduction to Sustainable Development ***9 Hours***

Glimpse into History and Current practices - Broad introduction to SD - its importance, need, impact and implications; definition coined; evolution of SD perspectives (MDGs AND SDGs) over the years; recent debates; 1987 Brundtland Commission and outcome; later UN summits (Rio summit, etc.) and outcome.

Module 2: Ecosystem and Sustainability ***9 Hours***

Fundamentals of ecology - types of ecosystems & interrelationships, factors influencing sustainability of ecosystems, ecosystem restoration - developmental needs. Introduction to sustainability & its factors, requirements for sustainability: food security and agriculture, renewable resources - water and energy, non-renewable resources, factors and trade-offs, sustainability conflicts, a conceptual framework for linking sustainability and sustainable development

Module 3: Dimensions to Sustainable Development ***9 Hours***

Society, environment, culture and economy; current challenges - natural, political, socio-economic imbalance; sustainable development initiatives and policies of various countries: global, regional, national, local; needs of present and future generation - political, economic, and environmental.

Module 4: Gauging Sustainable Development ***9 Hours***

Sustainability and development indicators and SDGs, UN's outlook of sustainable development and efforts, UN SDGs - structure, governance and partnerships; communities / society: ensuring resilience and primary needs in society; biosphere: development within planetary boundaries; strengthening institutions for sustainability; shaping a sustainable economy

Module 5: Frameworks of Sustainability ***9 Hours***

Analytical frameworks in sustainability studies, sustainability metrics: criteria and indicators; the significance of quantitative and qualitative assessments of sustainability; current metrics and limitations; metrics for mapping and measuring sustainable development; application of the metrics in real scenarios

Learning Resources	1. *Rogers, Peter P., Kazi F. Jalal, and John A. Boyd, "An Introduction To Sustainable Development," Routledge, 2nd Edition, 2012.* 2. *Sachs, Jeffrey D., "The Age Of Sustainable Development," Columbia University Press, New York, 2015.* 3. *Nhamo, Godwell, and Vuyo Mjimba, "Sustainable Development Goals And Institutions Of Higher Education," Springer, 2020.*

Learning Assessment							
	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*25%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*		*-*		*-*	*-*	*-*
Level 6	*Create*	*-*	*-*		*-*	*-*	*-*
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Natarajan Nagarajan, Vice President – Engineering, EPCOGEN Private Limited, Chennai	*Dr. S. Sundaramoorthy, Professor, Puducherry Technological University*	*1. Dr. P. Muthamilselvi, SRM IST*
		2. Dr. M. P. Rajesh, SRM IST

Course Code	21MCH112F	Course Name	BIOREFINERY TECHNOLOGY	Course Category	F	Foundation	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Understanding biomass and characterization fundamentals
CLR-2 :	Basics of biomass pre-processing and treatment methods
CLR-3 :	Introduction to biomass processing and conversion technologies
CLR-4 :	Explore biofuel production and biogas plant design concepts
CLR-5 :	Learn algal biomass processing for fuels and nutraceuticals

Course Outcomes (CO):	*At the end of this course, learners will be able to:*
CO-1 :	Understand the types, properties, and classification of biomass feedstock's
CO-2 :	Explain the pre-processing and types of biomass pre-treatment and fractionation
CO-3 :	Analyze thermochemical conversion technologies for biomass valorization
CO-4 :	Apply knowledge of microbial and enzymatic methods in biochemical conversion
CO-5 :	Demonstrate understanding of algae-based biorefineries and high-value product generation

Program Outcomes (PO)											
1	2	3	4	5	6	7	8	9	10	11	12
Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
	2	*3*									
2			*3*								
	3					*1*					
	2					*1*					
			3			*1*					

Module 1: Introduction to Biomass Resources ***9 Hours***

Importance of Bioenergy and bio-fuels, Global and Indian scenario, Availability of biomass, composition and energy potential, waste biomass (municipal, industrial, agricultural and forestry) availability. First, second and third generation biofuels and biomass as energy resources, characterization-proximate and ultimate analysis, determination of structural components of biomass.

Module 2: Pre-processing of Biomass ***9 Hours***

Biomass pre-processing: size reduction and densification, Pre-treatment processes specific to various conversion processes for production of targeted products, Physical treatment processes, thermal, biological, chemical, physiochemical treatment processes.

Module 3: Thermochemical Conversion Process ***9 Hours***

Biomass pre-processing: size reduction and densification, Fundamentals of thermal conversion process: pyrolysis, gasification, combustion, hydrothermal liquefaction. Barriers in lignocellulose biomass conversion, different pre-treatment technologies in the bio refinery concept.

Module 4: Biochemical Conversion Process ***9 Hours***

Lignocellulosic biofuels, direct fermentation for ethanol and butanol production. Biogas plants/systems; classification and models of biogas plant; Types of bio-digesters; floating/fixed dome reactors; Design concept and construction of biogas plant. Bio hydrogen generation from biomass feedstock's.

Module 5: Algae-Based Biorefineries ***9 Hours***

Algal biomass: microalgae vs macroalgae, Cultivation systems: open ponds, photo bioreactors, Lipid extraction and transesterification, Biohydrogen and biomethane from algae, High-value compounds: pigments, proteins, and nutraceuticals.

Learning Resources	1. *Brown, Robert C., "Thermochemical Processing Of Biomass: Conversion Into Fuels, Chemicals And Power," Wiley, 2011.* 2. *Chen, Hongzhang, "Lignocellulose Biorefinery Engineering: Principles And Applications," Elsevier Inc. Publishers, 2015.* 3. *Bajpai, R., Zilouei, A., Raman, R. A., and Patel, G. G., "Algal Biorefineries: Volume 1 And 2," Springer, 2013.*

Learning Assessment							
	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*25%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*		*-*		*-*	*-*	*-*
Level 6	*Create*	*-*	*-*		*-*	*-*	*-*
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Natarajan Nagarajan, Vice President – Engineering, EPCOGEN Private Limited, Chennai	*Dr. S. Sundaramoorthy, Professor, Puducherry Technological University*	*1. Dr. K. Tamilarasan, SRM IST*
		2. Dr. M. P. Rajesh, SRM IST

Course Code	21MCH113F	Course Name	INDUSTRIAL BIOPROCESS TECHNOLOGY	Course Category	F	Foundation	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Understand the historical landmark events that led to the development of bioprocess technology
CLR-2 :	Introduce fermenters and fermentation technology
CLR-3 :	Familiarize with stoichiometry, reaction kinetics and thermodynamics of bioprocesses
CLR-4 :	Plan for a fermentation and upstream related unit operations
CLR-5 :	Analyse for microbial and bioproduct growth related mechanisms and processes

Course Outcomes (CO):	*At the end of this course, learners will be able to:*
CO-1 :	Identify the historical developments of bioprocess technology
CO-2 :	Design the basic features of a fermenter and parameters to be monitored and controlled in fermentation
CO-3 :	Evaluate the stoichiometry, kinetics and thermodynamics of bioprocesess
CO-4 :	Appraise fermentation media and implement media sterilization strategy
CO-5 :	Assess the kinetics and mechanism of microbial growth and bioproduct formation

Program Outcomes (PO)											
1	2	3	4	5	6	7	8	9	10	11	12
Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
					3						*2*
	2	*3*									
		2		*3*							
	1	*2*									
		1	*2*								

Module 1: Introduction to Bioprocess Technology ***9 Hours***

Historical development of bioprocess technologies, role of bioprocess engineer in the biotechnology industry, concept of Bioprocess, outline of an integrated bioprocess and the various (upstream and downstream) unit operations involved in bioprocesses, generalized process flow sheets. A brief survey of organisms, processes, products and market economics relating to modern industrial biotechnology.

Module 2: Fermentation Process Technology ***9 Hours***

General requirements of fermentation processes; Isolation, preservation and improvement of industrially important micro- organisms, development of innocula for industrial fermentations. Different types of fermentations, Basic design and construction of fermentor and ancillaries, An overview of aerobic and anaerobic fermentation processes and their application in the biotechnology industry solid-substrate fermentation and its applications.

Module 3: Metabolic Stoichiometry and Energetics ***9 Hours***

Stoichiometry of cell growth and product formation, elemental balances, degrees of reduction of substrate and biomass available, electron balances, yield coefficient of biomass and product formation, maintenance coefficients, energetics analysis of microbial growth and product formation, oxygen consumption and heat evolution in aerobic cultures, thermodynamic efficiency of growth.

Module 4: Fermentation Media Design and Sterilization ***9 Hours***

Designing of media for fermentation processes, Types of media, design and usage of various commercial media for industrial fermentations, thermal death kinetics of micro-organisms, batch and continuous heat sterilization of liquid media, filter sterilization of liquid media, air, and design of sterilization equipment.

Module 5: Kinetics of Microbial Growth and Product Formation ***9 Hours***

Phases of cell growth in batch cultures, simple unstructured kinetic models for microbial growth, Monod model, growth of filamentous organisms. Growth associated (primary) and non-growth associated (secondary) product formation kinetics, Leudking – Piret models, substrate and product inhibition on cell growth and product formation.

Learning Resources	1. *Doran, Pauline, "Bioprocess Engineering Principles," Academic Press, 2nd Edition, 2012.* 2. *Stanbury, Peter F., and Whitaker, Allan, "Principles Of Fermentation Technology," 3rd Edition, Elsevier, 2016.* 3. *Shuler, Michael L., and Kargi, Fikret, "Bioprocess Engineering: Basic Concepts," Pearson, 3rd Edition, 2017.*

Learning Assessment							
	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*25%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*		*-*		*-*	*-*	*-*
Level 6	*Create*	*-*	*-*		*-*	*-*	*-*
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Natarajan Nagarajan, Vice President – Engineering, EPCOGEN Private Limited, Chennai	*Dr. S. Sundaramoorthy, Professor, Puducherry Technological University*	*1. Dr. M. P. Rajesh, SRM IST*
		2. Dr. K. Tamilarasan, SRM IST

Course Code	21MCH114F	Course Name	BIO ENTREPRENEURSHIP	Course Category	F	Foundation	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Understand the fundamentals and ethical aspects of bioentrepreneurship.
CLR-2 :	Explore biotech startup ecosystems, policies, and support frameworks.
CLR-3 :	Evaluate feasibility and create initial business models for biotech ventures.
CLR-4 :	Understand the steps for establishing and operating biotech enterprises.
CLR-5 :	Develop basic financial strategies and pitching skills for biotech business planning.

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
CO-1 :	Understand the concept, scope, and ethical framework of bioentrepreneurship.	*3*					*2*						
CO-2 :	Describe the current startup landscape and institutional support for biotech in India.	*2*					*3*						
CO-3 :	Analyze the feasibility and basic planning needed for a biotech business.	*2*		*3*									
CO-4 :	Recognize key steps involved in setting up a biotech enterprise.			*3*								*1*	
CO-5 :	Apply foundational budgeting and pitching concepts in a biotech business context.											*1*	*2*

Module 1: Introduction to Bioentrepreneurship ***9 Hours***

Meaning and scope of bioentrepreneurship; Importance in biotechnology and life sciences; Entrepreneurial traits and motivation; Introduction to innovation in biotech businesses; Basics of IPR and biosafety in entrepreneurship.

Module 2: Biotech Startups and Ecosystem ***9 Hours***

Notable biotech startups and sectors (agri, healthcare, pharma); Overview of Indian biotech policy and ecosystem; Role of government initiatives (e.g., DBT, BIRAC, BCIL); Key support systems: incubators, biotech parks, clusters.

Module 3: Business Planning and Feasibility ***9 Hours***

Identifying and evaluating biotech business ideas; Market, technical, and financial feasibility; Business model basics (introduction to canvas); Government funding and technology commercialization schemes.

Module 4: Enterprise Setup and Operations ***9 Hours***

Introduction to small, medium, and large biotech enterprise models; Basic concepts of production methods and layout; Quality control in biotech production; Steps to register and launch a biotech company.

Module 5: Financial and Pitch Planning ***9 Hours***

Budgeting and investment planning for biotech startups; Break-even and profitability basics; Introduction to pitching and presentation skills; Overview of funding sources: grants, VCs, crowd funding.

Learning Resources	1. *Kolchinsky, P., "The Entrepreneur's Guide To A Biotech Startup," 4th Edition, 2016.* 2. *Shimasaki, C., "Biotechnology Entrepreneurship," Academic Press, 2020.* 3. *Jakobsen, P. H., "Commercialization Of Biotechnology Research," Akademisk Publishing House, 2019.* 4. *Khanka, S. S., "Entrepreneurship Development," S. Chand, 2006.* 5. *Rallapalli, R., and Bali, G., "Bioethics And Biosafety," APH Publishing, 2007.* 6. *Puri, R. S., "A Practical Approach To IPR," IK International Publishing, 2009.*

Learning Assessment							
	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*25%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*		*-*		*-*	*-*	*-*
Level 6	*Create*	*-*	*-*		*-*	*-*	*-*
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Natarajan Nagarajan, Vice President – Engineering, EPCOGEN Private Limited, Chennai	*Dr. S. Sundaramoorthy, Professor, Puducherry Technological University*	*1. Dr. S. Sam David, SRM IST*
		2. Dr. MP Rajesh, SRM IST

Course Code	21MCH211E	Course Name	SUSTAINABLE FERTILIZERS AND PHARMACEUTICALS	Course Category	E	Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Recognize key historical milestones driving sustainability in fertilizers and pharmaceuticals.
CLR-2 :	Learn sustainable fertilizer technologies and production methods.
CLR-3 :	Apply green chemistry and process fundamentals in pharmaceuticals.
CLR-4 :	Understand regulatory, safety, and societal aspects of sustainable products.
CLR-5 :	Evaluate future trends like Industry 5.0 and circular economy in sustainable manufacturing.

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
CO-1 :	Appreciate the scope and need of sustainability in fertilizers and pharmaceutical industries.		*1*					*2*					
CO-2 :	Appraise the production methods and environmental impacts of sustainable fertilizers		*2*					*1*					
CO-3 :	Apply green chemistry principles for evaluating pharmaceutical manufacturing processes and sustainable drug synthesis routes.			*3*				*1*					
CO-4 :	Analyze regulatory, environmental, and health-related challenges related to conventional and sustainable products.		*3*				*2*						
CO-5 :	Evaluate future trends, Industry 5.0 practices, and circular economy concepts in fertilizer and pharmaceutical manufacturing.					*1*							*3*

Module 1: Introduction to Sustainable Fertilizers and Pharmaceutical ***9 Hours***

History and evolution of fertilizer and pharmaceutical industries; Need for sustainability in agrochemical and pharma sectors; Global and Indian scenarios; Concepts of green chemistry and green engineering in product development; Environmental impact and lifecycle perspective.

Module 2: Sustainable Fertilizer Technologies ***9 Hours***

Types of fertilizers: conventional vs. sustainable (biofertilizers, nano-fertilizers, slow-release fertilizers); Role of microorganisms and microbial consortia; Nutrient recovery from waste; Process design and production technologies; Environmental impacts of fertilizer run-off.

Module 3: Sustainable Pharmaceutical Manufacturing ***9 Hours***

Green chemistry principles in drug synthesis; Biocatalysis and enzymatic synthesis; Flow chemistry and solvent reduction; API manufacturing case studies; Pharmaceutical waste minimization and treatment strategies

Module 4: Regulatory, Safety, and Societal Perspectives ***9 Hours***

Indian and global regulatory frameworks (FCO, EPA, CDSCO, WHO, REACH); Biosafety and environmental risk of fertilizers and pharmaceuticals; Endocrine disruptors and antibiotics in water systems; Public health impacts; Ethics and societal acceptance of bio-based products.

Module 5: Future Trends and Industry 5.0 in Sustainable Production ***9 Hours***

AI and digital tools in sustainable production; Circular economy and zero-waste concepts; Valorization of biomass and agro-wastes; Sustainable supply chains; Innovation ecosystems and industry-academia collaboration; Case studies from India and abroad.

Learning Resources	1. *Singh, A., and Biswas, D., "Sustainable Agriculture: Fertilizers And The Environment," Springer, 1st Edition, 2022.* 2. *Anastas, P., and Warner, J. C., "Green Chemistry: Theory And Practice," Oxford University Press, 1998.* 3. *Sheldon, R. A., "Green Chemistry And Catalysis," Wiley-VCH, 2007.* 4. *Purohit, A., "Green Pharmacy: Environmentally Friendly Approaches To Pharmaceuticals," PharmaMed Press, 2019.* 5. *Datta, M., and Palit, P., "Biofertilizers And Sustainable Agriculture," New India Publishing Agency, 2017.*

Learning Assessment

	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*25%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*		*-*		*-*	*-*	*-*
Level 6	*Create*	*-*	*-*		*-*	*-*	*-*
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Natarajan Nagarajan, Vice President – Engineering, EPCOGEN Private Limited, Chennai	*Dr. S. Sundaramoorthy, Professor, Puducherry Technological University*	*1. Dr. S. Sam David, SRM IST*
		2. Dr. M.P. Rajesh, SRM IST

Course Code	21MCH212E	Course Name	SUSTAINABLE ENVIRONMENTAL ENGINEERING	Course Category	E	Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	State sustainable development practices
CLR-2 :	Identify existing methods that have environmental impact
CLR-3 :	Implement strategies for mitigating costal pollution
CLR-4 :	Manage solid and hazardous waste streams
CLR-5 :	Design and implement solutions for protecting and improving environmental quality

Course Outcomes (CO):	*At the end of this course, learners will be able to:*
CO-1 :	Identify sustainable development targets as set by various world's treaties and agreements
CO-2 :	Design effective waste treatment strategies
CO-3 :	Assess the deleterious consequences biogeochemical processes and current treatment methods
CO-4 :	Devise strategies for sustainable solid waste management
CO-5 :	Plan and organize sustainable processes to remedy environmental issues

Program Outcomes (PO)											
1	2	3	4	5	6	7	8	9	10	11	12
Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
3						*1*					
1						*2*					
	3					*1*					
						1				*3*	
2											*3*

Module 1: Introduction to Sustainability and Environment ***9 Hours***

Sustainable cities – cost effective air quality monitoring systems – aligning air quality with sustainable development – prioritizing sources on the basis of impact and future trends – cost benefit approach to reduce emissions-Sustainable Development Goals, Kyoto Protocol, COP21 Paris Agreement, Climate change adaptation and mitigation.

Module 2: Treatment Methods ***9 Hours***

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.

Module 3: Coastal Pollution ***9 Hours***

Definition, categories of additions, Pollutant and its classification. Organic wastes: BOD, COD, dilution factor, Fluctuations in DO, Consequences of organic discharges to estuaries with examples; Consequences of sludge dumping at sea. Sewage treatment: Primary, Secondary and Tertiary treatment processes. Solid waste pollution: Classification and disposal of solid wastes in Coastal region.

Module 4: Sustainability in Solid Waste Management ***9 Hours***

Types and Sources of solid and hazardous wastes - The Framework for Sustainability Assessment - Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, lead acid batteries, plastics and fly ash – Solid Waste Management Using a Community-Based Social Marketing Approach - Sensors and Sensor Networks for Solid Waste Management

Module 5: Sustainable Practices and Technologies in Environmental Engineering ***9 Hours***

Renewable Energy - Exploring different renewable energy sources like solar, wind, hydro, and geothermal power, and their integration into energy systems. Waste Management Addressing solid, hazardous, and wastewater management, including recycling, reuse, and waste reduction strategies. Pollution Control covering air, water, and soil pollution, along with control technologies and mitigation strategies. Water Resources and Management Focusing on water supply, wastewater treatment, and sustainable water resource management practices

Learning Resources	1. *Joseph, Benny, "Environmental Science And Engineering," Tata McGraw-Hill, New Delhi, 2016.* 2. *Ludwig, Christian, Hellweg, Stefanie, and Stucki, Samuel, "Municipal Solid Waste Management Strategies And Technologies For Sustainable Solutions," Springer, 2003.* 3. *Government Of India, "Environment Impact Assessment Guidelines," 2006.* 4. *Wang, Lawrence K., Perelra, Norman C., and Hung, Yung-Tse, "Air Pollution Control Engineering," Tokyo, 2004.*

Learning Assessment							
	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*25%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*		*-*		*-*	*-*	*-*
Level 6	*Create*	*-*	*-*		*-*	*-*	*-*
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Natarajan Nagarajan, Vice President – Engineering, EPCOGEN Private Limited, Chennai	*Dr. S. Sundaramoorthy, Professor, Puducherry Technological University*	*1. Dr. S. Kiruthika, SRM IST*
		2. Dr. M. P. Rajesh, SRM IST

Course Code	21MCH213E	Course Name	SUSTAINABLE AGRICULTURE AND FOOD SYSTEMS	Course Category	E	Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Understand sustainable farming and its effect on nature
CLR-2 :	Use better methods for soil, water, and nutrient use in farming.
CLR-3 :	Find clean energy choices for farm work
CLR-4 :	Reduce food waste and turn farm waste into useful products
CLR-5 :	Explore new tools, rules, and roles that support better farming

Course Outcomes (CO):	*At the end of this course, learners will be able to:*
CO-1 :	Compare advantages of sustainability as against. conventional practises in agriculture
CO-2 :	Apply sustainable resource management methods in agriculture
CO-3 :	Conduct energy audits in agriculture and suggest renewable and low-emission solutions
CO-4 :	Evaluate food systems using circular economy concepts and post-harvest innovations
CO-5 :	Examine the role of technologies, policies, and social factors in sustainable agriculture through case-based projects

Program Outcomes (PO)											
1	2	3	4	5	6	7	8	9	10	11	12
Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
						3					*1*
3	*2*										
						2				*2*	
2		*3*									
	3	*2*									

Module 1: Introduction to Sustainable Agriculture ***9 Hours***

Concepts and principles of sustainability in agriculture; Impacts of conventional agriculture on environment and food systems; Soil health, nutrient cycles, and sustainable soil management; Agroecology and climate-resilient agricultural practices; Traditional knowledge and community-based approaches in farming.

Module 2: Sustainable Resource Management in Agriculture ***9 Hours***

Sustainable soil management practices; Organic matter, erosion control, and cover cropping; Integrated nutrient management (compost, green manure, biofertilizers); Efficient irrigation systems and water-use efficiency; Water harvesting and conservation techniques; Climate-smart agriculture practices; Renewable energy in farming (solar pumps, biogas);Carbon footprint of agriculture and food systems; Interlinkages between agriculture and climate change.

Module 3: Energy Use and Climate-Smart Agriculture ***9 Hours***

Energy flow in food production systems; Direct and indirect energy inputs in agriculture; Fossil fuel dependency and its environmental impact; Solar energy applications in farming; Wind and biogas energy for agricultural use; Greenhouse gas emissions from agriculture; Climate change impacts on food production; Mitigation strategies in climate-smart agriculture; Adaptation strategies for resilient farming.

Module 4: Sustainable Food Systems and Circular Economy in Agriculture ***9 Hours***

Understanding Food Systems and Supply Chains; Circular Economy in Food Systems; Composting, Recycling, and Organic Waste Reuse; Converting Agri-Waste into Valuable Products; Food Loss and Waste: Causes and Solutions; Post-Harvest Technology and Storage Solutions; Innovations in Packaging and Eco-Design; Role of Cooperatives, FPOs, and Agri-Start-ups in Sustainability; Urban Agriculture and Community-Supported Farming.

Module 5: Innovations, Policies, and Future Trends in Sustainable Agriculture ***9 Hours***

Emerging Technologies in Agriculture; Government Policies and Their Impact on Agriculture; Sustainable Development Goals (SDGs) and Agriculture; Role of Youth, Women, and Indigenous Knowledge in Agriculture; Innovations in Precision Farming and Digital Agriculture; Circular Systems in Agriculture; Case Studies in Sustainable Agriculture; Collaborations Between Start-ups and Agriculture; Student Group Project/Presentation on a Real-World Sustainability Issue

Learning Resources	1. *Gliessman, S. R., "Agroecology: The Ecology Of Sustainable Food Systems," CRC Press, 2015.* 2. *Villalobos, F. J., and Fereres, E., "Principles Of Agronomy For Sustainable Agriculture," Springer International Publishing, 2024.* 3. *Marsden, T., and Morley, A., "Sustainable Food Systems: Building A New Paradigm," Routledge, 2014.* 4. *Stahel, W. R., "The Circular Economy: A User's Guide," Routledge, 2019.* 5. *Farooq, M., and Pisante, M. (Eds.), "Innovations In Sustainable Agriculture," Springer, 2019.* 6. *Pretty, J., "Agri-Culture: Reconnecting People, Land, And Nature," Earthscan, 2002.*

Learning Assessment

	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*25%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*		-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100%*		*100%*		*100%*	

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