SOLID WASTE MANAGEMENT **Course Code : 316312**

Programme Name/s	**: Civil Engineering/ Civil & Rural Engineering/ Construction Technology/ Civil & Environmental Engineering/**
Programme Code	**: CE/ CR/ CS/ LE**
Semester	**: Sixth**
Course Title	**: SOLID WASTE MANAGEMENT**
Course Code	**: 316312**

I. RATIONALE

Effective solid waste management (SWM) is required for maintaining a healthy, sustainable environment and ensuring the well-being of human populations. With rapid urbanization, industrialization, and increased consumption, the generation of solid waste has significantly risen, leading to severe environmental and health concerns. Proper management of solid waste is essential to mitigate its negative impacts and support sustainable development. As the global population continues to grow, effective waste management is key feature for conserving landfill space, reducing waste generation, and promoting sustainability. By adopting practices such as reducing, reusing, and recycling, communities can contribute to resource conservation and climate change mitigation.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:
Implement Solid Waste Management Techniques to reduce Environmental Footprint in Compliance with its Regulations.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Identify the different types of solid wastes.
- CO2 - Select the relevant methods of storage, collection, segregation and transportation for given solid wastes.
- CO3 - Execute an action plan for disposal of solid wastes.
- CO4 - Implement the relevant method for disposal of Bio-medical, Industrial and E-waste.
- CO5 - Select the relevant laws related to solid waste management.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316312	SOLID WASTE MANAGEMENT	SWM	DSE	3	-	2	1	6	3	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 2 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Classify the solid waste on the basis of its source of collection. TLO 1.2 Distinguish solid waste on the basis of their characteristics. TLO 1.3 Analyze the impact of solid waste on environment. TLO 1.4 Draw the labelled sketch of hierarchy of waste management. TLO 1.5 Propose the organization chart required to manage solid waste for the given village / town / city of your locality.	**Unit - I Introduction to Solid Waste Management** 1.1 Overview of Solid Waste- Definition, types and sources of– Domestic Waste, Commercial waste, Industrial waste, Market waste, Agricultural waste, Biomedical waste, E-waste, Institutional waste. 1.2 Characteristics of Solid Waste: Physical, Chemical, and Biological properties, Classification of solid waste- Hazardous waste and Non-hazardous waste. 1.3 Impact of Solid Waste on Environment and Human health. 1.4 Solid waste management hierarchy: Prevent, Reduce, Reuse, Recycle, Recover and Dispose (IKS*- Crafts, Tools made of animal bones, shells and plant materials) 1.5 Organization pattern of solid waste management system, and Steps involved in the development of a Solid Waste Management System.	Lecture Using Chalk-Board Presentations Video Demonstrations Case Study Site/Industry Visit

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Describe the factors affecting generation of given type of solid wastes. TLO 2.2 Suggest the relevant method of storage of solid waste for the given site conditions. TLO 2.3 Explain the relevant method of collecting the solid waste in the given situation. TLO 2.4 Suggest the relevant transportation system for transporting the municipal solid waste at the given location with justification. TLO 2.5 Justify the importance of Transfer station in collection and transportation of Solid Waste. TLO 2.6 Illustrate the different methods of segregation depending on type of solid waste. TLO 2.7 Implement the Recent techniques for segregation of solid waste in the given area. TLO 2.8 Analyze the financial requirement for solid waste management for a city or town.	**Unit - II Aspects of Solid Waste Management** 2.1 Waste generation, Factors Affecting Waste Generation: Population growth, urbanization, lifestyle, economic development etc. 2.2 Storage practices of solid waste generated, Tools and Equipment-Litter Bin, Broom, Shovels, Handcarts, Mechanical Road sweepers, Community bin - like movable and stationary bin. 2.3 Waste Collection Systems: a) Manual: Curb system, Alley, Setout and setback system b) Automated Collection Systems: Techniques, challenges, and innovations. 2.4 Transportation of municipal waste- Importance of Efficient Transportation, Transportation vehicles- Trucks, dumpsters, and other specialized vehicles. 2.5 Transfer station- meaning, necessity, location. 2.6 Segregation of Solid waste, its importance, reducing waste, improving recycling efficiency, Methods of Segregation: Manual and automated sorting. 2.7 Recent Innovations in segregation: Robotic sorting systems, AI in waste management-optical sorting, and smart bins. 2.8 Economic and financial aspects of waste management.	Lecture Using Chalk-Board Presentations Video Demonstrations Case Study Site/Industry Visit

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Suggest a relevant method of disposal of solid waste in given situation. TLO 3.2 Explain the principles of composting of Solid Waste. TLO 3.3 Describe the different steps of executing the relevant method of composting. TLO 3.4 Explain the factors considered for site selection of landfill. TLO 3.5 Explain the relevant operating method of sanitary land filling. TLO 3.6 Discuss the role of Bioreactor landfills, methane capture, leachate treatment in Municipal solid waste management system. TLO 3.7 Use the relevant incineration method for disposal of given type of solid waste TLO 3.8 Discuss the key applications of pyrolysis in solid waste management.	**Unit - III Treatment and Disposal of Solid Waste** 3.1 Solid waste disposal methods and its importance-Composting, Landfill, Incineration and Energy Generation 3.2 Concept, Principles, and Factors affecting the composting 3.3 Methods of composting: Manual Composting – Bangalore method, Indore Method, Vermicomposting (IKS*-Bio-fertilizers, organic farming) Mechanical Composting – Dano Process 3.4 Land filling techniques, methods and Factors to be considered for site selection of landfills. 3.5 Land filling methods :Area method, Trench method, Ramp method, Advantages and disadvantages of landfill method 3.6 Recent Developments: Bioreactor Landfills, Methane capture, Leachate treatment 3.7 Incineration of solid waste: Introduction, Types of incinerators - Flash, Multiple chamber Incinerators, Advantages and disadvantages of incineration process 3.8 Pyrolysis of waste – Purpose, process and Applications	Lecture Using Chalk-Board Presentations Video Demonstrations Case Study Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Apply suitable management technique for safe disposal and treatment of biomedical waste. TLO 4.2 Apply suitable management technique for safe disposal and treatment of Industrial waste. TLO 4.3 Apply suitable management technique for safe disposal and treatment of E- waste TLO 4.4 Explain various energy recovery methods, including heat recovery units, power generation from waste, and biofuels and their efficiency in sustainable waste management practices. TLO 4.5 Apply recent developments in waste-to-energy (WTE) technologies, including modern WTE plants and small-scale decentralized systems, and evaluate their effectiveness, scalability in sustainable waste management and energy recovery.	**Unit - IV Waste Management Systems** 4.1 Biomedical Waste Management- Definition, Sources and generation of Biomedical waste, Classification and Management technologies for Biomedical waste. 4.2 Industrial Waste Management- Definition, Sources and generation of Industrial Waste, classification and Management technologies for Industrial Waste. 4.3 E- Waste Management - Definition, Sources and generation of E- Waste Management, Classification and Management technologies for E- Waste Management. 4.4 Energy Recovery Methods: Heat recovery Units, Power generation, Biofuels, Refuse-Derived Fuel (RDF) 4.5 Recent Developments: Modern WTE plants, small-scale decentralized systems.	Lecture Using Chalk-Board Presentations Video Demonstrations Case Study Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 Explain Role of CPCB (Central Pollution Control Board) and MPCB (Maharashtra Pollution Control Board) in managing the given type of solid waste. TLO 5.2 Illustrate the relevant major provisions of Municipal Solid Waste Management Rules, 2016 for disposal of the given type of solid waste. TLO 5.3 Explain the different major provisions of Biomedical Waste Management Rules, 2016 for managing the given type of bio-medical waste. TLO 5.4 Illustrate the relevant major provisions of E-Waste management rules 2016 TLO 5.5 Explain the salient features of Hazardous and other wastes Management Rules, 2016 for the disposal of the given type of waste. TLO 5.6 Illustrate the relevant major provisions of Plastic Waste management rules 2016 TLO 5.7 Illustrate the relevant major provisions of Construction and Demolition Waste management rules 2016 TLO 5.8 Explain Extended Producer Responsibility (EPR) and articulate its principles, key objectives, and Role in waste management TLO 5.9 Discuss the role of NGOs in social, environmental, and economic impacts of initiatives in solid waste management	**Unit - V Legal Aspects of Solid Waste Management** 5.1 Role of agencies in management of solid waste from various sources : Central Pollution Control Board Maharashtra Pollution Control Board Municipal Corporations, Nagar Panchyat, Gram Panchayat etc 5.2 Municipal Solid Waste Management Rules, 2016 5.3 Biomedical Waste Management Rules, 2016 5.4 E- Waste Management Rules, 2016 5.5 Hazardous and other wastes Management Rules, 2016 5.6 Plastic Waste Management Rules, 2016 5.7 Construction and demolition Waste Management Rules, 2016 5.8 Extended Producer Responsibility (EPR) -The role of extended producer responsibility (EPR) in promoting, recycling, concepts, benefits of EPR 5.9 Role of NGO’s and community participation in Solid waste management	Lecture Using Chalk-Board Presentations Video Demonstrations Case Study Site/Industry Visit Flipped Classroom

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Analyze the impact of Solid waste on environment and Human health	1	*Prepare a report on the improper solid waste management and its impact on human health focusing on the effects of waste exposure, pollution, and disease transmission in rural/urban/metrocities.	2	CO1
LLO 2.1 Identify the recent innovations in segregation of Solid waste.	2	Undertake the survey through internet to prepare a report with relevant photos on recent innovations in the segregation of solid waste, focusing on effective methods, tools, and technologies in rural /urban/metro cities	2	CO2

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 3.1 Identify the different methodologies employed by cities, municipalities, and organizations for solid waste collection and transportation.	3	*Undertake the survey through internet to prepare a report on the methodology used in collection and transportation of Solid waste including equipment's, specifications used in rural /urban/metro cities	2	CO2
LLO 4.1 Apply knowledge of solid waste management best practices to design the organizational structure, ensuring that the staff, equipment, and machinery are optimally distributed to meet operational demands	4	Design the organization chart for the agency managing solid waste for a given area with respect to population to be served, pattern, equipment, manpower used.	2	CO1
LLO 5.1 Explain the working of vermicomposting plant.	5	*Prepare a report on observations along with relevant photographs and comments on working of Vermicomposting plant by visiting the Vermicomposting plant in your city/Vicinity or by viewing relevant video/simulation.	2	CO3
LLO 6.1 Analyze the landfill techniques used in Solid waste management.	6	Prepare a report on observations along with your comments on solid waste management system by landfills techniques by viewing the relevant video/simulation/visit.	2	CO3
LLO 7.1 Explain the methods of waste management employed by the plant, from collection and transportation to sorting, treatment, and disposal.	7	*Prepare a report along with relevant photographs and comments on disposal of municipal solid waste by visiting to Municipal Solid waste plant in your City/Vicinity or by viewing relevant video/simulation.	2	CO3
LLO 8.1 Explain the methods of waste management employed by the plant, from collection and transportation to sorting, treatment, and disposal of biomedical waste.	8	*Prepare a report along with relevant photographs and comments on disposal of bio-medical waste by visiting to bio-medical waste plant in your City/Vicinity or by viewing relevant video/simulation.	2	CO4
LLO 9.1 Describe the biogas production technology, including the type of digester and other equipment involved	9	*Prepare a report along with photographs and comments on working of Bio gas plant by visiting to Bio gas Plant in your City/Vicinity or by viewing relevant video/simulation.	2	CO3
LLO 10.1 Discuss any innovative technologies that could enhance e-waste recycling.	10	Prepare a report along with relevant photographs and comments on the disposal of E-waste by viewing the relevant video/simulation.	2	CO4
LLO 11.1 Illustrate the treatment methods used to manage or reduce industrial waste, such as chemical treatment, biological treatment, or thermal treatment	11	Prepare a report on your observations along with relevant photographs and comments on the disposal of Industrial waste by viewing the relevant video/simulation.	2	CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 12.1 Explain various recent technologies used in energy recovery from solid waste.	12	*Undertake the survey through internet to prepare a report on recent energy recovery methods from solid waste, highlighting the various technologies and processes used to convert waste into energy.	2	CO4
LLO 13.1 Interpret provisions of Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB)	13	*Compile the relevant provisions of Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) pertaining to solid waste management.	2	CO5
LLO 14.1 Examine the Extended Producer Responsibility policy (EPR) in promoting recycling and sustainable waste management.	14	Prepare a report on a role of Extended Producer Responsibility (EPR) in promoting recycling and sustainable waste management.	2	CO5
LLO 15.1 Enlist the NGO's involved in solid waste management program and submit the findings on their involvement in communities.	15	Undertake the survey through internet and prepare a report by exploring various strategies and models used by NGOs to engage communities in solid waste management.	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- Prepare charts showing tools, equipment, vehicles and machineries used in solid waste management practices.
- Write a report on case studies for solid waste management practices in Rural/Urban Aera
- Prepare detailed photographic report on impact of solid waste on environment.
- Collect information on recent developments in Solid waste management such as bioreactors, methane capture etc.
- Write a report on the Role of NGO's and community participation in Solid waste management.
- Write a detailed report on Energy recovery concept in solid waste management.
- Collect the relevant technical and commercial information of minimum four tools, equipment, used for collection of solid waste with specification.

Micro project

- Prepare compost using decomposable waste material at your home/institute adopting appropriate method.
- Prepare vermicompost using decomposable waste material and worms at your home/institute.
- Prepare a report on route used for collection and transportation of solid waste of your city/Village.
- Prepare a report on solid waste management practices adopted in your institute campus.
- Develop a specific model regarding solid waste management practices
- Prepare models concerned with solid waste management practices like incineration, pyrolysis etc.
- Write a detailed report on legal aspects about Municipal Solid Waste Management Rules, 2016
- Write a detailed report on legal aspects about Biomedical Waste Management Rules, 2016
- Write a detailed report on legal aspects about Construction and demolition Waste Management Rules, 2016
- Prepare a report on Waste Management Softwares based on Data tracking, optimization, and monitoring tools.
- Prepare a report on Smart cities waste management using Integration of IoT, AI, and big data.

- Prepare a report on Advancements in AI and robotics for automated waste sorting.
- Prepare a report on Use of drones and robotics in waste management systems
- Prepare a report on Refused Derived Fuel (RDF)

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Use of specific models and charts for explanation regarding solid waste management practices and Computer System for video demonstrations and simulation	1,2,3,4,5,6,7,9,10,11,12,13,14,15
2	Specific Uniform, Helmet, Goggle, Hand Gloves, Face mask etc. for visits	5,7,8,9

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Solid Waste Management	CO1	4	2	4	0	6
2	II	Aspects of Solid Waste Management	CO2	12	4	4	10	18
3	III	Treatment and Disposal of Solid Waste	CO3	15	2	8	12	22
4	IV	Waste Management Systems	CO4	8	0	8	6	14
5	V	Legal Aspects of Solid Waste Management	CO5	6	2	4	4	10
Grand Total				**45**	**10**	**28**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Termwork, Assignment, Microproject (60% Weightage to process and 40% weightage to product), Question and Answer.

Summative Assessment (Assessment of Learning)

- Practical Examination, Oral Examination, Pen and Paper Test.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	-	-	-	1	1	2			
CO2	2	2	2	3	3	1	1			
CO3	2	3	3	2	2	2	1			
CO4	2	2	2	2	2	2	1			
CO5	2	-	-	-	2	-	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Ashok K. Rathoure	Zero Waste: Management Practices for Environmental Sustainability	ISBN: 9780367180393
2	M.S. Bhatt and Asheref Illiyan	Solid Waste Management: An Indian Perspective	Synergy Books India ISBN-10 :789382059059 ISBN-13 : 978-9382059059
3	Sasikumar K	Solid Waste Management	Prentice Hall India Learning Private Limited, ISBN-10: 9788120338692 , ISBN-13 : 978-8120338692
4	Dr. Ranjita Roy Sarkar	Waste to Energy Efficient Municipal Solid Waste Management	Abhijeet Publications ISBN-10:9392816715 ISBN-13 : 978-9392816710
5	Dr. Harshita Jain, Dr. Renu Dhupper	Sustainable Solid Waste Management	S.K. Kataria & Sons ISBN:978-81-963589-2-1

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://archive.nptel.ac.in/courses/105/103/105103205/	NPTEL Video Lecture on Municipal Solid Waste management by IIT
2	https://nptel.ac.in/courses/105105160	NPTEL Video Lecture on Integrated Waste Management for a Smart City by IIT
3	https://onlinecourses.swayam2.ac.in/cec20_ge34/preview	Swayam Portal Video Lecture on Solid and hazardous Waste Management

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Sr.No	Link / Portal	Description
4	https://www.mospi.gov.in/sites/default/files/main_menu/Seminar/Policy%20on%20Waste%20Management%20-%20MOEFCC.pdf	Presentation on Policy on Waste Management by Government of India Ministry of Environment, Forest & Climate Change
5	https://mpcb.gov.in/wastes-management/municipal-solid-waste	Rules/Regulations/Notifications/Memorandum on Solid waste management by Maharashtra Pollution Control Board

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students