GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME02030051

Subject Name: Hazardous Waste Management

W.E.F. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Students should have a foundational understanding of environmental science, chemical process industries, material and energy balances, reaction engineering, and industrial safety to comprehend waste generation, treatment, and regulatory aspects effectively.
Rationale:	This course enables students to address hazardous waste challenges by equipping them with technical expertise, regulatory knowledge, and sustainability principles, preparing them to design efficient management systems and mitigate environmental risks.

Course Outcome:

Upon successful completion of this course, students will be able to:

No	Course Outcomes
01	Analyze hazardous wastes and suggest appropriate management strategies
02	Apply regulatory requirements to ensure compliance
03	Recommend sustainable solutions for waste minimization and recovery
04	Design and evaluate treatment, storage, and disposal systems

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR /2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	%of Weightage
1.	**Introduction to Hazardous Waste Management:** Definitions and Types of Hazardous Wastes, Sources and Characteristics of Hazardous Wastes, Global and National Perspectives: Magnitude and Challenges, Environmental and Human Health Impacts of Hazardous Wastes	**5**	11
2.	**Regulatory Frameworks and Policies:** Overview of National and International Regulations, Basel Convention, Hazardous Waste (Management and Transboundary Movement) Rules, 2016 (India), Compliance and Enforcement: Role of Authorities, Case Studies on Non-Compliance and Regulatory Failures	**6**	14
3.	**Waste Characterization and Risk Assessment:** Sampling and Analysis of Hazardous Wastes, Risk Assessment Framework: Hazard Identification, Exposure Assessment, and Risk Characterization, Use of Modeling Tools for Risk Assessment	**6**	14
4.	**Hazardous Waste Treatment Technologies:** Physico-Chemical Treatment: Neutralization, Precipitation, Adsorption, Ion Exchange; Thermal Treatment: Incineration, Pyrolysis, Plasma Arc; Biological Treatment: Bioremediation, Phytoremediation, and Enzyme-based Treatment, Stabilization and Solidification Techniques	**12**	27
5.	**Storage, Transport, and Disposal:** Design of Secure Landfills and Underground Storage, Transport Regulations and Packaging of Hazardous Wastes, Long-Term Monitoring and Maintenance of Disposal Sites, Emergency Response and Spill Management	**8**	18
6	**Waste Minimization and Resource Recovery:** Process Optimization for Waste Reduction, Recycling and Reuse of Hazardous Wastes, Recovery of Valuable Resources from Wastes	**4**	8
7	**Emerging Trends and Case Studies:** Advances in Hazardous Waste Management Technologies, Integrated Waste Management Strategies, Case Studies of Successful and Failed	**4**	8

	Waste Management Projects		
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
11	19	17	13	8	2

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Hazardous Waste Management by Michael D. LaGrega, Phillip L. Buckingham, Jeffrey C. Evans, Waveland Press Inc
2. Handbook of Hazardous Waste Management for Small Quantity Generators by Russell W. Phifer, William R Mctigui, Jr., Lewis Publisher
3. Integrated Solid Waste Management-Engineering Principles and Management Issues by George Tchobanoglous, Hilary Theisen and Samual A. Vigil, McGraw Hill Publishers
4. Hazardous Wastes - Sources, Pathways, Receptors by Richard J. Watts, John Wiley and Sons
5. Standard Handbook of Hazardous Waste Treatment and Disposal by Freeman H. M., McGraw-Hill

(b) Open-source software and website:

To enhance learning, students can use the following open-source software tools and websites for simulations, data analysis, and regulatory information related to hazardous waste management:

Open-Source Software

- EPA Waste Reduction Model (WARM): Calculates GHG emissions, energy savings, and costs of waste management strategies.
- QGIS: GIS tool for spatial analysis, mapping, and waste tracking.
- Scilab: Numerical computation for process optimization and treatment modeling.
- OpenLCA: Life cycle assessment tool for environmental impact analysis.

Websites and Resources

- UNEP: Reports and resources on global hazardous waste practices.
- Basel Convention: Information on international hazardous waste movement.
- MoEF&CC (India): Hazardous waste rules, guidelines, and updates.
- WHO: Insights into health and environmental impacts of hazardous waste.
- HazWasteOnline: Platform for hazardous waste classification and regulations.
- NEERI: Research papers and project reports on hazardous waste management.

Suggested Course Practical List:

1. Analyze physical and chemical properties (pH, moisture, volatile solids) of hazardous waste samples.
2. Determine the concentration of heavy metals (e.g., lead, cadmium, chromium) using atomic absorption spectroscopy (AAS).
3. Assess the leachability of hazardous constituents from waste samples.
4. Evaluate adsorption of contaminants (e.g., dyes, metals) using activated carbon or other adsorbents.
5. Study thermal degradation of hazardous waste and analyze ash residue properties.
6. Perform Solidification/Stabilization of Hazardous Waste using cement or other binding materials and test the structural integrity.
7. Study microbial degradation of hazardous organic compounds in waste samples.
8. Simulate landfill conditions and analyze generated leachate for contaminants.
9. Use software tools to model risk scenarios for hazardous waste exposure.
10. Demonstrate the recovery of valuable metals using chemical or electrochemical techniques.
11. Simulate hazardous waste spill and test containment and clean-up strategies.

Major Equipments Atomic Absorption Spectrometer (AAS), Gas Chromatography-Mass Spectrometry (GC-MS), TCLP Extraction Apparatus, High-Temperature Furnace/Incinerator, Spectrophotometer (UV-Vis), Adsorption Column Setup Solidification/Stabilization Molds and Tools, Bioreactor Setup, Leachate Collection and Analysis Setup, Electrochemical Cell Setup etc.

List of Laboratory/ Learning Resources Required:

Laboratory Facilities

1. Hazardous Waste Sample Collection Area
2. Chemical Storage Cabinets
3. Fume Hoods and Waste Disposal Unit
4. Personal Protective Equipment (PPE)

Suggested Project List:

- Design of a Hazardous Waste Treatment Facility
- Risk Assessment for a Hazardous Waste Landfill
- Development of Adsorbent Materials for Waste Treatment
- Case Study Analysis: Successful and Failed Hazardous Waste Management Projects
- Assessment of Leachate Contamination from Landfills
- Bioremediation of Hazardous Wastes
- Life Cycle Assessment of Hazardous Waste Disposal Methods
- Development of a Waste Minimization and Resource Recovery Plan
- Modeling Air Emissions from Hazardous Waste Incineration
- Integration of IoT for Hazardous Waste Tracking
- Advances in Stabilization and Solidification of Hazardous Wastes

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