Program Name : **Civil Engineering Program Group**

Program Code : **CE/CR/CS**

Semester : **Sixth**

Course Title : **Solid Waste Management (Elective-II)**

Course Code : **22605**

1. RATIONALE

Industrialization and urbanization is increasing day by day. As a result of this, the generation of solid waste is a major problem all over the country within the urban as well as rural area and it is increasing day by day. In view of this, the management of solid waste produced is of prime need to keep the environment safe and clean. Information on classification and characteristics of solid waste will enable to decide appropriate technology about the collection and transportation of waste produced. Various disposal methods of solid waste will enable to recommend suitable method of disposal of solid waste with economy and acceptable environmental constraints including reuse and recycle wherever applicable. Content on other types of solid waste such as biomedical waste, construction waste, E-waste and plastic waste will be useful in deciding appropriate method for collection, transportation and disposal of these wastes. Thus, the knowledge of solid waste management with the concept like recycling, recovery and reuse will lead to proper disposal with acceptability. This will further lead to keeping the natural resources condemnation free.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Manage the solid waste effectively to maintain the hygienic conditions.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a) Identify the different sources of solid wastes.
b) Execute the relevant method of collection and transportation of solid wastes.
c) Execute an action plan for disposal of solid wastes.
d) Implement the relevant method for disposal of Bio-medical wastes.
e) Implement the relevant method for disposal of Industrial wastes and E-waste.
f) Implement the relevant laws related to solid waste management.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme													
				Theory							Practical						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain COs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

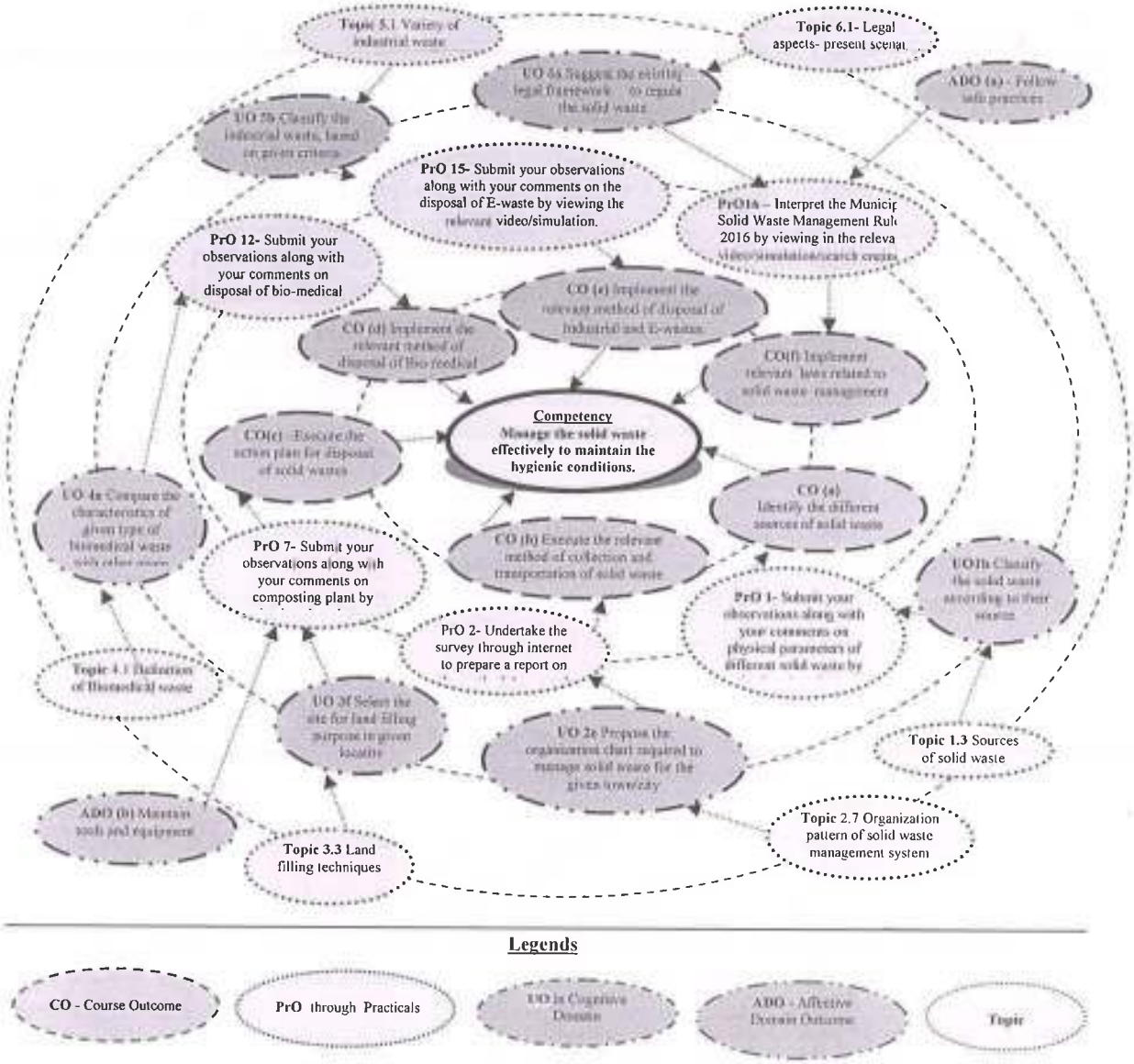

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Submit your observations along with your comments on physical parameters of different solid waste by viewing the relevant video/simulation/photographs.	I	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
2	Undertake the survey through internet to prepare a report on the methodology used in collection and transportation of Solid waste including eequipments, specifications used therein	II	02*
3	View the relevant video/simulation/photographs/print material/non-print material of the operations in transfer station to draw the flow chart for the same.	II	04*
4	Design the organization chart for the agency managing solid waste for a given area with a report on w.r.t. population to be served, pattern, machineries, equipment, manpower used.	II	02*
5	Submit your observations along with your comments on solid waste management techniques by viewing the relevant video/simulation.	II	02
6	Submit your observations along with your comments on solid waste disposal plant by viewing the relevant video/simulation/photographs.	III	04*
7	Submit your observations along with your comments on composting plant by viewing the relevant video/simulation/photographs.	III	04*
8	Submit your observations along with your comments on Bio gas plant by viewing the relevant video/simulation/photographs.	III	04
9	Prepare the specifications of vermin-composting plant for the given type of building with suggested action plan to implement it by viewing the relevant video/simulation/photographs..	III	04*
10	Submit your observations along with your comments on working of vermin-composting plant by viewing the relevant video/simulation.	III	02
11	Submit your observations along with your comments on solid waste management system by landfills techniques by viewing the relevant video/simulation.	III	02
12	Submit your observations along with your comments on disposal of bio-medical waste by viewing the relevant video/simulation.	IV	04*
13	Prepare the specifications for the disposal of bio-medical waste by viewing the relevant video/simulation.	IV	04*
14	Submit your observations along with your comments on the problems of human agencies dealing with solid waste management by viewing the relevant video/simulation.	IV	02
15	Submit your observations along with your comments on the disposal of E-waste by viewing the relevant video/simulation.	V	02
16	Submit your observations along with your comments on the disposal of Industrial waste by viewing the relevant video/simulation.	V	02
17	Compile the relevant provisions Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) pertaining to solid waste management by viewing in the relevant video/simulation/search engine..	V	02
16	Interpret the Municipal Solid Waste Management Rules, 2016 by viewing in the relevant video/simulation/search engine..	VI	02*
17	Interpret the Biomedical Waste Management Rules, 2016 by viewing in the relevant video/simulation/search engine..	VI	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
18	Interpret the E- Waste Management Rules, 2016. by viewing in the relevant video/simulation/search engine.	VI	02
19	Interpret the Construction and demolition Waste Management Rules, 2016" by viewing in the relevant video/simulation/search engine.	VI	02
20	Interpret the Hazardous and other waste Management Rules, 2016; by viewing in the relevant video/simulation/search engine.	VI	02
21	Interpret the Plastic Waste Management Rules, 2016 by viewing in the relevant video/simulation/search engine	VI	02
	Total		**60**

Note

i. *A suggestive list of **PrOs** is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical UOs/tutorials need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Safety measures during visit	20
2	Observations and Recording	30
3	Answer to sample questions	20
4	Submission of report in time	30
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a) Follow safety practices.
b) Practice good housekeeping.
c) Work as a leader / team member.
d) Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year.
- 'Organization Level' in 2nd year.
- 'Characterization Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will be useful in uniformity in conduct of experiments, as well as aid to procure equipment by adiministrators.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Specific Uniform, Helmet, Goggle, Hand Gloves, specific shooes etc.	6-11
2	Use of specific models and charts for explanation regarding solid waste management practices.	6-11
3	Demonstration of specific Documentary, films or animated film related to solid waste management practices	6-11

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit I Fundamentals of solid waste management	1a. Explain the principles of waste reduction in the given condition. 1b. Classify the given solid wastes according to their sources. 1c. Describe the characteristics of the given solid wastes. 1d. Justify the need of solid waste management in the given situation. 1e. Assess the impact of solid waste management on the environment in the given situation. 1f. List the factors generating solid wastes in the given specific area with justification.	1.1 Definition of solid waste 1.2 Meaning of different solid waste – Domestic Waste, commercial waste, industrial waste, market waste, agricultural waste, biomedical waste, E-waste, hazardous waste, institutional waste 1.3 Sources of solid waste, Classification of solid waste – hazardous and non- hazardous waste. 1.4 Physical and chemical characteristics of municipal solid waste. 1.5 Impact of solid waste on environment. 1.6 Solid waste management techniques – solid waste management hierarchy, waste prevention and waste reduction techniques. 1.7 Factors affecting the solid waste generation.
Unit– II Storage, Collection and Transportation of Municipal Solid Waste	2a. Suggest the relevant method of storage of solid waste for the given site conditions with justification. 2b. Explain the relevant method of collecting the solid waste in the given situation. 2c. Implement the relevant techniques for management of solid waste in the given area. 2d. Suggest the relevant transportation system for	2.1 Storage of solid waste 2.2 Collection methods of solid waste 2.3 Tools and Equipment-Litter Bin, Broom, Shovels, Handcarts, Mechanical road sweepers, Community bin - like movable and stationary bin 2.4 Transportation of municipal waste. 2.5 Transportation vehicles with their capacity Working -Animal carts, Auto vehicles, Tractors or Trailers, Trucks, Dumpers, Compactor

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	transporting the municipal solid waste at the given location with justification. 2e. Propose the organization chart required to manage solid waste for the given village / town / city of your locality.	vehicles. Transfer station- meaning, necessity, location 2.6 Role of rag pickers and their utility for society 2.7 Organization pattern of solid waste management system, practices according to Population of the town or city.
Unit- III Disposal of Municipal Solid Waste	3a. Explain the principles of preparing the compost for the given site. 3b. List the relevant factors affecting the given composting process with justification. 3c. Describe the different steps of executing the relevant method of composting for the given site. 3d. Suggest the design criteria adopted in execution of vermicomposting for the given area with justification. 3e. Explain the relevant operating method of sanitary land filling for the given site condition and given type of waste. 3f. Select the site suitable for the land filling purpose in the given locality with justification. 3g. State the relevant parameters to select a site for land filling with justification. 3h. Propose the relevant method to control the liquid Leachate generated in the given land filling site. 3i. Suggest the relevant situation for disposal of given type of solid waste through incineration process with justification. 3j. Select the relevant type of incinerator for the given type of solid waste.	3.1 Concept of composting of waste, Principles of composting process. Factors affecting the composting process 3.2 Methods of composting – A) Manual Composting – Bangalore method, Indore Method B) Mechanical Composting – Dano Process C) Vermicomposting. 3.3 Land filling technique, Factors to be considered for site selection • Land filling methods-Area method, Trench method and Ramp method. • Leachate and its control, Biogas from landfill • Advantages and disadvantages of landfill method • Recycling of municipal solid waste 3.4 Incineration of waste: • Introduction of incineration process. • Types of incinerators - Flash, Multiple chamber Incinerators, • Products of incineration process with their use, • Pyrolysis of waste – Definition, Methods 3.5 Products of incineration process • Advantages and disadvantages of incineration process

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– IV Biomedical Waste management and Health aspects and public Involvement in Solid Waste Management	4a. Compare the characteristics of the given type of biomedical waste with other given type of waste material. 4b. Describe the different sources of generating the given type of biomedical waste in the given locality. 4c. Classify the biomedical waste on the basis of given criteria. 4d. Explain the method of executing the disposal of the given type of biomedical waste in the given area. 4e. Explain the ill effects on the health of humans handling the given type of solid waste in the given area. 4f. Justify the need of public participation in effective implementations of schemes managing the given type of solid waste in the given area.	**Biomedical Waste Management** 4.1 Definition of Bio medical Waste. 4.2 Sources and generation of Biomedical Waste 4.3 Classification of Biomedical Waste. 4.4 Management technologies. **Health aspects and public Involvement in solid waste management** 4.4. Health aspects during handling and processing 4.5. Health problems during time of segregation, recovery, recycling and reuse of solid waste. 4.6. Public involvement and participation in solid waste management practices.
Unit –V Industrial waste management and E-waste waste management	5a. Explain the relevant method of disposal of given type of industrial waste. 5b. Classify the industrial waste based on the given criteria. 5c. Describe the process of controlling the generation of Given type of industrial waste at the given site. 5d. Suggest the relevant appliance for the disposal of given type of E-waste with justification 5e. Explain the ill effects of given type of E-waste on the environment of that area. 5f. Suggest the relevant method of recycling and disposal of the given type of E-waste in the given situation.	**Industrial waste Management** : 5.1. Variety of industrial waste 5.2. Collection and disposal of industrial waste, 5.3. Control measures for industrial waste, 5.4. Recycling of industrial waste. **E-waste Management** 5.5. Definition of E- waste, Varieties of E- wastes, Dangers of E- waste, 5.6. Recycling of E- waste. 5.7. Disposal of E- waste.
Unit –VI Legal aspects of solid waste management.	6a. Suggest the existing legal framework to regulate the given type of solid waste with justification. 6b. Explain the relevant major provisions of Municipal Solid	**Legal Aspects** : 6.1. Legal aspects- present scenario 6.2. Municipal Solid Waste Management Rules, 2016 6.3. Biomedical Waste Management Rules, 2016

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	Waste Management Rules, 2016 for disposal of the given type of solid waste. 6c. Explain the different major provisions of Biomedical Waste Management Rules, 2016 for managing the given type of bio-medical waste. 6d. Compile the major features of Construction and demolition Waste Management Rules, 2016 for the disposal of the given type of waste. 6e. Explain the salient features of Hazardous and other wastes Management Rules, 2016 for the disposal of the given type of waste. 6f. Explain Role of CPCB (Central Pollution Control Board) and MPCB (Maharashtra Pollution Control Board) in managing the given type of solid waste.	6.4. E- Waste Management Rules, 2016 6.5. Construction and demolition Waste Management Rules, 2016 6.6. Hazardous and other wastes Management Rules, 2016 6.7. Plastic Waste Management Rules, 2016 6.8. Role of Central Pollution Control Board and Maharashtra Pollution Control Board in management of solid waste from various sources.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamental of Solid Waste Management.	04	02	04	---	06
II	Storage, Collection and Transportation of Municipal Solid Waste	10	04	04	06	14
III	Disposal of Municipal Solid Waste	14	02	06	08	16
IV	Biomedical Waste Management and Health Aspects and Public Involvement in Solid Waste Management.	08	04	04	06	14
V	Industrial waste management and E- Waste Management	08	04	04	06	14
VI	Legal aspects of Solid Waste Management.	04	02	04	--	06
Total		**48**	**18**	**26**	**26**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*

***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Preparation of charts showing solid waste management techniques.
b) Preparation of charts showing tools, equipment, vehicles and machineries used in solid waste management practices.
c) Preparation of compost using decomposable waste material at home adopting appropriate method.
d) Preparation of compost using decomposable waste material at the institute adopting appropriate method..
e) Preparation of vermicompost using decomposable waste material and worms at home.
f) Preparation of vermicompost using decomposable waste material and worms at institute.
g) Recycling of plastic wastes obtained from various sources and study the machineries and outcome product.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics***, which is relatively simpler or descriptive in nature, is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Arrange visit to nearby newly started site for understanding various solid waste management practices.
g) Show video/animation films to explain various instruments used in solid waste management practices.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he can contributes to the projects of the industry or society in future. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs

which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the micro-project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project report by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a) Carry out comparative study of vehicles used for collection of solid wastes from various sources.
b) Collect the relevant technical and commercial information of tools, equipment, vehicles and machineries used for collection, segregation, transportation, processing and disposal of solid waste with specifications
c) Preparation of report about route used for collection and transportation of solid waste of the city and optimization of it.
d) Preparation of report regarding solid waste management practices adopted in the campus of the institute
e) Writing a report on case studies for solid waste management practices of specific cities
f) of the country.
g) Writing a detailed report on legal aspects about Municipal Solid Waste Management
h) Rules, 2016
i) Writing a detailed report on legal aspects about Biomedical Waste Management Rules,
j) 2016
k) Writing a detailed report on legal aspects about E- Waste Management Rules, 2016
l) Writing a detailed report on legal aspects about Construction and demolition Waste Management Rules, 2016
m) Writing a detailed report on legal aspects about Hazardous and other wastes
n) Management Rules, 2016
o) Writing a detailed report on legal aspects about Plastic Waste Management Rules, 2016
p) Develop a specific model regarding solid waste management practices.
q) Preparation of models concerned with solid waste management practices like incineration, pyrolysis etc.
r) Preparation of charts, PPT presentation concerned with solid waste management practices
s) Creation of awareness about good habits of scientific; better solid waste management practices
t) Any other suitable topic for various solid waste management practices in the area, town, city or country as a whole

13. SUGGESTED LEARNING RESOURCES

S. No	Title	Author	Publisher
1	Solid Waste Management	Bhide A. D.	Indian National Scientific Documentation Centre, New Delhi Edition 1983 **ASIN:** B0018MZ0C2
2	Solid Waste	Techobanoglous George; Kreith, Frank	McGraw Hill Publication, New Delhi 2002, ISBN 9780071356237
3	Environmental Studies	Manjunath D. L.	Pearson Education Publication, New Delhi, 2006ISBN-13: 978-8131709122

4	Solid Waste Management	Sasikumar K.	PHI learning, New Delhi, 2009 ISBN 8120338693
5	Environmental Pollution	Khopkar S. M.	New Age International limited, Delhi, 2007, ISBN 8122415075
6	Environmental Studies	Basak Anindita	Pearson Publication, Delhi, 2009 ISBN : 8131785688, 9788131785683
7	Environmental Pollution Control Engineering	Rao C. S.	New Age International, 2006, New Delhi, ISBN-13: 978-8122418354
8	Prospect and Perspectives of Solid Waste Management	Hosetti B. B.	New Age International Publisher, 2006 New Delhi, ISBN-13: 978-8122417777

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a) www.hsagolden.com
b) www.almitrapatel.com
c) www.yousee.in
d) www.skgsangha.org
e) www.epa.gov/epaoswer/non-hw/muncipal/index.htm
f) En.wikipedia.org/waste-management