Semester I

Part I

Source Reduction and Waste Management
Biomedical and Hotel Waste Management

PG Diploma in
Waste Management & Environmental Hygiene

सत्यमेव जयते

Department of Higher Education
Ministry of Human Resource Development, Government of India

Where there is Rural Wellbeing
there is Universal Prosperity

Course 1 Waste Characterization and Source Reduction

PG Diploma in
Waste Management & Environmental Hygiene

Mahatma Gandhi National Council of Rural Education
Hyderabad - 500004

Foreword

"Solid wastes are the discarded leftovers of our advanced consumer society. This growing mountain of garbage and trash represents not only an attitude of indifference toward valuable natural resources, but also a serious economic and public health problem" —Jimmy Carter.

Reducing the severity of hazardous waste can be achieved through modifications in process, substitutions in feedstock, improvements in feedstock purity, changes in housekeeping and management practices, increases in the efficiency of equipment, and recycling within a process. The United States follows the rule that all large hazardous waste generators must have a program at their facility to encourage source reduction and recycling. Other countries including Austria, Germany, and Denmark, have initiated direct subsidies to encourage preferable waste-management options. India relies on inadequate waste infrastructure, the informal sector and waste dumping. Public participation in waste management is poor and there is generally a lack of responsibility towards waste in the community. Community awareness needs to be cultivated and change of attitude of people towards waste is fundamental to developing proper and sustainable waste management systems.

Source reduction, also known as waste prevention or pollution prevention, is the elimination of waste before it is created. It involves the design, manufacture, purchase or use of materials and products to reduce the amount of toxicity of what is thrown away. Source reduction means stopping waste before it happens.

Waste characterisation and source reduction benefit the environment by reducing energy consumption and pollution, helping in conservation of natural resources, and extension of valuable landfill space. Economic benefits are reduced costs associated with transportation, disposal, or recycling of waste.

This course on Waste Characterisation and Source Reduction is suitable for students of all streams - Commerce, Humanities, Science, Management, Journalism, Mass Media, Healthcare services (B Pharm, Social Work), Education, and Engineering. The extent of environmental damage and the innovations in combating the issues require scientific understanding of the subject.

The subject has vast possibilities and several interlinking themes. There is extensive scope to explore and experience different aspects of sanitation, pollution, environmental hygiene and waste management during classroom learning, practical experiments in field and laboratory, internship and dissertation. There is a sea of opportunity in this field of waste management and environmental hygiene, and an urgent need of skilled as well as dedicated workers to make our country clean and green.

Nature has interlinked realms. Similarly, subjects dealt in this course cannot be compartmentalized. They necessarily have to merge with one another. It is therefore important that students try to make these linkages in their minds rather than treating subjects in isolation. Students can make the most of this learning opportunity as they prepare to launch their careers in a field that holds great premise.

Dr. W G Prasanna Kumar
Chairman, MGNCRE

Acknowledgement

This Post Graduate Diploma course on Waste Management and Environmental Hygiene is a cumulative effort of several sincere and committed visionaries and academicians. Envisioned by Shri VLVSS Subba Rao, Senior Economic Advisor, MHRD, the curriculum took shape under his keen guidance.

The sincerity with which the course curriculum was completed and published can be assessed from the fact that a prior National Consultation Workshop was held with several subject matter experts and academicians across the country, to review the contents of the course material.

The workshop was held to familiarize Central, State and Private Universities, local and social bodies with the contents of the curriculum and to discuss and share feedback on ways to improve the course curriculum. The workshop also focused on building industry–academia partnerships in Waste Management and Environmental Hygiene through an intellectual interaction. The findings and inputs of the consultation were subsequently incorporated in the course material.

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Course Objective and Introduction

Objective

- To orient in estimating the value of waste as a potential resource and the impasse caused by mixing of wastes.

Rationale

Waste management and environmental hygiene is the need of the hour and needs to be addressed across all sectors and communities. The course on Waste Management and Environmental Hygiene gives the student an overview of waste management including collection, transfer, transport, and disposal along with methods of processing, basic disposal facilities, disposal options, recycling, project management and GIS applications, reclamation and remediation, entrepreneurship and job opportunities in waste sector. In addition, this course provides the student with relevant information about waste markets, recycling trends, cost and affordability of waste management practices, and incentive based concepts. This course is therefore essential for the students who wish to pursue a career in waste sector, as moving ahead, waste management will become an infrastructural necessity.

Competency

The course will be taught and implemented with the objective to develop required skillsets in the students so that they are able to acquire following competency: Plan segregation, collection, transportation, recycling and disposal of wastes, know recycling trends and available waste markets, acquire skill development and know the scope and entrepreneurship opportunities in the waste management sector.

Methodology

The theory will be taught and practicality of the course will be addressed through questionnaires, self-assessment and dissertation. The course will be through class room lectures, guest lectures, field visits, audio–video learning mode, brainstorming sessions, seminars and Q&A. A lecture series will strengthen students' understanding of waste management which will help in acquiring different learning outcomes in rational and theory to practice approach. Competency that will be gained as part of course outcome includes - understanding, learning, applying and implementing skills, knowing career prospects in waste management sector, internship and placement opportunities.

Topics Covered

- Solid waste management
- Domestic Waste
- Market Waste
- Food Waste
- Agri-waste
- Source reduction
- Fruit-Veg Market Waste
- e-Waste

- Industrial Inert Waste
- Industrial Hazardous Waste
- Bio-Medical Waste and Radioactive Waste
- Environmental Audit

Waste Characterisation and Source Reduction – An Introduction

The traditional use of the word "waste" means inefficient use of resources. Waste reduction is the efficient use of all resources. Efficient operations will minimize waste in materials, labour, and money. A waste reduction programme includes reduction in energy, water and utility costs; reduction in raw material usage, storage and disposal costs; and decreased printing and postage costs. Waste reduction, in whatever form, results in direct cost savings for the country**.** Waste, if not properly managed, especially excreta and other liquid and solid waste from households and the communities, becomes a serious health hazard and leads to spread of several infectious diseases. Unattended waste dumped around attracts flies, rats, and other creatures that in turn spread disease. Normally it is the wet waste that decomposes and releases a bad odour. This leads to unhygienic conditions and thereby, to a rise in health problems. Solid wastes includes wastes such as product packaging, newspapers, office and classroom paper, bottles and cans, boxes, wood wastes, food scraps, grass clippings, clothing, furniture, appliances, automobile tyres, consumer electronics, and batteries. For purposes of analysis, these products and materials are then grouped in the following categories: durable goods, nondurable goods, containers and packaging, food scraps/degradable wastes, inorganic wastes, non-degradable wastes.

India is home to 1.21 billion people (based on 2011 Census) and the population has increased by almost 181.5 million (mn) since the last decade. The population growth in India has been high and it grew by 22% during 1991–2001 and 18% in the last decade. The beaming economy of the Indian sub-continent has also resulted in a rapid change in the demographics of the country from a rural to an urban society with a fast pace of urbanization, due to which an estimated 600 mn Indians will start living in urban areas by 2031.(As per estimations made under the 'Report on Indian Urban Infrastructure and Services – High Powered Expert Committee (HPEC). As per a recent World Bank report estimates, ten years ago there were 2.9 billion urban residents who generated about 0.64 kg of municipal solid waste per person per day (0.68 billion tonnes per year), which, as of today, is estimated at 3 billion residents generating 1.2 kg per person per day (1.3 billion tonnes per year). By 2025, this will likely increase to 4.3 billion urban residents generating about 1.42 kg/capita/day of municipal solid waste (2.2 billion tonnes per year). As per the Central Pollution Control Board (CPCB) report (2012–13), municipal areas in the country generate around 170,000 metric tonnes per day (TPD) of municipal solid waste (annual generation of 62 milliontonnes of waste). As per 2011 census, 31.16 % population (i.e. 377 mn people) of India lives in 4,041 municipal authorities. It is estimated that by 2050, 50% of the population will be living in urban areas, and the volume of waste generation will grow by 5% per year. Accordingly, the expected waste quantity would be for the year 2021, 2031, and 2050 as - 101 mn metric tonnes per year, 164 mn metric tonnes, and 436 mn metric tonnes per year respectively.

The purpose of having waste characterization and source reduction in subject curriculum is to make thestudents understand the characteristics of wastes which are divided into categories – agriculture wastes,food and domestic wastes, fruits and vegetables wastes, e-wastes, hazardous wastes, radioactive wastes,biomedical wastes, industrial wastes, plastic wastes, other industrial inert wastes. This subject also includesdetailing on waste source reduction. It provides inputs on solid waste reduction strategies through reduce,reuse and recycle. It also shall reflect how source reduction of waste provides economic benefits and how itcan be operated efficiently on a daily basis. Waste audit chapterprovides details on how waste audit is conducted, what does scoping, benchmarking, characterization ofwaste streams,planning, mitigation and management measures can be undertaken via checklist.

During the course work through this subject, students will be able to develop understanding on sourcereduction and waste characterization. They are provided practical knowledge on how to conduct

wasteaudit. It shall allow students to interact with varied stakeholders as a part of questionnaire. The subjectshall be a combination of lectures, online tutorials/audio-video sessions, seminars, problem based learning, assignments. It shall include industry visit to make the students have know-how of conducting waste audit– hands on experience and checklist preparation

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Chapter 1
Waste

Objective

- To introduce different waste types
- To understand inappropriate mixing of wastes
- To understand characterization of wastes

Structure

1.1 Waste Handling in Previous Ages
1.2 UN Sustainable Development Goals
1.3 Categories of Solid Wastes
1.4 Source Reduction
1.5 Effects of Excess Waste Generation
1.6 Waste Characterisation

To Do Activities

1. Explain the issues of waste.
2. Class discussion about consequences of untreated and undisposed waste - 5- 10 min.
3. Invite a guest speaker to talk on Types of Waste and how to categorise and handle them. Facilitate a discussion.
4. Recap of Chapter, open discussion on what topics each student is interested in, scope out possibilities of career development, research or internship opportunities.
5. Make them note their choices in their notebooks. After every chapter, they must add topics to this running list. This will help them select their study topic(s).

1.1 Waste Handling in Previous Ages

Vedic India Wasted Nothing. Household wastes were fed to livestock or composted in backyard pits and returned to the soil every season. This practice continued while cities were small, with surrounding farmers bringing their produce to town and returning with city waste, for composting on their land.

British India followed good hygienic practices for other wastes. Night soil from dry latrines was buried in trenches in rotation. Large “grass farms” outside cities naturally purified sewage through land application. Domestic waste was collected door-to-door in bullock-carts and sent to the outskirts of town for composting. City garbage was mostly organic then, and unpolluted. Farmers used it on their fields to return nutrients and micro-nutrients to their soils before synthetic fertilizers became available. So there was no need for large areas for treatment or disposal of MSW. All this changed when urea was subsidized and the Plastic Yug began. The Green Revolution changed the urban environment too.

Urea subsidies completely distorted nutrient application. Synthetic fertilizers get annual subsidies over Rs 14,000 crores. Just 12% of this subsidy is the one-time cost of compost plants for 300 cities! Organic manures are denied any subsidies worth Rs 227 on equivalent NPK basis, without the drought-proofing and water-holding benefits of its humus content and microbes that restore soil vitality, strengthen roots

and reduce pest attacks. So, agricultural use of city waste declines, just when cities are growing exponentially.

The advent of plastic packaging, thrown away indiscriminately with kitchen wastes, made both types of waste unusable and unrecyclable. In fields it prevents germination and absorption of rain by the soil. Left uncollected in cities, it blocks drains, causes flooding, kills cows that eat garbage

Open dumping is ruining the lives of peri-urban villagers. Mixed urban waste, unwanted, now blights the outskirts of every Indian city. Wastes left to rot in airless heaps generate methane and catch fire. The smoke from such smouldering dumps is continuous and intolerable. Villagers are plagued with flies by day and mosquitoes by night, which breed in pockets of moisture within garbage heaps.

Stray dogs that feed and breed without a human touch, become feral (half-wild). They form hunting packs that kill hens and sheep by day and night, bite children especially, and spread rabies. They terrorise home-going farm-hands and two-wheeler riders, causing daily accidents, with school-going kids suffering the most injuries. It is vital for public health, for dogs to be declared VERMIN within compost-yards and land-fills and within a half-kilometer radius of open dumps.

Wasteful Living

Understanding waste is very important and it is becoming a problem to be addressed. Also, it is crucial to note that the current generation is generating waste than older generations. The following are the reasons.

1. Consumerism
2. Disposable income
3. Excess production- pushing goods into new markets.
4. Packaging
5. Changed attitude and lifestyle of the new generation
6. Globalization
7. Improper utilisation of resources, leading to wastes

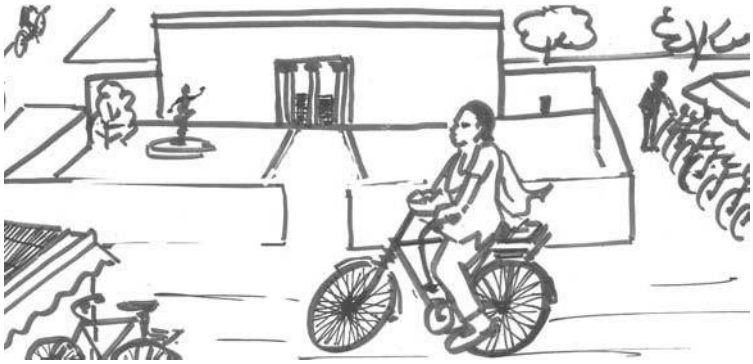
More non-degradable materials are being invented and used. Consumption is being encouraged to meet mass-production. Excess disposable income encourages throwing away goods without fully utilizing them. Development of logistics (especially e-retail) and packaged food require proper packaging for safe and convenient transport. There is a vast geographical and social gap between the producers and the consumers, whereby the consumer cannot relate to the different aspects of production and the waste generated in the intermittent process.

1.2 UN Sustainable Development Goals (SDGs)

In September 2015, the United Nations General Assembly formally adopted the 2030 Agenda aiming for global action consisting of 17 Sustainable Development Goals (SDGs) and 169 associated targets. The implementation of SDGs initiated since 2016 needs every country to meticulously plan, prioritize, and adapt the goals and targets in accordance with the local challenges, capacities and resources availability.

The 17 goals include - no poverty, no hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth, industry, infrastructure, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action, life below water, life on land, peace, justice and strong institutions and partnerships for goals. Though these are not mandatory goals for countries, but each

goal in a way if applied shall provide tangible benefits. India being a signatory to these goals is working on these goals and its targets set.



UN SDGs and Waste Management – Linkages –

Which goals matters the most with regard to waste management?

As regard to waste management, the following goals are applicable SDG # 4 quality education – in the form of awareness and capacity building in waste management can be applied, clean water and sanitation (SDG#6) which can focus on waste water and environmental hygiene and sanitation, affordable and clean energy (SDG#7), here it can be applicable with regard to the generation of energy from waste., SDG #9 industry and infrastructure – applicable in terms of developing recycling centers, better infrastructure for waste management, sustainable cities and communities (SDG #11) - it is applicable as waste management is an infrastructure necessity along with environmental and social connect, as cities have the major issues handling and disposing wastes . The efforts of communities through their attitude towards wastes connect its SDG #11. SDG #12 goal of responsible consumption and production – is applicable as it works on sustainable consumption, valuing resources, produces more from less. SDG # 13 climate action – as waste disposal and treatment practices results in GHGs emissions, the goal 13 too is relevant to waste management. SDG #14 – Life below water – since plastics menace is a problem both to marine and other aquatic life forms, this goal is relevant in waste management. SDG #16 – Life on land is relevant as landfill, illegal dumping are a major targets for working.

Problem of wastes

Over the last few years, the consumer market has grown rapidly leading to products being packed in cans, aluminium foils, plastics, and other such nonbiodegradable items that cause incalculable harm to the environment. In India, some municipal areas have banned the use of plastics and they seem to have achieved success. For example, today one will not see a single piece of plastic in the entire district of Ladakh where the local authorities imposed a ban on plastics in 1998. In many large cities, shops have begun packing items in reusable or biodegradable bags. In fact proper handling of the biodegradable waste will considerably lessen the burden of solid waste that each city has to tackle. There are different categories of waste generated, each take their own time to degenerate (as illustrated in the table 1.1 below).

Table 1.1 Categories of Waste

Type of litter	Approximate time it takes to degenerate
Organic waste such as vegetable and fruit peels, leftover foodstuff, etc.	a week or two

Paper	10–30 days
Cotton cloth	2–5 months
Wood	10–15 years
Woolen items	1 year
Tin, aluminium, and other metal items such as cans	100–500 years
Plastic bags	one million years?
Glass bottles	undetermined (but it's not harmful as plastics)

1.3 Categories of Solid Wastes

Waste can be classified into different categories:

Fig 1.1 Types of Wastes

Degradable waste: It includes organic waste like kitchen waste, vegetables, flowers, leaves, fruits.
Non-degradable waste: Includes recyclable waste (like paper, glass, metals, plastics) and non-recyclable waste includes thermocol, Styrofoam as well as inert waste like Construction & Demolition waste, dirt collected from sweeping.

Solid waste can be classified into different types depending on their source:

a) Municipal waste includes household waste and market waste. Municipal solid waste consists of household waste which now includes e-waste also, construction and demolition waste, sanitation waste and waste from sweeping streets. This waste is generated mainly from residential and commercial complexes. With changes in lifestyle, there has been rapid increase in amount of garbage and its composition changing drastically. More than 25% of the municipal solid waste is not collected at all; 70% of the Indian cities lack adequate capacity to transport it and there are no sanitary landfills to dispose of the waste.

b) Hazardous waste

Industrial waste is considered hazardous as they may contain toxic substances. Certain types of household waste are also hazardous like old batteries, shoe polish, paint tins, old medicines and medicine bottles. Hospital waste contaminated by chemicals used in hospitals is considered hazardous. These chemicals include formaldehyde and phenols, which are used as disinfectants, and mercury, which is used in thermometers or equipment that measure blood pressure and old medicines. The major generators of hazardous waste are the metal, paints, batteries, chemical, paper, pesticide, dye, refining, and rubber goods industries.

c) Biomedical waste

it is also called as hospital waste and is infectious in nature. Waste from hospitals, diagnostic laboratories, clinics, healthcare facilities. Hospital waste is generated during the diagnosis, treatment, or immunization of human beings or animals or in research activities in these fields or in the production or testing of biologicals. It may include wastes like sharps, soiled waste, disposables, anatomical waste, cultures, discarded medicines, chemical wastes, etc. These are in the form of disposable syringes, swabs, bandages, body fluids, human excreta, etc. This waste is highly infectious and can be a serious threat to human health if not managed in a scientific and discriminate manner.

d) E-Waste

Electronic Waste, also called e-waste, refer to various forms of electric and electronic equipment that have ceased to be of value to their users or no longer satisfy their original purpose. Electronic waste (e-waste) products have exhausted their utility value through redundancy, replacement, or breakage and include both “white goods” such as refrigerators, washing machines, and microwaves and “brown goods” such as televisions, radios, computers, and cell phones. (Gitanjali Nain Gill, 2011).

e) Agricultural Waste

Agricultural wastes are an output of production and processing of agricultural products containing material that can benefit man, but whose economic values are less than the cost of collection, transportation, and processing for beneficial use.

- Organic wastes
- Used pesticide bottles
- Excessive fertilizer (NPK) in surface runoff

Overview of Different Categories and Sub-Categories of Waste that can be used in the Characterization

Table 1.1 Categories and Sub-Categories of Wastes Characterization

Categories	Sub-Categories
Refundable aluminum containers	
Non-refundable aluminum containers	
Wood	Engineered wood
	Lumber
Cardboard boxes and cartons	Shipping boxes
	Corrugated cardboard
Aseptic packaging (laminated containers)	
Construction, Recovery and Demolition Waste	Plasterboard - Brick - Stone - Cement - Metal - Cables and wiring - Asphalt - Asphalt shingles - Construction lumber - Carpeting and floor coverings
Durable goods waste	Office furniture - Furniture - Appliances - Television sets - Computers - Monitors and screens - Partitions - Shelving, filing cabinets, bookcases - Air conditioners, ventilators, auxiliary heaters - Cell phones
Ferrous metals	
Compostable material	Paper towels - Starch-based biodegradable containers and bags
Hazardous Material	- Unwashed containers of dangero products - Chemical products - Pressurized containers (propane, butane, etc.) - Explosive material - Combustive material - Oil and gas products - Products containing asbestos or

	PCBs
Spoilable waste	- Table scraps - Green waste /Gardening waste
Recyclable paper	Office stationery - Wrapping paper /Kraft paper - Newspapers - Paper cups for water and coffee - Shredded paper
Plastic packaging, wraps	- Plastic bags - Food wrappings
Hazardous material	- Batteries - Electronics - Incandescent, Fluorescents bulbs - Ink cartridges
Refundable plastic containers	PET #1
Non-refundable plastic containers	- PET #1 - HDPE #2 - PVC #3 - PEbd #4 - PP #5 - Others #7
Non-recyclable plastic	- Polystyrene for food products (#6 plastic) - - Protective polystyrene (#6 plastic)
Glass containers	
Biomedical	Tubings, pipes, cotton, swabs, needles, syringes, medicines, anatomical wastes, bandages etc.

Table 1.2 Source, Facilities /Locations where Waste is Generated and Types of Wastes

Source	Typical Facilities, Activities, or Locations where Wastes are Generated	Types of Solid Waste
Agricultural	Field and row crops, orchards, vineyards, diaries, feedlots, farms, etc	Spoiled food wastes, agricultural wastes, rubbish, and hazardous wastes
Industrial	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition, etc.	Industrial process wastes, scrap materials, etc.; non-industrial waste including food waste, rubbish, ashes, demolition and construction wastes, special wastes, and hazardous waste.
Commercial and Institutional	Stores, restaurants, markets, office buildings, hotels, auto repair shops,	Paper, cardboard, plastics, wood, food wastes, glass, metal wastes, ashes, special wastes, etc.

Municipal solid waste	Includes residential, commercial and institutions	Special waste, rubbish, general waste, paper, plastics, metals, food waste, etc.

1.4 Source Reduction

To solve the problem of waste we need to first work to reduce the consumption of items.

Measures taken before a substance, material or product has become waste are defined as waste prevention measures.

Source reduction benefits in the following ways:

(a) Reduces the quantity of waste,
(b) Extends the life span of products;
(c) Reduces adverse impacts on the environment and human health
(d) Prevents exposure to harmful substances that may release on the breakdown of products, and
(e) The cost of waste management is reduced.
(f) In turn, the ecological footprint reduces.

Though an attractive solution, waste prevention is not necessarily easy to implement due to:

- A lack of knowledge about what strategies are efficient.
- Difficulty to assess the results of a preventive action, make source reduction difficult to practice and quantify. A number of organizations around the world have developed a consistent and comprehensive approach to help local and regional authorities to popularize source reduction.
- Reducing consumption contradicts people's perception of high-living. They are unwilling to compromise on their lifestyles.
- There is unfounded fear that source reduction practices will slow down the economy and the country's development.

But the fact is that source reduction alone can long term economic growth for a nation or an individual. This is possible because source reduction is sustainable- it allows a country the natural resources to stay intact for longer and these resources will drive the economy.

Table 1.3 Waste Source and Products

Sources of Waste	Products / Types
Residential	Newspapers, clothing, disposable tableware, food packaging, cans and bottles, food scraps, yard trimmings
Commercial	Corrugated boxes, food scraps, office papers, disposable tableware, paper napkins/tissue papers, yard trimmings
Institutional	Cafeteria and restroom trash, can wastes, office papers, classroom wastes, yard trimmings
Industrial	Corrugated boxes, plastic film, wood wastes, lunchroom wastes, office papers.

1.5 Effects of Excess Waste Generation

Waste generated creates awful smell, also has an adverse effect on resources, if it is not treated properly. Excessive waste generation pollutes air, water and soil, if not handled properly. This will damage the

health of individuals and also damage the ecosystem. The increase in volume of waste is not limited to domestic waste, but also spreads to residential, commercial, institutional, and industrial waste which leads to piling up of mounting wastes.

Root Causes of Mounting Wastes

The root causes of mounting wastes are:

- Improper utilisation of resources, leading to wastes
- Inadequate waste disposal infrastructure and indiscretion in waste dumping
- Poor public participation in waste management
- Lack of responsibility towards waste in the community
- Lack of awareness in sustainable waste management systems

Figure 1.1 Types of Waste

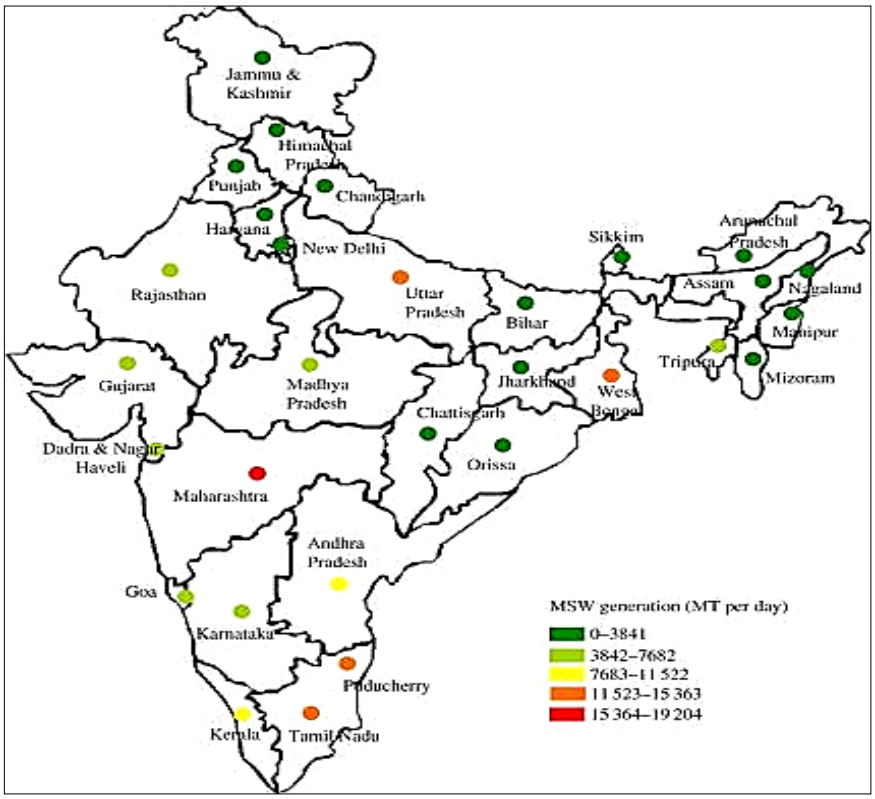


Fig 1.2 State Level Statistics of MSW Generation in India (2009-2012)[1]

The local economy impacts waste composition. The affluent groups use more packaged products, resulting in higher volumes of plastics, paper, glass, metals and textiles. Municipal Solid Waste (MSW) may also contain hazardous wastes such as pesticides, paints, used medicine, batteries and plastic disposables. An important cause for increase in waste generation and management is general lack of awareness, knowledge, and attitude towards wastes. The above figure 1.2 shows State Level Statistics of MSW generation in India.

[1] Central Pollution Control Board, Government of India, 2012

Occupational Hazards Associated with Waste Handling Infections

- Skin and blood infections resulting from direct contact with waste, and from infected wounds.
- Certain chemicals if released untreated, e.g. cyanides, mercury, and polychlorinated biphenyls are highly toxic and exposure can lead to disease or death.
- Eye and respiratory infections resulting from exposure to infected dust, especially during landfill operations.
- Many diseases are caused by the bites of the flies and mosquitoes, feeding on the wastes.

Chronic diseases

Incineration operators are at risk of chronic respiratory diseases, including cancers resulting from exposure to dust and hazardous compounds.

Accidents[2]

- Bone and muscle disorders resulting from the handling of heavy containers. Infected wounds result from contact with sharp objects.
- Poisoning and chemical burns resulting from contact with small amounts of hazardous chemical waste mixed with general waste.
- Burns and other injuries resulting from occupational accidents at waste disposal sites or from methane gas explosion at landfill sites.

Challenges in Managing Increased Waste Generation

1. Lack of segregation at source
2. No source reduction
3. No recycling opportunities
4. Lack of secondary waste markets – for reuse and resale
5. No efficient disposal practices
6. Lack of awareness and capacity building initiatives in waste management

Methods for Managing Waste

- Segregation
- Recycling
- Composting
- Incineration

Segregation of waste at source by identifying its characteristics would help the humans as well as environment.

Recycling the objects at operations, engineering and other services will reduce the production cost and cost of inventory.

Composting is a process to treat the organic waste either by aerobic or anaerobic methods.

Incineration is a type of thermal decomposition with different conditions which is used for hazardous wastes. It will destroy the hazardous character by destroying its molecular structure by pyrolysis process.

[2] Adapted from UNEP report, 1996

The end product can be disposed of. Biomedical wastes are also managed through same method for treatment.

Waste generation rate depends on factors such as population density, economic status, level of commercial activity, culture and city/region

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Ill-effects of Mixing of Waste

If the wet and dry wastes are not segregated at source level, during collection and after transport, it causes harm to environment and health. Population living close to the waste dumps, landfills and areas where there is no proper waste segregation are susceptible to health problems due to the contamination in the surroundings and the water bodies near that place.

Organic domestic waste poses a serious threat, since they ferment, creating conditions favourable to the survival and growth of microbial pathogens. Direct handling of solid waste can result in various types of infectious and chronic diseases to the waste workers and the rag /waste pickers. Exposure to hazardous waste can affect human health, children being more vulnerable to these pollutants. Indirect exposure can lead to diseases through chemical exposure as the release of chemical waste into the environment leads to chemical poisoning.

Waste from agriculture and industries can also cause serious health risks. Other than this, co-disposal of industrial hazardous waste with municipal waste can expose people to chemical and radioactive hazards. Uncollected solid waste obstructs storm water runoff, resulting in the forming of stagnant water bodies that leads to the breeding ground for mosquitoes, flies and other parasites. Waste dumped near a water source also causes contamination of the water body or the ground water source. The dumping of untreated waste in rivers, seas, and lakes results in the accumulation of toxic substances in the food chain through the plants and animals that feed on it.

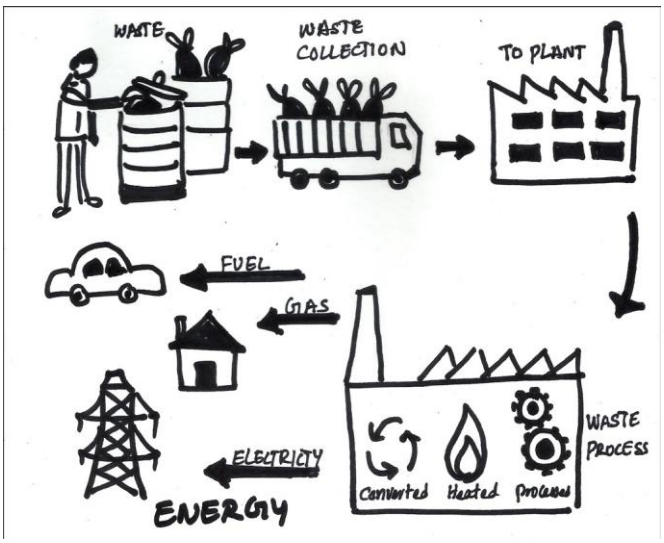
Disposal of hospital and other medical waste requires special attention since they can create major health hazards. This waste generated from the hospitals, health care centres, medical laboratories, and research centres such as discarded syringe needles, bandages, swabs, plasters, and other types of infectious waste are often disposed with the regular non-infectious waste.

Waste treatment and disposal sites can also create health hazards to the neighbourhood. Improperly operated incineration plants cause air pollution and improperly managed and designed landfills cause leachate problem. Ideally these sites should be located at a safe distance from all human settlements. Landfill sites should be well lined and walled to ensure that there is no seepage into the nearby ground water sources. Recycling too carries health risks if proper precautions are not taken. Workers working in these units may experience toxic exposure.

1.6 Waste Characterization

Waste characterization is defined as the process of finding out how much paper, glass, food waste, etc. is discarded in the waste stream. Waste characterization helps in planning source reduction, setting up of recycling programs, and cost savings and resources. Characterization is a scientific approach aimed at collecting precise data about the characteristics of waste, including composition, quantity and disposal. To be credible, characterization should be conducted using a sound methodology

Waste characterization process involves collecting, sorting and categorizing waste in order to obtain a statistical representation of the quantity of waste and their disposal methods.



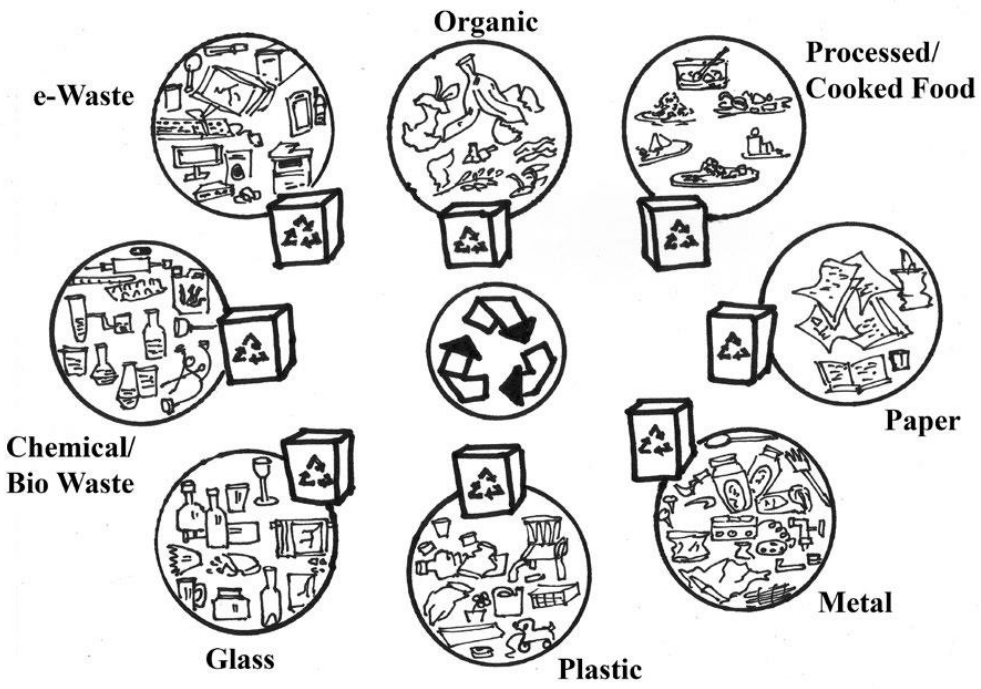
Six descriptive categories for waste types are:

1. Recyclable general waste
2. Non-recyclable general waste
3. Recyclable special management waste
4. Non-recyclable special management waste
5. Recyclable dangerous waste (e.g., waste oil, waste antifreeze)
6. Non-recyclable hazardous waste

Also based on category of products - waste characterization can be done. This includes

1. **Consumer Products** These materials come from everyday single-use or consumer non-durable products and include paper, packaging, food waste, plastics, containers, etc.
2. **Durable Goods**: This category consists of tools and objects that last a long time, such as furniture, appliances, electrical equipment, computers, electronics, etc. They are often disposed of separately from everyday consumer products, but can nonetheless introduce a bias into the characterization as they are placed in the trash sporadically, not on a regular basis.
3. **Construction/Renovation/Demolition (CRD) or Construction and Renovation (C&D) Wastes:** Waste generated from building project. This cannot be included in consumer products waste. This one too is not on a regular basis.
4. **Hazardous Materials:** These wastes depending on the applicable rules and regulations are subjected to special methods of disposal. Hazardous materials include batteries, fluorescent tubes and chemical products, paints and solvents containers, refrigerants, cleaning agents,

motor oil and propane cylinders. Hazardous materials should never be placed into regular trash, but instead recovered by specialized firms that will recycle or properly dispose of the material.



One of the most i*mportant responsibilities in waste characterization is identification of the waste collected, so as to conduct follow-up on the origins of waste and to obtain a precise idea of the situation and plan waste management accordingly. The most common method for tracing waste is to label garbage bags and the wastes - wet and dry wastes. Each bag collected thus has a unique profile, and the waste can be analysed in terms of means of collection, collection site and periods of the day/ week. Labelling must contain the following minimum information:

- Day and time of waste collection;
- Collection site
- The means of collection (garbage bag, recycling bin, and its category, if applicable)
- Maintenance and collection personnel

Summary

Waste from residential, commercial, industrial and institutional sources need to be managed in a way that turns challenges into opportunities. Hazardous content, e-waste, biomedical, biodegradable, recyclable wastes etc are some of the categories that need individual attention. The Sustainable Development Goals #4,#6,#7,#11,#12,#13, #14 and #16 are affected by waste management.

Self-Assessment Test

1. Characterize your residential waste. Please provide the details of how at individual level you contribute to waste segregation - via wet and dry waste bins?

2. Provide the details of waste segregation practices in your municipality.

Further Readings

1. Waste Generation & Characterization: https://www.youtube.com/watch?v=CFTOlgwzizY
2. Best Practices for Waste Characterization : https://www.youtube.com/watch?v=aLhFel9OEak

Case Studies

1. Municipal waste management case studies in India https://pdfs.semanticscholar.org/ccf1/63a6e7f0d007acf007d5698e4bb09a068832.pdf

2. Characterization of municipal solid waste http://www.ijcrar.com/vol-2-8/Rajani%20Srivastava,%20et%20al.pdf

3. Waste characterization study report http://www.elcita.in/wp-content/uploads/2017/08/Waste-Characterization-Study-Report.pdf

4. Characterization and composition of municipal solid wastes http://www.iaeme.com/MasterAdmin/uploadfolder/IJCIET_07_06_007/IJCIET_07_06_007.pdf

5. How the United Nations Development Programme in India is helping cities turn their plastic waste into roadshttp://www.in.undp.org/content/india/en/home/climate-and-disaster-reslience/successstories/made-of-plastic--it-s-fantastic.html

6. Sustainable Development Benefits of Integrated Waste Management https://sdghelpdesk.unescap.org/sites/default/files/201807/Sustainable%20Development%20Benefits_FINAL%20200618.pdf

Chapter 2
Categories of Waste and Managing Methods - 1

Objective

- To provide details on different categories of bio-degradable waste and also create understanding about the composition of wastes, its characteristics and ways to handle it.

Structure

2.1 Agricultural waste
2.2 Fruit-vegetable market waste
2.3 Food waste
2.4 Domestic waste
2.5 Market for by-products

2.1 Agricultural waste

To Do Activities

1. Open discussion on agricultural wastes and farm wastes
2. Visit to a vegetable and fruit market to survey their waste management plan. Make students compile a report after interviewing various fruit and vegetable sellers and waste managers of the fruit market, and present in class as a brief seminar.
3. Class discussion on by-products that can be made out of farm waste.
4. Importance of in-situ waste management for better profits and ease of business.
5. Recap of Chapter possibilities of career development, research or internship opportunities in agricultural and fruit waste management.
6. Make students note their choices in their notebooks. After every chapter, they must add topics to this running list. This will help them select their study topic(s).

Agricultural/ Food waste or loss refers to the decrease in edible food products throughout the part of the supply chain and hence unavailable for human consumption. Food losses take place at production, marketing, post-harvest and processing stages in the food supply chain. The Agriculture Produce Market Committee (APMC) – a marketing board operating under the aegis of State Governments ensures that farmers are not exploited and all food is brought to the market yard and sold through auction.

Food and agricultural commodity is wasted through the Food Supply Chain in various stages starting from agricultural production till consumption. India loses 40% of its produce at post-harvest and processing levels while in industrialized countries more than 40% of losses happen at retail and consumer levels.

Food losses are influenced by crop production choices and patterns, internal infrastructure and capacity, marketing chains and channels for distribution, and consumer purchasing and food use practices. Food losses represent a waste of resources used in production such as land, water, energy and inputs.

Wastage during the post-harvest storage and handling:

- improper bagging without crating,
- lack of temperature controlled vehicles,
- non-availability of cold chain facilities for preserving the produce,
- significant processing of the agricultural produce

Fruits and vegetables are perishable, seasonal, bulky and delicate. The supply chain should be made efficient by reducing the length of the chain and by adopting global best practices in storage, packaging, handling, transportation and value added services.

Learning to Manage Agro Waste

Agro-waste refers to those parts of the plant which is not the fruit, vegetable, grain or fibre being grown, like stalks, leaves, etc. Part of it is used as fodder for farm animals, but the bulk is burnt by most farmers. There is no awareness among farmers that the materials / waste they burn away could be used for making revenue of Rs. 1000 per tonne. Currently there are no takers for this produce. For the past 5 to 6 years, agricultural scientists have been working on developing technology to make use of the waste. The government could play as a liason among farmers by setting up a small waste processing unit and produce could be delivered on time. The government can step in by setting up units to process this waste and buy it directly from farmers. A market for pellets and briquettes can also be created for any use. Every year, in India, approximately 1500 lakh tonnes of agro- waste has been getting produced.

There is need to support entrepreneurs in the field of agro-waste management. This will boost the rural economy, help farmers earn more from the same crop. In addition, other people in the village can also be gainfully employed in the industries based on these products.

Agro-waste can be

- Utlised for making pellets and briquettes to be used as alternative to coal, firewood, cooking gas
- Generating power through biomass
- Converted to ethanol to be used as an alternative to fossil fuels

Advantages of utilizing agro-waste

- Checks pollution caused by burning
- Boosts rural economy through entrepreneurial opportunities and job creation
- Enhances the income of farmers

The Ministry of Agriculture and Farmers Welfare has decided to provide Rs 10 lakh for every ‘mandi’ (market) for setting up waste management plants under ‘e-Nam scheme’ and to spend one percent of the Rashtriya Krishi Vikas Yojna (RKVY) fund on solid waste management. Cleaning drives were undertaken in 271 agricultural ‘mandis’ (Waste Management, IANS, 2016). Further, under Swachhta Action, 10 lakh would be provided for each ‘mandi’ to set up waste management plants under the Electronic National Agriculture Market (e-NAM) scheme.

Agricultural Waste Management System

An agricultural waste management system (AWMS) has been planned, consisting of six basic functions: Production, Collection, Storage, Treatment, Transfer and Utilization. For a specific system, these functions may be combined, repeated, eliminated, or arranged as necessary.

(a) **Waste Production:** The amount and nature of agricultural waste generated by an agricultural enterprise requires management if the quantities are significant. Production waste analysis includes the kind, consistency, volume, location, and timing of the waste produced. Seasonal variation in the rate of production needs to be accommodated. The production of unnecessary waste should be kept to a minimum.

A large part of the waste associated with many livestock operations includes contaminated runoff from open holding areas. The runoff can be reduced by restricting the size of open holding areas, roofing part of the holding area, and installing gutters and diversions to direct uncontaminated water away from the waste. Leaking watering facilities and spilled feed contribute to the production of waste. These problems can be reduced by careful management and maintenance of feeders, watering facilities, and associated equipment.

A record should be maintained, comprising the data, assumptions, and calculations used to determine the kind, consistency, volume, location, and timing of the waste produced. The production estimates should factor in future expansion.

(b) **Collection:** The initial capture and gathering of the waste from the point of origin or deposition to a collection point. The AWMS plan should identify the method of collection, location of the collection points, scheduling of the collection, labour requirements, necessary equipment or structural facilities, management and installation costs of the components, and the impact that collection has on the consistency of the waste.

(c) **Storage:** Temporary containment of the waste. The storage facility gives the manager control over the scheduling and timing of the system functions. The storage period should be determined by the utilization schedule. The waste management system should identify the storage period; the required storage volume; the type, estimated size, location, and installation cost of the storage facility; the management cost of the storage process; and the impact of the storage on the consistency of the waste.

(d) **Treatment of Waste:** Treatment is any function designed to reduce the pollution potential of the waste, including physical, biological, and chemical treatment. It includes pre-treatment, such as the separation of solids. The plan should include an analysis of the characteristics of the waste before treatment; a determination of the desired characteristics of the waste following treatment; the selection of the type, estimated size, location, and the installation cost of the treatment facility; and the management cost of the treatment process.

(e) **Transfer:** Movement and transportation of the waste throughout the system--- from the collection point to the storage facility, to the treatment facility, and to the utilization site. The system plan should include an analysis of the consistency (solid, liquid, slurry) of the waste to be moved, method of transportation, and distance between points. Frequency and scheduling, necessary equipment, and the installation and management costs of the transfer system.

(f) **Utilization of Agriculture Waste:** A common practice is to recycle the nutrients in the waste through land application. A complete analysis of utilization through land application includes selecting the fields; scheduling applications; designing the distribution system; selecting necessary equipment; and determining application rates and volumes, value of the recycled products, and installation and management costs associated with the utilization process. The agricultural residues should be either used quickly or stored well to prevent spoilage. Some applications include:

Fertilizer: Manure can supply 61% of the chemicals N, P, K. However, transport is the primary expense. There is a possibility of ground water pollution due to excess phosphorus.

- Poultry waste contains higher phosphorus content-- good for crops use.
- Manure increases soil fertility, nutrient retention capacity, water holding capacity and soil structure stability.

Anaerobic Digestion: This produces methane gas with acid-forming bacteria breaking down volatile solids to organic acids. Next, methanogenic bacteria yield methane-rich gas. The heating value of the gas is in the range of 18-25 MJ/m3. It is expensive to set up digestion systems and there is a risk of explosion. Advantages are that large volumes of poultry, dairy and swine waste treatment is feasible with minimal odour. The digested sludge is odour-free, good fertilizer.

Activated Carbon: Agricultural waste (sugarcane bagasse, rice husk, coconut husk, sawdust, oil palm shell, neem bark) makes excellent activated charcoal which can be used for adsorption of heavy metals (Copper, cadmium, mercury, zinc, chromium, and lead ions) alcohols, ammonia, glucose can be prepared from agricultural waste.

Pyrolysis: Heating agricultural waste to 400-600°C vaporizes it to produce low heating-value gas.
Animal feed: Straw is high in fibre, low in protein, starch and fats. Waste residues can bring in the required protein.

Direct Combustion: For efficient direct combustion, briquettes should be made to burn for cooking, charcoal production, stem, mechanical and electric power applications. Combustion is the dominanttechnology accounting for more than 95% of all biomass energy utilized .

Recycling reusable waste products, reintroducing non-reusable waste products into the environment, use as a source of energy, bedding, and animal feed, mulch, organic matter, or plant nutrients. Properly treated, they can be marketable.

Colossal Waste

Despite India being the world's largest producer of milk and second largest producer of fruits and vegetables, a staggering 40 to 50 per cent of the total output, worth $ 440 billion, ends up being wasted, according to a recent study.

"India has about 6,300 cold storage facilities with a capacity of 30.11 million tons, which are only able to store about 11 per cent of the country's total perishable produce," said DS Rawat, the Assocham Secretary General. Highlighting that about 60 per cent of this capacity was spread across Uttar Pradesh, West Bengal, Gujarat and Punjab, the Assocham-MRSS India joint study said: "The situation is more severe in the southern parts of India due to unavailability of cold storage units, moreover as the climate is far hotter and more humid."

Agricultural Waste Creates Fields of Gold in Rural India

All farmers are not burning stubble, thereby adding to pollution levels. Some of them have started turning garbage into gold. The husks, weeds and other agricultural waste, long considered useless, are now being converted by enlightened sections among the farmers into sustainable, non-polluting and cheap energy that is lighting up villages and changing lives.

2.2 Fruit-Vegetable Market Waste

India produced around 81.285 MT fruits and 162.187 MTs of vegetables which accounts for nearly 14.0% of the country's share in the world production of vegetables (Rais and Sheoran, 2016). Although, more than 70 types of vegetables are grown in our country, emphasis is given to more popular vegetables like tomato, brinjal, chilli, cauliflower, cabbage, peas, potatoes, onions and few common cucurbits and leafy vegetables. These also generate high income and employment, particularly for small farmers. Among the vegetables, potato is cultivated over large areas, followed by onion, tomato and brinjal. Although India has many positives in vegetable production and marketing sector, it has several negatives too. The country lacks an efficient supply chain for the distribution of the fruits and vegetables. According to the Central Institute of Post-Harvest Engineering and Technology (CIPHET), approximately 18 per cent of the country's fruits and vegetables are wasted annually.

The reasons include:

- Lack of storage facilities
- High demand-and-supply fluctuations
- Lack of back-end infrastructure,
- Post-harvest management facilities/infrastructure and
- Lack of state-of-the-art retailing practices in fresh produce results in wastage –about 30-40% of high-value perishable commodities like fruits and vegetables in India.

The wastes generated in the APMCs are disposed of as garbage. It is rarely used as earth filling or feed. Out of total waste generated, only 5% is converted in to compost. It is essential to collect fruit and vegetable waste separately and sent directly to the piggery or composting pit.

If composted, this can make good quality natural fertilizer, which has the following qualities:

- Long-term health for soil
- Buffer for soil, neutralizing pH and making nutrients available.
- Helps sandy soil retain water and nutrients.
- May suppress diseases and harmful pests that could over runpoor quality soil.
- Well-composted material also makes good filling material for construction.

Constraints/challenges in implementing market waste management:

- Limited awareness in best waste practices
- Less importance given to the matter; hence, less funds
- Space constraints due to rising real estate costs

Nuisance in Landfills

Fruit and vegetable wastes (FVW) are produced in large quantities in markets and constitute a source of nuisance in municipal landfills because of their high biodegradability (Misi and Forster, 2002). In India, FVW constitute about 5.6 million tonnes annually and currently these wastes are disposed of by dumping them on the outskirts of cities (Srilatha et al., 1995). The processes that are being used nowadays include: thermal, evaporation, membrane, anaerobic digestion, anaerobic co-digestion, biodiesel production, combustion, supercritical and subcritical fluid extraction, coagulation and composting.

Salient Features of Agricultural Waste Handling in APMCs:

- Food and agricultural commodities are wasted through the food supply chain during various stages, starting from production till consumption.
- In developing countries like India, 40% of losses occur at post-harvest and processing levels, while in industrialized countries more than 40% of losses happen at retail and consumer levels.
- Lack of storage facilities, high demand and supply fluctuations, lack of back-end infrastructure, post-harvest management facilities and infrastructure, and lack of state-of-the-art retailing practice in fresh produce lead to a high wastage -- 30-40% of high value perishables commodities like fruits and vegetables in India.
- Food losses represent a waste of resources used in production such as land, water, energy and inputs. Producing food that is not consumed, leads to loss of economic value of the food produced.
- Economically avoidable food losses have a direct and negative impact on the income of both farmers and consumers. Irrespective of the development status of the country, every possible measure should be taken to minimize food losses.
- Special focus is required to combat the food supply chain losses, which are quite substantial and significant.
- Most of wastes generated in APMCs are disposed of as garbage. Seldom is it used as earth filling or feed. Hence, the entire volume of food waste is unutilized and results in food loss and hence economic loss.
- Wastes generated in the market yard are collected and then disposed of by engaging contractors. Compactors, jetty machines, skid loaders, tractor/trolley or open truck/dumpers are used for the purpose. Most of them have outsourced sanitation to a contractor.
- Initiatives to utilize the waste generated include electricity generation, oil from paddy husk, and compost production.
- The expenditure incurred on waste disposal ranges from a significant 5.97% in APMCs like Mumbai who use scientific and mechanized waste disposal mechanism to as low as 0.06% in APMC Kanpur, where waste disposal mechanism involves maintaining basic sanitation and cleanliness.
- In the near future, power generation can be a significant output of agricultural wastes generated.
- Traders are aware that wastes have an adverse effect on human health, hygiene and environment.

Steps for Promoting Agricultural Waste Management

- Crops should be harvested as per the harvesting indices. Premature harvesting or harvesting of over mature crops leads to crop loss. Harvesting should be done at the proper maturity stage, during appropriate time of the day by proper harvesting methods.
- Care should be taken to prevent any injury to the produce during harvest in order to prevent damage and decay. Poor farmers often harvest crop early for need of cash. Sometimes they even use chemical colours to make the produce presentable for marketing. This results in loss of nutritional

value of the crop besides posing a food safety hazard. This would further lead to economic loss as the food may be wasted if not suitable for consumption. If consumed, it may be a health hazard further, involving financial loss due to costs involved in treatment and cost to society.

- Enhancing awareness among farmers regarding proper post-harvest management techniques would help a lot as that they can harvest and market their produce following techniques which would result in less crop loss.

Planning for Waste Management in APMCs

Reducing Wastage

In most of the APMCs, there is a huge quantum of arrival of perishables each day. Yet, the APMCs are plagued by insufficient space, poor layout, no proper platform for trade, improper handling and packaging practices, lack of adequate shelter from rain and sunlight, and insufficient cold storage facilities. This results in distress sale, spoilage of the produce, and huge wastage of fruits and vegetables. Corrective measures include:

- Reducing arrival in APMC by way of alternative marketing – farmers should have the choice of selling their produce through alternative channels, instead of having to bring their produce only to the APMCs. Direct marketing and contract farming should be encouraged.
- Markets should be reorganized in terms of layout. There should be proper platform for sale of commodities. There should be adequate space for arranging the produce.
- Developing adequate cold storage facilities and post-harvest management infrastructures so that the surplus produce can be stored by farmers and traders.

Managing the Wastes Generated

Several types of agricultural wastes are generated daily in the APMCs. Due to their nature and composition, they deteriorate easily and cause foul smell. In order to maintain sanitation and cleanliness in the market as well as utilization of the food wastes, adequate measures should be taken for waste management in the APMCs.

Sanitation and Hygiene

In the markets, each vendor should keep his own bin/ basket and deposit his vegetable waste and hand it over to the waste collectors periodically. The collection timings shall be fixed with the consent of all the vendors in the market as per their convenience. No waste shall touch the ground. A small penalty or fine can be imposed on those who do not maintain sanitation.

Re-using Agricultural Wastes

Setting up Fruit and Vegetable Compost Unit in APMC

The huge amount of food waste generated in the APMCs can be used in making organic manure like compost. Preparation of compost is not a very difficult process. With a little expertise and training, compost can be created by the APMC staff. Such compost can be made available to farmers at subsidized rates. Besides APMC, compost preparation can be taken up by farmers' groups or trader associations within the APMC itself. For this, the farmers and traders have to organize themselves. The APMC has to organize training programmes for compost preparation with help of SAU. For setting up the units, the State government can provide incentives and subsidy. APMC can also set up compost unit from their own budget.

Biogas Preparation from Agricultural Waste

The waste from fruit and vegetable processing industries can be used for production of biogas. Biogas is produced by anaerobic digestion of fruit and vegetable wastes. The conversion of fruit and vegetable wastes to biogas using anaerobic digestion process is a viable and commercial option. Bioconversion processes are suitable for wastes containing moisture content above 50% than the thermo-conversion processes. Vegetable wastes, due to their high biodegradability nature and high moisture content (75 – 90%) are a good substrate for bio-energy recovery through anaerobic digestion process. However, most of the technologies for waste utilization are developed at laboratory scale; so these technologies need to be standardized for commercial utilization. Collaboration with the concerned agencies and SAU having expertise in this area can be fruitful.

The wastes generated in the markets are disposed of in municipal landfill or dumping grounds. These wastes can be reused for productive purpose such as electricity production. Collaboration with atomic research station and thermal power plants can be effective in converting these wastes into a valuable source of energy.

Problems Large Cities Face in their Market Facilities

In large cities where perishable fruits and vegetable are distributed each morning, there are some peculiar problems, which can be classified as follows:

- Urban-related: Traffic congestion near the marketplaces, large amounts of waste products rapidly filling landfills (garbage disposal problems), operating costs that exceed market revenues and dilapidated appearance as well as strong odors creating a bad public image
- Trading-related: Substantial spoilage and loss of revenue for traders because of market gluts, high marketing costs as a result of non-competitive trading practices, and multiple layers of traders; and
- Facility/management-related: Commodity losses or damage during loading and unloading because of insufficient space, poor layout, improper handling and packaging practices, lack of adequate shelter from rain and sunlight, inefficient management practices including little arbitration for disputes, reduced earnings of traders within markets as a result of part-time traders selling at reduced prices outside the facility, and insufficient cold storage space.

2.3 Food waste

Food losses occurring at the end of the food chain (retail and final consumption) are called “food waste”, which relates to retailers’ and consumers’ behaviour. There is a woeful lack of statistics and data on the quantum of food waste actually generated. Food losses represent a colossal waste of resources used in production such as land, water, energy and inputs. Producing food that will not be consumed leads to significant loss of economic value of the food produced. Economically avoidable food losses have a direct and negative impact on the income of both farmers and consumers. Special focus is needed to combat the food supply chain losses.

Only about 5 per cent of the total waste generated is converted into compost and the rest of the waste goes into the landfills and loses its potential value, which, if tapped, could provide a great benefit to various stakeholders.

Problems Caused by Waste Disposal

The collection, transportation and disposal of waste from the vegetable markets in Delhi are a huge problem. Improper management of such waste can lead to public health problems. The current mode of treatment used for the vegetable waste from the markets is to collect the waste in the market and transport it to the landfills. Heaps of such waste are spread all over the market place and remain uncollected for days together and start rotting at the same place. This creates very unhygienic conditions. Further, during collection and transportation process, it gets mixed with non-biodegradable waste, creating problems during treatment. In Delhi, there are 3 landfills sites namely Ghazipur sanitary land fill site, Okhla Sanitary land fill site, Bhalswa landfill site. These landfill sites are not designed as per the MSW rules. In the absence of availability of other landfill sites, all the 5 municipal bodies are using these three sites for illegal disposal of waste. Strict compliances of SWM rules, 2016 are the only ultimate solutions for avoiding all swachh problems

Problems Caused by Landfills

Landfills cause many unavoidable problems. These include:

- odour nuisance from gaseous decomposition
- potential for methane migration which may lead to explosions or fires
- negative health effects of carbon dioxide (CO2), methane, and non-methane organic compounds(NMOC)

Benefits of Converting Organic Waste into Compost

There are many benefits of converting organic waste into compost. They include:

- The waste problem can be alleviated through waste reduction since the organic part of the waste will be now composted. Thus, it will lead to a better quality of life for the citizens
- Fertilizers from organic waste are more effective for the health of soil (compost maintains the fertility of the soil in the long run) as well as of humans
- Compost buffers the soil, neutralizing both acid & alkaline soils, bringing pH levels to the optimum range for nutrient availability to plants
- Compost helps sandy soil retain water and nutrients
- Compost may suppress diseases and harmful pests that could overrun poor, lifeless soil
- Methane is produced at uncontrolled anaerobic decomposition at landfill sites, while composting does not produce any such gas. Harmful greenhouse gas emissions are therefore reduced, since large amounts of waste undergo controlled decomposition at a solid waste management site.
- Composted waste can also be used as the filling material while constructing the roads under major highway projects. It has been observed that roads constructed using this waste tends to be more solid and durable.

Multiple benefits

- **Farmers:** Working on food waste management can be a big step in backing farmers and their interests. This will allow them to significantly reduce their costs by providing them with manure and reduce their dependency on chemical fertilizers.
- **Businessmen:** People involved in wholesale and retail businesses in the mandi can benefit a lot from the waste reduction because they invest high value in procuring and storing food and if they get wasted they have to bear the cost. Not only this, their cost of procurement too will decline with fall in production costs of farmers as the process is interlinked. They will also get a clean and hygienic working place.

- **Consumers:** As farmers and businessmen benefit from lowered costs, consumers can enjoy more purchasing power. Reduced food waste will lead to reduction in consumers' expenses too. When waste is low, farmers would produce quality goods which will provide consumers with healthy food.
- **Environment/Natural Resources:** With a high level of consumer demand, the environment and natural resources are currently being negatively affected. Reducing wastage will in turn reduce the claim on natural resources (land, water, and energy) used in producing the food.

There is a colossal waste during post-harvest storage and handling due to improper bagging without crating, lack of temperature-controlled vehicles, no cold chain facilities for preserving the produce, coupled with significant processing of the agricultural produce, all of which cause enormous losses to the nation. Given the characteristics of fruits and vegetables such as perishability, seasonality, bulkiness and delicate nature of the products, coupled with inadequate storage and transport facilities, the supply chain can be made efficient by reducing the length of the chain and improving cold chain facilities. The supply chain management in vegetables has to be improved in all the stages of the supply by adopting globally bench-marked practices in storage, packaging, handling, transportation, value-added services etc.

Food losses influence efforts to combat hunger, raise income, provide food security, ensure food quality and address safety, all of which contribute to the economic development of a nation. The exact causes of food losses vary throughout the world and are very much dependent on specific conditions and local situation in a given country. In broad terms, food losses are influenced by crop production choices and patterns, internal infrastructure and capacity, marketing chains and channels for distribution, and consumer purchasing and food use practices. Irrespective of the development status of the country, every possible measure should be taken to keep food losses to minimum. Food losses represent a waste of resources used in production such as land, water, energy and inputs.

2.4 Domestic Waste

The population of India crossed the 1.2 billion mark in 2013, and now it stands at 1.33 billion. With a population density of 325 per square kilometres, India's 2.9 million square kilometre land area holds close to 18% of the world's population (Census 2011). Although the administration has tried to keep up with the burgeoning cities, either policies designed to address basic public services have been poorly framed or the time to implement policies has taken decades, thus virtually rendering them ineffective. With megacities registering a growth of 30.47% (Census 2011), India's basic necessities have sometimes been ignored. With focus on services such as water, electricity and food for the growing population, the Indian administration has unfortunately ignored another major public service, which is waste management.

Magnitude of Problem

Per capita waste generation is known to be increasing by 1.3% per annum. Urban population is increasing anywhere between 3% and 3.5% per annum. The annual increase in waste generation is around 5%. India produces 42.0 million tons of municipal solid waste annually at present. Per capita generation of waste varies from 200 gm to 600 gm per day. The average of waste generation rate is 0.4 kg per capita per day in 0.1 million plus towns.

Collection efficiency in respect of solid waste generated is between 50% and 90%. Urban local bodies spend Rs.500/- to Rs.1500/- per ton on solid waste management, of which 60-70% of the amount is on collection alone and 20% – 30% on transportation. No fund is spent on treatment and disposal of waste. Crude dumping of this waste is practiced in most of the cities.

Quantity of Waste Generation

The total quantity of solid waste generated in urban areas per day (tpd) of the country – 1.15 lakh tonnes.

- Waste generated in six mega cities – 21,100 tpd, 18.35%.
- Waste generated in metro cities (1 million plus towns)- 19,643 tpd , 17.08%.
- Waste generated in other, Class-1 towns (0.1 million plus towns) - 42,635.28 tpd, 37.07%.

If waste produced in all the Class-1 cities is tackled, total percentage of waste scientifically managed would be 72.5% of total waste.

Characteristics of Municipal Solid Waste

- Compostable/Bio-degradable: 30% – 55% matter (can be converted into manure)
- Inert material: 40% – 45% (to go to landfill)
- Recyclable materials: 5% – 10% (Recycling)

These percentages differ from city to city, depending upon food habits and lifestyle.

Reasons of Improper Management of Waste

- Improper planning for waste management while planning the townships
- Impractical institutional set up for waste management, planning and designing in urban local bodies
- Lack of technical and trained manpower
- Incomplete community involvement
- Less expertise and exposure to the city waste management using modern techniques and best practices
- Partial awareness creation mechanism
- Outdated Management Information Systems
- Less funds with ULBs
- Indifferent attitudes of ULBs in user charges and sustainability

Ideal Approaches to Waste Management

1. Possible Waste Management Options:
   - Waste Minimization
   - Material Recycling
   - Waste Processing (Resource Recovery)
   - Waste Transformation
   - Sanitary Landfilling – limited land availability

   The ULBs have lost people's confidence due to irregular and interrupted delivery of services. Mostly the reasons for irregular services are
   - Lack of planning
   - Absenteeism of workers
   - Frequent breakdowns of vehicles
   - Lack of preventive maintenance of vehicle
   - Lack of proper monitoring

- By addressing the above gaps service delivery can be improved to the satisfaction of the people

2. Processing / Treatment should be
   - Technically sound
   - Financially viable
   - Eco-friendly
   - Robust operate & maintained by local community
   - Long term sustainability

Approaches to Waste Processing & Disposal

Wealth from Waste (Processing Of Organic Waste)

1. Waste to Compost
   - Aerobic / Anaerobic Composting
   - Vermi-composting
2. Waste to Energy
   - Refuse Derived Fuel (Rdf) / Pelletization
   - Bio-methanation
3. Recycling of Waste
4. Sanitary Landfilling
5. Treating Bio-medical Waste separately

Various Technology Options Recommended for Waste Processing

Towns Generating Garbage

- Upto 50 Metric Tons / Day(mt/Day) = Vermi-composting
- Between 50 Mt & 500 Mt / Day = Vermi-composting + Mechanical Composting
- More Than 500 Mt / Day = Mechanical Composting + Refuse Derived Fuel(rdf) from rejects keeping in view the type of the city (Industrial Or Non-Industrial) Or Bio-methanation

Initiatives by Government of India

1. Bio-medical Waste Handling Rules, 1998 – Notified
2. Municipal Solid Waste Management Rules, 2000 – Notified.
3. Reforms Agenda (Fiscal, Institutional, Legal)
4. Technical Manual on Municipal Solid Waste Management
5. Technology Advisory Group on Municipal Solid Waste Management
6. Inter-Ministerial Task Force on Integrated Plant Nutrient Management from city compost.
7. Tax Free Bonds by ULBs permitted by Government of India
8. Income Tax relief to Waste Management agencies
9. Public-Private Partnership in SWM
10. Capacity Building
11. Urban Reforms Incentive Fund
12. Guidelines for PSP and setting up of Regulatory Authority
13. Introduction of Commercial Accounting System in ULBs & other Sector Reforms
14. Model Municipal Bye-Laws framed / circulated for benefit of ULBs for adoption
15. Financial Assistance by Government of India – 12th Finance Commission Grants

Main issues

- Absence of segregation of waste at source
- Lack of technical expertise and appropriate institutional arrangement
- Unwillingness of ULBS to introduce proper collection, segregation, transportation and treatment / disposal systems
- Indifferent attitude of citizens towards waste management due to lack of awareness
- Lack of community participation towards waste management and hygienic conditions
- Lack of funds with ULBS

2.5 Market for By-Products

Proper waste management generates useful by-products (compost in the case of composting, energy in the case of WTE plants and fuel in the case of RDF plants) and creates a circular economy. With heavy subsidies in chemical fertilizers, farmers are dis-incentivized to move towards organic farming, thus reducing the market for compost drastically. While the new SWM rules attempt to correct the inefficiencies by mandating the Department of Fertilizers to take up marketing of compost, a lot more needs to be done to create a market for compost and encourage farmers to adopt organic farming. Similarly, recycling companies today compete at par with industries using fresh raw materials (virgin products). Buyers of recycled plastic pellets, for instance, have no incentives to go for sustainable initiatives, unless lucrative cost savings are involved.

Revenue generation from the waste shall not be taken into consideration as the revenue generated shall be the property of workers as an incentive. Public health is more important and primary responsibility of the ULBs. Once the cities/towns/villages maintained liveable environment, people will have good health and the eco system will improve, thereby the expenditure on the ex-chequers to the government will come down. Ultimately this is the revenue generation to the authorities but not from the waste.

Case: Analysing the Profit &Loss for a Composting Facility

Survey across three decentralized composting facilities in Hyderabad has shown that the operating costs of running the composting operations by far outweigh the revenue generated by sale of compost. Composting is a highly scientific and operations-heavy process. There are three major costs involved in operations: labour, machinery and additive cost. While costs remain fairly similar, the two potential sources of revenue, sale of compost and service fee paid by households for processing waste are currently too low or nil.

Chemical fertilizers are heavily subsidized by the government – urea, for example, sells at less than Rs 5/kg (Government of India, Department of fertilizers). This survey indicates that in the absence of financial incentives such as tax benefits or government subsidies, compost is sold at much lesser, sometimes at a price point as low as Rs 2/kg.

As illustrated in Table, a composting facility servicing 5,000 households only recovers 0.86% of monthly operational costs.

Table 2.1 Revenue by Operational Cost Breakdown for a Composting Facility (Adapted from Primary Research at a Composting Facility in Waste Ventures in India)[3]

	Number of households	5,000
	Kgs of organic waste handled per day	4,500
	Labour FTE required	13
	Supervisor FTE required	1
Monthly Operational Costs (Rs)	Labour costs	125,500
	Other labour costs	20,000
	Material costs	540,000
	Machinery leasing costs	100,000
	Total monthly costs	**785,500**
Monthly Revenue	Revenue per kg of compost (Rs)	5
	Amount of compost produced per month (kg)	1,350
	Total Monthly Revenue (Rs)	**6,750**

This observation reinforces the first recommendation that residents need to pay for the waste management service, in order to make up the deficit and ensure the sustainability of the process. The government also needs to take a more holistic view of:

(i) The impact of overuse of fertilizers on agricultural land

(ii) How sustainable waste management models could be encouraged to attract more players and investments into the market.

Thus, key policy interventions need to be in place for:

Compost: Tax incentives and buy-back of compost from waste producers while fixing minimum standards of compost quality would enable more formal certified waste management companies to thrive in the system sustainably.

Recycled products: Along with the Extended Producer Responsibility (EPR) introduced by SWM 2016 rules, mandating corporate companies to also use a minimum percentage of recycled products as part of their manufacturing process would be beneficial. Tax benefits to recycling companies will bring in standards and therefore accountability into the recycling system. The survey reveals that only five

[3]Swaminathan, Mathangi (2018) https://www.epw.in/engage/article/institutional-framework-implementing-solid-waste-management-india-macro-analysis How can India's Problems See a Systemic Change?, Vol 53 (16).

recyclers out of 300 plastic recyclers in the city of Hyderabad are Pollution Control Board (PCB) certified, thus increasing the importance of standardising the industry to national norms.

The European Commission's ambitious Circular Economy Package is a right step in this direction (European Commission, 2015). While the European Environment Agency aims to establish a recycling rate of atleast 50% across the 31 countries, some countries have surpassed the targets. Sweden, for example, has a recycling rate of 99% and only 1% of daily waste generated goes into landfills, with most of the organic waste being used to generate power through WTE plants *(*Sweden *Sverige* 2014*).*

Research and Development on Indigenous Techniques

While RDF and WTE plants have worked well in many countries, most notably China and Europe (Qiu 2012), India has had eight failed projects worth millions of dollars in the last two decades alone (Chandra 2014), showing that there are country-specific issues that need to be understood before trying to replicate the success of China or Europe. Two major issues exist specifically in India:

Low Calorific Value of Organic Food

The higher content of organic food (this is 65% of household waste and 50% in municipal solid waste) is a reflection of cultural values of consuming more cooked food as compared to processed and packaged food. Although this trend could quite possibly reverse as food habits become more Westernised, today's municipal waste is soggy and heavy in water. Organic food generates 30% lesser calorific value as compared to recyclable waste, and this has been the primary reason for the malfunctioning of WTE plants in India.

High Cost of Construction

While WTE plants need to be highly regulated for pollutant emissions (otherwise completely negating the benefits of waste management) the high cost and scale of such projects are also an impediment to a decentralized set-up for successful waste management system in India.

While the concept of producing energy from waste seems to be a panacea, the Indian administration needs to invest in research and development to come up with locally designed cost-effective solutions that would work better in the current cultural context.

Conclusion

With two Indian cities leading the way in India today, through source segregation and decentralized waste management system, the central government should create an appropriate national framework to incentivize and monitor implementation by the states. European countries have set clear benchmarks, which India can adopt. Ultimately, to overhaul the waste management sector and induce the necessary behavioural change, citizen participation and engagement is the key. Building appropriate institutional framework along with policy-level directions will help facilitate the necessary change.

Summary

This chapter looks primarily at biodegradable waste that arises in large volumes from agricultural lands, in the form of straw and plant matters as well as farm produce from markets where some amount gets rotten. These wastes have great potential for producing manure, if they are properly collected and treated.

Case Studies

1. Types of Solid Waste: Municipal Vs. Non-Municipal https://study.com/academy/lesson/types-of-solid- waste-municipal-vs-non-municipal.html
3. Agricultural Waste

https://www.powershow.com/viewfl/164c43-ZDc1Z/Agricultural_Waste_powerpoint_ppt_presentation
4. Vegetable, fruits and kitchen waste to natural manure https://www.youtube.com/watch?v=NfYY2PJdURc
5. Introducing Solutions to the Global Food Crisis by Dr. Evan Fraser https://www.youtube.com/watch?v=raSHAqV8K9c
6. Domestic Wastes https://slideplayer.com/slide/4710228/
7. Biodegradable and Non-biodegradable Wastes https://byjus.com/chemistry/biodegradable-and-non-biodegradable/
8. TNN (2015) https://timesofindia.indiatimes.com/city/nagpur/Farmers-must-learn-to-managing-agro-wasteExperts/articleshow/47569956.cms

Self-Assessment Questions

1. Write an account on the different types or categories of wastes generated in your house?
2. Do you practice waste segregation as per the degradability and non-degradable wastes types in the wet and dry bins provided?

Further Readings

- Waste Management, IANS (2016), https://swachhindia.ndtv.com/vegetable-markets-get-rs-10-lakh-setting-waste-management-plants-3722/
- Agricultural Wastes Creates Fields of Gold in Rural India, https://www.iatp.org/news/agricultural-waste-creates-fields-of-gold-in-rural-india

Chapter 3
Categories of Waste and Managing Methods - 2

Objective

- To provide details on different categories of wastes, other than biodegradable.
- To help students understand their composition.

Structure

3.1 E- Waste
3.2 Hazardous waste
3.3 Radioactive waste
3.4 Bio-medical waste
3.5 Industrial inert waste
3.6 Plastic waste

To Do Activities

1. Open discussion on special wastes
2. Class room teaching about e-waste.
3. Conduct e-waste practical.
4. Classroom teaching on hazardous and radioactive wastes
5. Conduct practical- radioactive waste in hospital
6. Class activity- Enumerate industrial and construction inert wastes.
7. Importance of in-situ waste management of e-wastes, hazardous wastes and industrial inerts.
8. Find out all the e-waste collection centres or recycling units in your city. Does the e-waste centre pay for the e-waste? Create an e-waste collection kiosk in your department and advertise it across the campus to collect a large volume of e-waste. Find out its composition before delivering it to the nearest e-waste recycling unit/ collection centre you have discovered. Prepare a balance sheet and report profit and loss from this activity. Can it be scaled up? Discuss in Class.
9. Visit a hospital to find out about the radioactive waste component among biomedical waste. How does the hospital deal with radioactive material.
10. Recap of Chapter. Discuss possibilities of career development, research or internship opportunities in waste management from these categories of waste.
11. Make students note their choices in their notebooks. After every chapter, they must add topics to this running list. This will help them select their study topic(s).

3.1 E-Waste

Electronic waste is defined as broken or unwanted electrical or electronic parts or equipment as a whole. E-waste consists of computers, refrigerators, televisions and more than 1,000 such different electronic materials which are non-biodegradable. Otherwise known as 'Waste Electrical and Electronic Equipment'

(WEEE), e-waste contains over 1000 different substances, many of which are toxic, and creates serious pollution upon disposal.

Electronic waste or e-waste is a new type of waste that has emerged in the recent years due to fast developments in the field of electronics, which keeps on changing the configuration and technology and as a result of that older models of electronic devices become obsolete in a short span of time. E-waste consists of obsolete telecommunication devices, reprographic devices, security devices, automobile devices, besides refrigerators, air conditioners, microwaves and recording devices such as DVDs, CDs, Floppies, Tapes, Printing Cartridges and a myriad of other electrical and industrial electronics such as sensors, alarms, sirens and automobile electronic devices which add to the waste stream.

An estimated 50 MT of e-waste is generated globally every year. Most electronic goods, especially in the West, have very short lifespan. Such goods are routinely replaced at least every two years, and then either simply are discarded or exported to developing countries where there is still a demand for second-hand merchandise. The markets in the West have matured; it is expected to account for only 2 per cent of the total solid waste generated in developed countries by 2010. The larger chunk of e-waste is being generated by new-consumer countries, like India and China. A report of the United Nations predicted that by 2020, e-waste from old computers would jump by 400 per cent on 2007 levels in China and by 500 per cent in India. Additionally, e-waste from discarded mobile phones would be about seven times higher than 2007 levels and, in India, 18 times higher by 2020.

In India, the electronic waste management assumes greater significance not only due to the generation of our own waste but also dumping of e-waste, particularly computer waste from the developed countries. Manufacturers and assemblers are estimated to produce around 1200 tons of electronic scrap annually. India being a developing country needs to adopt low cost technology with maximum resource recovery in an environment friendly manner.

IT industry has emerged as the fastest growing segment of Indian industry and its growth rate is almost double the growth rate of IT industries in many of the developed countries. In the IT action plan, the government has targeted to increase the present level. Out of the nearly five million PCs presently in India, about 1.38 million are either of the old configuration (486) or even below. So a vast amount of equipment is soon going to be added to the waste stream, because upgradation beyond a point would not be feasible. Besides this, huge import of junk computers from other countries in the form of donations or gifts or low cost reusable PCs are going to create a big solid waste management problem in India. PC scrap in the form of monitors, printers, keyboards, CPUs, floppies, CDs, Typewriters, PVC wires have already started piling up that are going to increase enormously in the coming years.

There are 10 States that contribute to 70 per cent of the total e-waste generated in the country, while 65 cities generate more than 60 per cent of the total e-waste in India. Among the 10 largest e-waste generating States, Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab. Among the top ten cities generating e-waste, Mumbai ranks first followed by Delhi, Bengaluru, Chennai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat and Nagpur.

Bangalore, the most revered electronic city in India is the home of over 1,200 overseas as well as domestic technology firms. Figures prominently in the danger list of cities that face e-waste hazard. In Bangalore, e-waste is dumped in landfills as well as is incinerated, releasing harmful toxins into air and soil.

The contribution of individual households is relatively small at about 15 %; the rest being contributed by manufacturers. They consume large quantities of consumer durables and are, therefore, potential creators of waste. Equipments discarded by individuals and small businesses form part of solid waste which gets disposed in landfills or incinerators. For large businesses, since it is illegal by law to dispose of computers in landfills, e-waste goes to the re-use/re-cycling/export market.

E-waste, which on the face of it seems quite clean and safe is not so. Its qualitative characterizations show it to be very complex consisting of several hazardous constituents that can play havoc with our health. These toxic and hazardous substances are as follows:

i. Lead and cadmium in circuit boards
ii. Lead oxide and cadmium in monitor cathode ray tubes (CRTs)
iii. Mercury in switches and flat screen monitors
iv. Nickel and Cadmium in computer batteries
v. Polychlorinated biphenyls (PCBs) in older capacitors and transformers
vi. Brominated flame retardants on printed circuit boards
vii. Plastic casings, cables and polyvinyl chloride (PVC) cable insulation that release highly toxic dioxins and furans when burned to recover copper from the wires. After separating all remaining components, motherboards are put for open pit burning to extract the thin layer of copper foils laminated in the circuit board.

Scope for Reuse: Data from a single-day recycling collection event in USA revealed that more than 50 per cent of rejected computers are in good working order, but they are discarded nonetheless to make way for the latest technology.

E-waste from consumer and industrial wastes are collected by formal actors (public or private collection points) and directly transferred to authorized treatment facilities. Here, depending on the type of WEEE, these are disassembled up to divide valuable components and hazardous elements. Both valuable and

hazardous components are stored and, then, transferred to dedicated recycling plants. The remaining WEEE mass is directly shredded and separated onsite up to recover basic materials (e.g. construction metals, plastics, wood, glass, concrete, etc.). Polychlorinated Biphenyl (PCBs) are separated from the waste product during disassembly, classified, stored and transferred to dedicated plants for the final recovery of precious metals. Components embedded into WEEEs are, generally, low / medium value elements and their remanufacturing would not allow re-entering from sustained costs.

Management of E-Waste

It has serious legal and environmental implications due to the toxic nature of the waste. These materials are complex and difficult to recycle in a safe manner even in developed countries. The recycling of computer waste requires sophisticated technology and processes, which are not only very expensive, but also need specific skills and training of operation.

Unlike many other countries there are no specific governmental legislations on e-waste. As such there are no standard procedures for disposal or handling of these toxic hi-tech products. Consequently, the electronic wastes in our country mostly end up in landfills or are partly recycled in most unhygienic conditions and partly thrown into waste streams.

In India, most of the recyclers currently engaged in recycling activities are poor people, mostly women and children, ignorant about the hazardous materials they are handling and have no access to the expensive technology to handle the waste.

Computers scrap in our country is managed through product reuse, conventional disposal in landfills, incineration and recycling. However the disposal and recycling of computer waste in our country are still not safe and pose grave environmental and health hazards

The management of electronic waste has to be assessed in the broad framework of Extended Producer Responsibility and the Precautionary Principle, so that in future policies the producers should own the responsibility of dealing with the waste management by taking back such wastes and recycle or reuse them in a safe manner. At present, management options for e-waste are extremely polluting and hence a cause of grave concern.

Effects on the Environment and Human Health

The disposal of e-waste is a global problem and the computer waste that is used for landfill produces contaminated leachates which eventually pollute the ground water. Acids and sludge obtained from melting computer chips, if disposed of in the ground, cause acidification of the soil.

The incineration of e-waste emits toxic fumes and gases. The vaporization of metallic mercury and other chemical substances create extremely toxic dioxins and such fumes are carcinogenic in the long term for e-waste management workers. This is why, we should be very careful in the management of e-waste.

India generates about 1.5 lakh tones of e-waste annually and almost all of it finds its way into sections of the community as there is no organized alternative available at present. This is especially true in metropolitan cities like Delhi, Mumbai, Bangalore, Kolkata etc. Because there is a higher risk of environmental pollution in these cities, this pollution leads to lung disease with complications and can damage the brain, the nervous system, the kidneys and the reproductive system. These e-waste elements are dangerous for working people employed in scrap yards handling the e-waste. About 25

thousand workers are employed in Delhi alone, where 10,000 to 20,000 tonnes of e-waste are handled every year. Other e-waste scrap-yards exist in Meerut, Ferozabad, Chennai, Bangalore and Mumbai. There is an urgent need for improvement in e-waste management covering technological improvement, institutional arrangements, operational plans, more protective protocol for workers in e-waste disposal and a general education and awareness in needed for public health workers in the disposal of e-waste.

Table 3.1.Effects of E-Waste Constituents on Health

Source of E-Waste	Constituent	Health Effects
Solder in printed circuit boards, glass panels and gaskets in computer monitors, batteries	Lead (PB)	• Damage to central and peripheral nervous systems, blood systems and kidney damage • Affects brain development of children
Chip resistors and semiconductors	Cadmium (Cd)	• Toxic irreversible effects on human health • Accumulates in kidney and liver • Causes neural damage • Teratogenic
Relays and switches, printed circuit boards	Mercury (Hg)	• Chronic damage to the brain • Respiratory and skin disorders due to bio-accumulation in fishes
Corrosion protection of untreated and galvanized steel plates, decorator or hardener for steel housings	Hexavalent chromium (Cr) VI	• Ashmatic bronchitis • DNA damage
Cabling and computer housing	Plastic including PVC	Burning produces dioxin. It causes • Reproductive and development of problems • Immune system damage • Interferes with the regular function of hormones
Plastic housing of electronic equipments and circuit boards	Brominated flame retardants (BFR)	• Disrupts the functions of the endocrine system
Front Panel of CRTs	Barium (Ba)	Short-term exposure causes • Muscle weakness • Damage to the heart, liver and spleen
Motherboard	Beryllium (Be)	• Carcinogenic (lung cancer) • The inhalation of fumes and dust causes chronic beryllium disease or beryllicosis • Skin diseases such as warts

List of Substances Contained in Electronic Waste

Substances in bulk: Polychlorinated biphenyls (PCB), polyvinyl chloride (PVC), thermosetting plastics, epoxy resins, and fiberglass

Elements in bulk: Lead, tin, copper, silicon, carbon, iron and aluminium

Elements in small amounts: Cadmium, mercury, thallium

Elements in trace amounts: Americium, barium, cobalt, europium, gallium, indium, palladium, rhodium, selenium, tantalum, vanadium and yttrium

Technology currently used in India

For non-CAT e-waste, the two e-waste treatment facilities in India use the following technologies:

Facility at Chennai

1. Decontamination
2. Dismantling
3. Pulverization/hammering
4. Shredding

Facility at Bangalore

1. Decontamination
2. Dismantling
3. Pulverization/hammering
4. Shredding
5. Density separation using water

However, both the e-waste treatment facilities at Chennai and Bangalore use thermal shock splitting technology along with abrasive wire brush and vacuum systems for CRT treatment. There is no interaction with water or air for CRT treatment in either of the facilities.

3.2 Hazardous Waste

Hazardous wastes refer to wastes that may cause adverse health effects on the ecosystem and human beings. These wastes pose present or potential risks to human health or living organisms due to the fact that they:

- Are non-bio-degradable or persistent in nature;
- Can be biologically magnified;
- Are highly toxic and lethal even at very low concentrations

The threat to public health and the environment of a given hazardous waste is dependent on the quantity and characteristics of the waste involved. Wastes are secondary materials, which are generally classified into six categories as inherently waste: like materials, spent materials, sludge, by-products, commercial chemical products and scrap metals, Solid wastes form a subset of all secondary materials and hazardous wastes form a subset of solid waste. However, note that certain secondary materials are not regulated as wastes, as they are recycled and reused.

By using either or both of the following criteria, we can identify as to whether or not a waste is hazardous:

(i) The list provided by government agencies declaring that substance as hazardous,

(ii) Characteristics such as ignitability, corrosivity, reactivity and toxicity of the substance.

Characteristics of Hazardous Wastes

Dangerous good are materials or items with hazardous properties. If it is not properly controlled, would lead to a potential hazard to human health and safety, infrastructure and or their means of transport. There exist different regimes, operating procedures, regulatory frameworks at both national and international levels. Dangerous goods are broken down in to the following 9 classes.

1. Explosives
2. Gases
3. Flammable Liquids
4. Oxidising Substances
5. Toxic and Infectious Substances
6. Radioactive Material
7. Corrosives
8. Miscellaneous Dangerous Goods

For a waste to be deemed a characteristic hazardous waste, it must cause, or significantly contribute to, an increased mortality or an increase in serious irreversible or incapacitating reversible illness, or pose a substantial hazard or threat of a hazard to human health or the environment, when it is improperly treated, stored, transported, disposed of, or otherwise mismanaged

Table: 3.2 Hazardous Waste Characterization

Hazardous Waste Code	Hazardous Material Class	Exploration Example
Ingnitable Hazardous Waste	Flammable Gas (Class 2)	Used Grease and Oil (Class 2)
	Flammable Liquid (Class 3)	
	Flammable Solid or Substance Susceptible to Spontaneous Combustion (Class 4)	
	Oxidising Substance (Class 5)	
Corrosive Hazardous Waste	Corrosive Material (Class 8)	Pb- Acid and Vehicle Batteries (Class 8)
Reactive Hazardous Waste	Explosive (Class 1)	
	Compressed Gas (Class 2)	
	Dangerous When Wet Substance (Class 4)	
Radiio-active Hazardous Waste	Radioactive Material (Class 7)	Certain Samples Collected in Uranium Prospection (Class 7)

Toxic Hazardous Waste	Poisonous (Toxic) Material (Class 6)	Used Hydrocarbon Solvents (e.g. Varsol) Used for Cleaning Oil Parts (Class 6)

Common Hazardous Wastes

Radioactive Substance: Substances that emit ionizing radiation are radioactive. Such substances are hazardous because prolonged exposure to radiation often results in damage to living organisms. Radioactive substances are of special concern because they persist for a long period.

The management of radioactive wastes is highly controlled by national and state regulatory agencies. Disposal sites that are used for the long-term storage of radioactive wastes are not used for the disposal of any other solid waste.

Chemicals: Most hazardous chemical wastes can be classified into four groups: synthetic organics, inorganic metals, salts, acids and bases, and flammables and explosives. Some of the chemicals are hazardous because they are highly toxic to most life forms. When such hazardous compounds are present in a waste stream at levels equal to, or greater than, their threshold levels, the entire waste stream is identified as hazardous.

Biomedical wastes: The principal sources of hazardous biological wastes are hospitals and biological research facilities. The ability to infect other living organisms and the ability to produce toxins are the most significant characteristics of hazardous biological wastes. This group mainly includes malignant tissues discarded during surgical procedures and contaminated materials, such as hypodermic needles, bandages and outdated drugs. This waste can also be generated as a by-product of industrial biological conversion process.

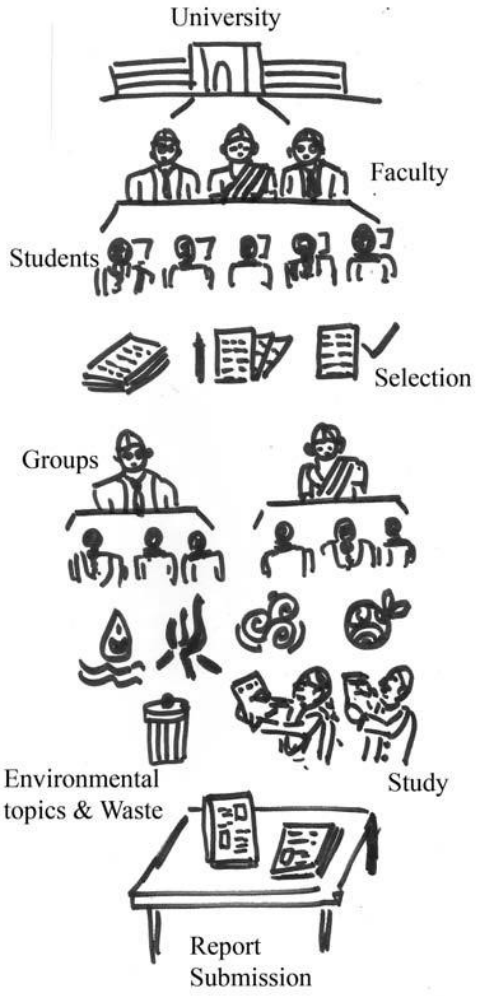
Flammable wastes: Most flammable wastes are also identified as hazardous chemical wastes. This dual grouping is necessary because of the high potential hazard in strong, collecting and disposing off flammable wastes. These wastes may be in the form of liquid, gas or solid, but most often they are liquids. Typical examples include organic solvents, oils, plasticizers and organic sludge.

Explosives: Explosive hazardous wastes are mainly ordnance (artillery) materials, i.e., the wastes resulting from ordnance manufacturing and some industrial gases. Similar to flammables, these wastes also have a high potential for hazard in storage, collection and disposal, and therefore, they should be considered separately in addition to being listed as hazardous chemicals. These wastes may exist in solid, liquid or gaseous form.

Table 3.3.Sources of Hazardous waste

Waste Category	Sources
Radioactive substances	Biomedical research facilities, colleges and university laboratories, offices, hospitals, nuclear power plants, etc.
Toxic chemicals	Agricultural chemical companies, battery shops, car washes, chemical shops, college and university laboratories, construction companies, electric utilities, hospitals and clinics, industrial cooling towers, newspaper and photographic solutions, nuclear power plants, pest control agencies, photographic

	processing facilities, plating shops, service stations, etc.
Biological wastes	Biomedical research facilities, drug companies, hospitals, medical clinics, etc.
Flammable wastes	Dry cleaners, petroleum reclamation plants, petroleum refining and processing facilities, service stations, tanker truck cleaning stations, etc.
Explosives	Construction companies, dry cleaners, ammunition production facilities, etc.



Battery Wastes: Waste batteries and accumulators (WB & A) or simply batteries, are distinguished into two non-rechargeable batteries (primary batteries) and rechargeable batteries (secondary batteries). From the broader perspective, the batteries types include:

- portable batteries
- vehicle batteries
- industrial batteries

Further division into composition based nomenclature includes:

- Lead Batteries
- Ni – Cd batteries
- Batteries containing mercury
- Alkaline batteries
- Other batteries and accumulators

The environmental effects of non-recycling WB & A are related to the heavy metals, particularly lead-contained. In case of combustion, the metal evaporates and disperses in rain which drops on soil and water bodies. In addition, the drainage of liquids in unsealed landfills can contaminate the aquifer. Batteries contain corrosive acids which can cause harm to living organisms. Also some batteries are flammable and may cause fire, especially if large amounts are disposed in landfills near forest areas.

By recycling the WB &A, we recover precious metals such as lead, which is relatively easily recycled and can be reused. In addition, we conserve energy, since each battery that is recycled saves energy.

Disposal

Regardless of their form (i.e. solid, liquid or gas), most hazardous waste is disposed of either near the surface or by deep burial.

Although, controlled landfill methods have been provided adequate for disposing off municipal solid waste and limited amounts of hazardous waste, they are not suitable enough for the disposal of a large quantity of hazardous waste, due to the following reasons:

- Possible percolation of toxic liquid waste to the ground water;
- Dissolution of solids followed by leaching and percolation to the ground water;
- Dissolution of solid hazardous wastes by acid leachate from solid waste, followed by leaching and percolation to the ground water;
- Potential for undesirable reactions in the landfill that may lead to the development of explosive or toxic gases;
- Volatilization of hazardous waste leading to the release of toxic or explosive vapours to the atmosphere;
- Corrosion of containers with hazardous wastes.

We must, therefore, take care both in the selection of a hazardous waste disposal site and its design. In general, disposal sites for hazardous wastes should be separate from those for municipal solid wastes.

While designing a landfill site for hazardous waste, provision should be made to prevent any leachate escaping from landfill site. This requires a clay liner, and in some cases, both clay and impermeable membrane liners are used. A layer of limestone is placed at the bottom of the landfill to neutralize the pH of leachate. A final soil cover of 25 cm or more should be placed over the liner. The completed site should be monitored continuously, both visually and with sample wells.

Characteristics of Hazardous Wastes

Other characteristics such as carcinogenicity, mutagen city, bioaccumulation, or phytotoxicity etc. are also classified as hazardous.

Management of Hazardous Wastes

The main sources of hazardous wastes are the industrial units. Law requires that industries dispose of their hazardous wastes, only after proper treatment. Unfortunately it is seldom heeded in practice especially in developing countries. As a result most hazardous wastes are commingled with the municipal wastes. Ultimately hazardous waste reaches the landfills and is leached to the ground water with grave impact on the human health.
Hazardous waste treatment and disposal strategies are usually industry-specific and are best implemented on the basis of an environmental audit of each industrial unit.

Apart from audits, other management strategies for hazardous waste management include life cycle analysis, volume reduction, toxicity reduction, recycling and reuse, avoiding waste mixing, and good housekeeping practices. A periodic review of housekeeping procedures is necessary. Training of staff is a major element in the implementation of these practices in any facility.

Treatment and disposal techniques for hazardous wastes include chemical oxidation, vitrification, and incineration, pyrolysis, and land disposal.

Hazardous Wastes Landfills
No single technique of waste management e.g. waste minimization, recycling can completely manage hazardous wastes. Some treatment technologies such as incineration, biological or chemical treatment produce residues and by-products which need to be disposed off securely. Landfills are commonly developed for disposal of hazardous wastes or for disposal of residues from other treatment processes.
Comprehensive rules, regulations and guidelines have been prescribed by the MoEFCC for the development of Hazardous Wastes Landfill.

Criteria for Wastes Acceptance at Landfill
Characteristics of hazardous wastes may be highly variable. Generally a landfill is not suitable for disposal of all types of hazardous wastes. It is necessary therefore to monitor the waste being transported to the landfill site. CPCB has laid down guidelines for acceptance of wastes at hazardous waste landfill sites. These are as follows:

- All wastes shall be accepted only if the truck carries authorized documents indicating the source and type of waste. Such waste shall be routinely inspected visually at the tipping area in the landfill site.
- Bulk or non-contaminated liquid hazardous waste or slurry-type hazardous waste containing free liquid or sludge, which has not been dewatered, shall not be placed in landfills. Such wastes shall be placed in hazardous waste impoundments designed specifically for liquid hazardous waste.
- Incinerable/compostable wastes or any other type of waste from which energy/material recovery is recovery is feasible, shall not be placed in hazardous wastes landfills.
- Incompatible wastes i.e. any two types of wastes, which could result in aggressive chemical changes after coming in contact, shall not be placed in the same landfill unit. Compatible wastes will be grouped together and placed in the same landfill unit (each such unit shall have its own phase, cells et.). Incompatible wastes group shall be accommodated in separate landfill units.
- Waste that can cause damage to the liner material shall either be containerized before disposal in landfill or be placed in a separate landfill unit made of alternate compatible liner material.
- Extremely hazardous wastes e.g. radioactive wastes shall not be disposed off in hazardous wastes landfills but in specially designed wastes disposal units.
- Non- hazardous wastes e.g. municipal solid wastes shall not be deposited in hazardous wastes landfills but in specially designed wastes disposal units.

- Non-hazardous wastes e.g. municipal solid wastes shall not be deposited in hazardous wastes landfills.
- Residues system should be designed specifically for each landfill. However a minimum of treated biomedical wastes e.g. incinerator ash can be deposited in hazardous wastes landfills.

Non-compatibility of Hazardous Wastes

Wastes to wastes compatibility is an important aspect of hazardous wastes management. Some wastes should not be mixed, stored, transported or disposed of together. If no compatible wastes are commingled they can pose increased risk to environment or human health e.g. generation of toxic fumes, fire or explosion hazards, violent reactions.

These consequences should be taken into account in planning for common disposal facilities or effluent treatment plants. A waste-to-waste non-compatibility matrix should be formulated before planning of common facilities. These matrices are also useful in the estimation of risk involved in disposal of hazardous wastes.

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal is the most comprehensive global environmental treaty on hazardous and other wastes. It was adopted on 22 March 1989 by the Conference of Plenipotentiaries in Basel, Switzerland. The Government of India has ratified the Basel Convention on the control of transboundary movement of hazardous wastes and their disposal (under the aegis of UNEP). The issues and options available for India, within the framework of the Convention

3.3. Radioactive Wastes

Radioactivity is defined as the property possessed by some elements of spontaneous emissions of alpha particles (α), beta particles (β), or sometimes, gamma rays (γ) due to disintegration. Radiation from alpha particles loses energy very quickly when passing through matter. As a result, alpha particles travel only a few inches in air and can easily be stopped by the outer layer of human skin. But they are harmful to humans if they are ingested and can damage body organs specially the lungs. Beta radiation travel farther as compared to alpha radiations. These can penetrate several layers of human skin. The human body can be damaged by exposure to a source of beta radiation or by ingesting it. Beta radiation can be stopped by an aluminium foil at least 2 mm thick.

Gamma radiation has a much smaller wavelength and can therefore penetrate much deeper. It can pass completely through the human body damaging cells or can be absorbed by tissues and bones. Damage to human health is therefore much larger. At least three feet of concrete or two inches of lead are required to stop 90% of the typical gamma radiation.

The process of unstable nuclei giving off radiation to reach a stable condition is called radioactive decay. Isotopes of elements having atomic number larger than 83 (Bismuth) are radioactive. A few elements with lower atomic numbers, such as potassium and rubidium, radioactivity. A few elements with lower atomic numbers, such as potassium and rubidium, have naturally occurring isotopes which are also radioactive. Radioactivity is measured in terms of curie (Ci), which is defined as the quantity of a radioactive material in which the terms of number of disintegrations is 3.7 x 10 10 per second. Each radioactive element has a characteristic speed of decay, is called the half-life of the element.

The biological effect of radiation is measured in units called rems. A rem is the amount of beta or gamma radiation that transfers a specific amount of energy to a kilogram of matter.

Some instruments used in the detection of radiation include:

(i) Geiger Mueller Counter
(ii) Ionization Chamber
(iii) Scintillation Counter
(iv) Film Badges
(v) Thermo luminescent Dosimeter (TLD)

The Geiger Muller Counter, Ionization Chamber and Scintillation Counter are used for detection of surface contamination. Film badges and TLDs are used for long term monitoring of exposure to workers. Gamma Ray Spectroscopy is also used for analysis of gamma radiations.

Classification of Radioactive Wastes

Radioactive wastes or Low-level Radioactive Wastes (LLRW) is a general term used for a wide range of materials contaminated with radioisotopes. LLRW may be disposed on specially designed landfills. These include wastes which are potential hazards and will persist long after such precautions as institutional controls, improved waste forms and deeper disposal have ceased to be effective.

Radioactivity in the environment comes from both natural and man-made sources. Natural sources are natural deposits of radioactive materials such as uranium and thorium. Man-made sources include mining activities, nuclear power plants, medical and laboratory facilities, nuclear weapon testing etc.

Table 3.4.Overview of Classes A, B, and C for Radioactive Wastes

Characteristics	Class A	Class B	Class C
Concentration	Low concentrations of radionuclides	Higher concentrations of radionuclides	Highest concentrations of radionuclides
Waste form	Does not require stabilization but may be stabilized	Requires stabilization for 300 years	Requires stabilization for 300 years or more
Intruder Protection	Decays to an acceptable levels requires no additional measure to protect	Waste recognizable requires stabilization	After 500 years, decays to acceptable levels Required stabilization and deeper disposal or barriers
Segregation	Class A must be segregated from B and C	No need to segregate from Class C	No need to segregate from Class B
Waste Types	Protective clothing,	Resins and filters from	Reactor components high activity industrial

	paper, laboratory trash	nuclear power plants	waste

Disposal of Radioactive Wastes

Management of radioactive wastes includes various operations similar to the MSW e.g. transportation, processing and disposal. But the techniques adopted for such wastes are different. Cementation, Polymerization, Vitrification, and Land Disposal are the common techniques for hazardous waste management. Another techniques is Hold-for-decay disposal i.e. storage of radioactive wastes to allow decay of short-lived radionuclides to low levels so that wastes can be disposed off safely.

Land disposal of radioactive wastes is carried out both in the below ground vaults (BGV) and above ground vaults (AGV). A vault is an engineering structure built to hold the most hazardous low-level radioactive wastes such as Class C waste. Earth-mounted Concrete Bunkers (EMCB) is also used for land burial of radioactive wastes. It involves isolating the waste in an engineered vault located above or below the ground. A multilayer earthen cover is positioned over the vault to provide an additional barrier to the nuclear radiations.

3.4. Biomedical Waste

Biomedical Waste Management calls for responsible and safe disposal of Biomedical Waste. Procedures need to be followed for collection, treatment and disposal, adhering to prescribed standards. All persons who generate, collect, receive, store, transport and treat or handle Biomedical Waste in any form need to be properly educated in this matter and must comply with the rules (as per Biomedical Waste rules notified in India in 1998). Any waste which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities is known as Biomedical Waste. Disposal of Biomedical Waste depends on the type of waste and different types of expertise and resources are required for different types of establishments. The various methods of disposal include incineration, microwaving, autoclaving, disinfecting and deep burial.

Healthcare Waste - Sources

Doctors, nurses, patients, visitors, administration staff, laundry staff, and all other miscellaneous cleaning staff, and waste handlers are always at perennial risk of exposure to biomedical and healthcare waste.

The institutions involved in the generation of biomedical waste are:

- Government Hospitals
- Private Hospitals
- Nursing homes
- Physician’s office/clinics
- Dentist’s office/clinics
- Dispensaries
- Primary health centres
- Medical research and training establishments
- Mortuaries
- Blood banks and collection centres
- Animal houses
- Slaughterhouses

- Laboratories
- Research Organizations
- Vaccinating centres
- Biotechnology institutions/Production units

Approximate percentage of waste types per total waste in biomedical care centres:

- Non-infectious waste: 80% is domestic waste
- Pathological waste and infectious waste: 15%
- Sharps waste: 1%
- Chemical or Pharmaceutical waste: 3%
- Pressurized cylinders, broken thermometers: less than 1%

Table 3.5 Average Composition of Hospital Waste in India

Material	Percentage (Wet-Weight basis)
Paper	15
Plastics	10
Bags	15
Metal (Sharps, etc)	1
Infectious waste	1.5
Glass	40
General waste (food waste, sweeping from hospital premises etc)	53.5

Source: NEERI, 1997

Biomedical Waste - Hazards

Biomedical waste is hazardous due to its composition of:

1. Chemicals and Pharmaceuticals toxins
2. Infecting Agents and Pathological Waste
3. Sharp Instruments
4. Genotoxic matter
5. Radioactive matter
6. Pressurized Containers
7. Heavy Metals and Mercury

Healthcare Waste exposure leads to ailments like eye irritation, asthma and other health disorders and also to deadly diseases such as AIDS, tuberculosis and skin diseases. On an average, in Delhi, hospital waste amounts to 3 Kg of wastes per bed/day including bottles, cotton, plasters, syringes, needles, bandages, human organs, as well as wastes from X-ray and radiological departments. Segregation packing, transportation, storage and disposal of these constituents needs to be carried out according to the guidelines laid down by the regulatory authorities.

Treatment and Disposal Techniques for Biomedical Waste

There are so many methods for the treatment and disposal of dangerous biomedical waste that it needs specific management and treatment for its disposal

1. Incineration
2. Chemical disinfection
3. Wet and Dry thermal treatment
4. Microwave
5. Irradiation
6. Land Disposal
7. Inertization

The treatment and disposal strategies of these wastes depend upon the waste characteristics. The Ministry of Environment and Forests, Government of India has classified biomedical wastes into 10 categories. These wastes should be collected in separate bags with different colour coding for easy identification and proper disposal.

Table 3.6 Treatment of Biomedical Wastes

Category	Types of Wastes	Treatment and Disposal
1	**Human Anatomical Wastes** Human tissues, organs, body parts	Incineration/ deep burial
2	**Animal Wastes** Animal tissues, organs body parts carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals colleges, discharge from hospitals, animal houses	Incineration/ deep burial
3	**Microbiology and Biotechnology Wastes** Wastes from laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research, infectious agents from research and industrial laboratories, wastes from production of biological, toxins, dishes and devices used for transfer of culture	Autoclaving/ microwaving/ incineration
4	**Waste Sharps** Needles, syringes, scalpels, blades, glass etc. that may causepuncture and cuts. This include both used and unused sharps	Disinfection (chemical treatment / autoclaving / microwaving) and mutilation/ shredding
5	**Discarded Medicines and Cytotoxic Drugs** Wastes comprising of outdated contaminated and discarded medicines	Incineration/destruction and drugs disposal in secured landfills
6	**Solid Wastes** Items contaminated with blood and body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material	Incineration / autoclaving / microwaving

	contaminated with blood	
7	**Solid Wastes** Wastes generated from disposable items other than the waste sharps such as tubing's, catheters, intravenous sets	Disinfection / autoclaving / microwaving and mutilation / shredding
8	**Liquid Waste** Waste generated from Laboratory and washing, cleaning, housekeeping, disinfecting activities	Disinfection / Discharge into drains
9	**Incineration Ash** Ash from incineration of any biomedical wastes	Disposal in Secured landfills
10	**Chemical Wastes** Chemicals used in production of biological, chemicals used in disinfection, as insecticides	Chemical Treatment and discharge into drains for liquid and secured landfills for solids

Source: MoEF (1998, 2016)

Treatment methods include burial, autoclaving, incineration, microwaving, shredding, disposal in landfills, chemical treatment etc.

Autoclaving

Autoclaving or steam sterilization is a low-heat process designed to provide direct contact of wastes with the steam in a controlled manner in order to disinfect the waste materials.

Microwaving

Microwaving is a thermal process used for treatment of hospital wastes. But unlike other thermal processes, which heat the wastes externally, microwave heating occurs inside the waste materials. The system involves shredding of wastes, injection of steam, and heating for 25 minutes at 95°C under a series of microwave i.e., electromagnetic radiation of frequencies 300 to 300,000 MHz. The microbial destruction occurs as a result of the thermal effect of the radiation.

3.5 Industrial Inert Waste

Fly ash

Fly ash is a major by-product in the coal-based thermal power plants. It is a finely divided residue resulting from the combustion of coal in a thermal power plant. It is generally grey in colour, abrasive, acidic, refractory in nature and has fineness (specific surface) of 4000 to 8000 sq. cm per gram. The particles range in size from as much as 120 to less than 5 microns in equivalent diameter. The part of ash that falls to the bottom of the boiler during combustion is called bottom ash, which is coarser in size and is washed away with water. Ash, which is fine and is carried away with flue gases, is called as "fly ash". It is separated from hot gases in the electrostatic precipitators of cyclone separators, from where it is carried away by wet method (slurry form) or by dry method. A portion of the fly ash escapes along with the hot gases through chimneys. Approximately, fly ash accounts for about 80 percent of the total ash produced.

Fly ash, being light in weight, gets airborne very fast and pollutes the atmosphere. Long inhalation causes silicosis, fibroses of lungs, bronchitis etc. It corrodes structural surfaces and its deposition damages horticulture and agriculture. Slurry disposal lagoons or settling tanks become source of mosquitoes and bacteria. Further, these have potential to contaminate the subsurface water with traces of toxic meals present in fly ash. Disposal of fly ash in the sea also disrupts the aquatic life cycle. Since the fly ash has severe environmental consequence it should be disposed of carefully.

Fly ash disposal

Disposal of fly ash is carried out in ash ponds. Ash is transported from the thermal power plants to the ash ponds thorough pipelines in the form of slurry. Fly ash can also be utilized in various construction and manufacturing operations. A great deal of literature is available on the utilization of fly ash especially as a construction material. Some of these are as follows:

Backfilling: Fly ash can be used in backfilling of open-cast mines. This avenue is very promising for ash utilization particularly if the thermal power plants are located near the mines. Fly ash can also be used in filling up of low-lying areas, for reclaiming land, and for construction of road embankments. Up to about 95 percent of maximum dry density can be achieved if controlled filling is carried out.

Blended cement: Being rich is silica and due to presence of pozzollons fly ash can be used either as a raw material for production of cement clinker or blended with finished cement. About 10 to 25 percent of dry fly ash can be mixed with clinker during manufacture of cement or blended with ordinary portland cement to produce Portland pozzolana cement.

Fine aggregate: Pond ash has particles size about the same as fine sand. It can therefore be used as a partial or complete replacement of sand in concrete. The mix design required for such concrete is somewhat different from that of the normal concrete.

Bricks, blocks and other products: Fly ash can be used as a raw material for the manufacture of fired clay bricks. Fly ash blocks can be used in the construction of pavements or for other purposes by adding appropriate amount of coarse aggregate to the mix e.g. mortar used for plastering of walls. Other applications include use of fly ash as a filler material in polymer composites which is a construction material.

Other important factors include pH of groundwater and the soil and the pesticide content etc. The depth of water table and vadoze zone and moisture content of soil are also important parameters. Climatological factors e.g. the ambient air temperature, rainfall etc. is also considered. Chemicals present naturally in soil e.g. chlorides, sulfates, carbon, nitrogen and the profile of various nutrients and metals present at the site should be analyzed before selecting a particular remediation technique.

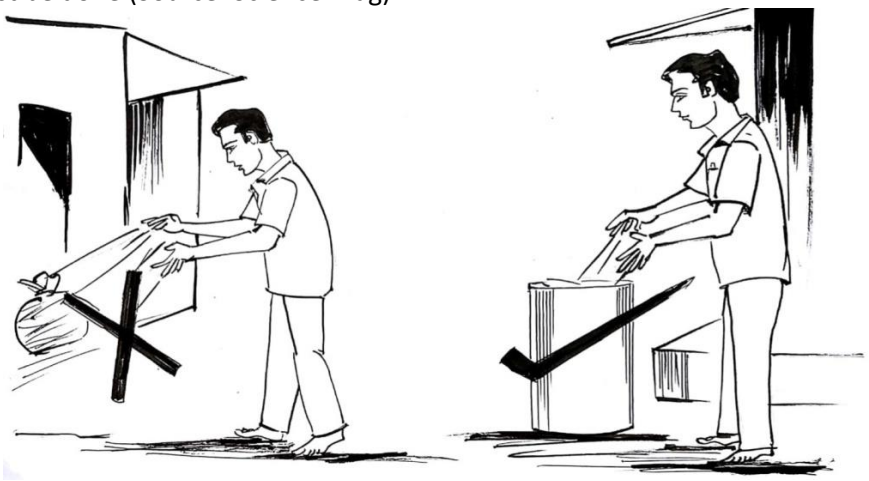
The nature and characteristics of contaminant in the soil should be estimated. This includes identification of organic and inorganic fraction, volatile, semi-volatile, and non-volatile fraction; halogenated or non-halogenated compounds; metals especially heavy metals present in the contaminant. Some contaminants may be predominantly hydrocarbons e.g. due to oil spillage, leakage in petrol pumps. Other important considerations in deciding the techniques for remediation are solubility and biodegradability of contaminants. Finally, the volume and toxicity of such contaminants is always important.

A geotechnical or environmental engineer should also be aware of the legal requirements and guidelines to be followed for any remediation work in terms of the goals to be achieved. These goals are usually specified as:

(i) In terms of the permissible limits of contaminants in the soil;
(ii) In terms of permissible limits of site where the wastes are to be disposed off; or
(iii) In terms of the technique employed e.g. disposal on secure landfills.

3.6 Plastic Waste

Plastic waste has a significant impact on the environment. Every day, a gigantic amount of plastic leaks into the environment, the seas and oceans (5 to13 million t/year).It stays there for a very long time, damaging nature and the ecosystems that support life on Earth. To prevent this leakage, we need to manage waste better and we need to see plastic waste as a valuable resource. Almost 40% of plastics are used for packaging. Raising recycling rates and stopping plastic packaging from becoming litter aren't easy, but they must be done (Source: Science Mag).



Sources of Plastic Wastes

- Plastic bottles, pots, tubs and trays.
- Plastic film.
- Rigid plastics, such as crates, pipes and mouldings.
- Plastic foams, such as expanded polystyrene (EPS)
- Flexible plastics, such as strapping and cable sheathing

Harmful Effects of Plastic Wastes

- Through polymerization process fugitive emissions are released.
- During product manufacturing various types of gases are released.
- Indiscriminate dumping of plastic waste on land makes the land infertile due to its barrier properties.
- Burning of plastics generates toxic emissions such as Carbon Monoxide, Chlorine, Hydrochloric Acid, Dioxin, Furans, Amines, Nitrides, Styrene, Benzene, 1, 3- butadiene, CCl4, and Acetaldehyde.
- Lead and Cadmium pigments, commonly used in LDPE, HDPE and PP as additives are toxic and are known to leach out.

- Single use plastic bags Non-recyclable plastic wastes and such as multilayer, metalized pouches and other thermoset plastic poses disposal problems.
- Sub-standard plastic carry bags, packaging films etc. pose problem in collection and recycling.
- Littered plastics give unaesthetic look in the city, choke the drains.
- Garbage mixed with plastics interferes in waste processing facilities and also cause problems in landfill operations

Summary

The chapter deals with special categories of wastes, each of which have to be managed individually. The methods of managing these wastes will be elaborated in other courses. E-waste, biomedical waste, radioactive wastes and industrial inerts should not be mixed into municipal solid waste. If this is done, the volume of waste, leachate pollution and difficulty in recycling are experienced.

Case Studies

1. Characterization of waste https://www.youtube.com/watch?v=4Ixuv-qhRs8
2. E-waste: How big of a problem is electronic waste? https://www.youtube.com/watch?v=UyIpG7UJKyI
3. E -Waste in India Short documentary https://www.youtube.com/watch?v=sFfaYc_pIx8
4. E -Waste, Bangalore's challengehttps://www.youtube.com/watch?v=upRdfYgnQEk
5. What is a Hazardous Material and Hazardous Waste https://www.youtube.com/watch?v=E_ui1maDVgs
6. The Basel convention on the control of Tran boundary movement of Hazardous wastes: Environment https://www.youtube.com/watch?v=I9GYb2EqXFk
7. Solid and hazardous waste management https://www.youtube.com/watch?v=4usR910eqeU
8. Radioactive Wastes https://www.youtube.com/watch?v=RgEGPQVXbXY
9. Radioactive waste management https://www.youtube.com/watch?v=qYDjjJxc4h4
10. Biomedical wastes: Definition, sources, classification, collection, segregation, Treatment https://www.youtube.com/watch?v=l4q5_Mz_Kh8
11. Biomedical Waste Management Rule, 2016 https://www.youtube.com/watch?v=eD9PSwX3tMU
12. Rotary "Swachh Mumbai": Biomedical Waste and E-wastehttps://www.youtube.com/watch?v=8EgpFaxkv4Y
13. Biomedical Waste Management at King George's Medical University, Lucknow, India https://www.youtube.com/watch?v=RVVKR5Hd-po
14. What is plasticshttps://www.youtube.com/watch?v=KIAp38NEcMQ
15. Know Your Plasticshttps://www.youtube.com/watch?v=_qTelxi3MjU

Self-Assessment Questions

1. Write a short report on the biomedical waste management practices being undertaken or followed at the hospital located nearest to your place?
2. Do you deposit the E-Wastes at the e-wastes centers that are being provided? If, yes write a brief note about it.
3. Since plastic bags have become a norm, do you firmly believe that we can do away without plastics bags? If the answer is yes, mention the alternatives or local eco-friendly choices which you opt for. If no, then do you believe plastics are a huge economy as regard to recycling by providing job opportunities, making secondary markets available?

Chapter 4
Source Reduction

Objective

- To define solid waste reduction and explain the strategies involved in waste source reduction through reduce, reuse and recycle.
- To reflect how source reduction of waste provides economic benefits and how it can be operated efficiently on daily basis.

Structure

4.1 Solid Waste Reduction
4.2 Waste reduction strategies
4.3 Economic benefits
4.4 Operation on a daily basis

To Do Activities

1. Discuss the ways of source reduction of solid waste.
2. Discuss ways in which one could persuade people to change their thinking pattern, and lifestyle. Also discuss on how they will apply it.
3. Make people more aware of the unhygienic activities and educate them to evaluate the consequences of excessive consumption resulting in waste generation
4. Facilitate group discussion on waste reduction strategies.
5. Invite a guest speaker who is an expert in waste management and facilitate an interaction with the students
6. Recap of Chapter. Discuss possibilities of career development, research or internship opportunities in waste management from these categories of waste.
7. Make students note their choices in their notebooks. After every chapter, they must add

4.1 Solid Waste Reduction

Solid waste source reduction can be defined as any change in the basic design, manufacture, purchase, or use of materials or products, which includes packaging as well; to reduce their volume and amount of toxicity before it becomes a waste of no further use. In simple terms, source reduction refers to reuse or recycling of products or materials. For the waste management hierarchy, source reduction is the first tier of the pyramid, its basic function and priority is to increase product durability, reusability and reparability. The very basis of solid waste management hierarchy as per the first and foremost efforts of Environmental Protection Agency (US EPA, 1989), which had the agenda for action with concept integrated waste management and included source reduction or managed practices with emphasis on tailored made to the requirement of societies, communities, municipalities, cities, businesses and organization's needs. To place, in nutshell the components of waste management hierarchy includes:

- Source Reduction (At source prevention of waste) – this includes reuse of products and at site or backyard composting practices
- Recycling, including off site composting
- Combustion with energy recovery

- Disposal through landfilling or combustion without energy recovery

Source reduction activities may include:

- Redesigning products or packaging to reduce the quantity of the materials used;
- Replacing lighter materials for heavier ones;
- Lengthening the life of products;
- Using packaging that reduces product damage or spoilage;
- Reducing the amount of products or packages used by businesses or consumers;
- Reusing products or packages; and
- Managing organic wastes such as food waste

Any sound waste management plan begins with prevention of waste in the first place. This is because today's generation generates wastes far beyond the levels ever recorded in the past. It is essential, therefore, to first understand why unmanageably huge waste is being generated by the current generation. The main reasons include

- Consumerism
- Higher disposable income
- Surplus production - pushing goods into new markets
- Packaging
- Changed attitude and lifestyle of the new generation
- Globalization

Case Study- Decentralized Waste Management

In July 2012, Alappuzha was facing a crisis. Known as the Venice of the East for its large network of canals, backwaters, lagoons and beaches, the city looked like a waste dump. Rotten garbage had piled up on roadsides, and canals and drains were clogged with bags of stinking waste. Swarms of mosquitoes and flies had invaded the city, spreading chikungunya and dengue.

Two-and-a-half-years later, Alappuzha had undergone a dramatic transformation. The dumping spots have disappeared. But where has all the waste gone? Is the city burying or burning waste under the cover of darkness? "No," smiles Mercy Diana, chairperson of the Alappuzha municipality. "We're on a clean city drive."

Alappuzha, which has a population of 0.174 million and produces 58 tonnes of solid waste a day, is implementing a project called Nirmala Bhavanam Nirmala Nagaram (Clean Homes Clean City) since November 2012. The focus of the initiative is segregation and treatment of wet waste at the source. "About 75 per cent of the waste is biodegradable, and one-third of this comes from households," points out Thomas Isaac, member of the Kerala Legislative Assembly from Alappuzha, who leads the initiative.

Source:https://www.downtoearth.org.in/coverage/waste/waste-smart-cities-54119

More and more non-degradable materials are being invented and used with frightening consequences. Consumption is being encouraged to meet mass production. Higher disposable income encourages a culture of throwing away goods without fully utilizing them. Development of logistics (especially e-retail) and consumption of packaged food require proper packaging material for safe and convenient transport. There is a vast geographical and social gap between producers and consumers, whereby the consumer cannot relate to the different aspects of production and the waste generated in the intermediate process.

In any case, it does not make sense to first produce waste and then struggle to find ways of handling it**.** For solving problems relating to waste in a realistic manner, we need to work initially to reduce consumption of items. Many people think that limiting consumption would impact the social standing of people and the country's development. Almost everyone is blinded by this mad rat race for becoming a developed nation. But the glaring fact is that an individual or a nation can hope for long-term growth, economically or otherwise, only by reducing consumption. In a country where consumption is limited by choice, the natural resources will be intact as the strength of the economy hinges on the availability of natural resources.

Suitable measures need to be taken before a material or product has becomes waste. This reduces:
(a) The quantity of waste, including through the **re-use** of products or the extension of the lifespan of products;
(b) The adverse impacts of the generated waste on the environment and human health;
(c) The content of harmful substances in materials and products.

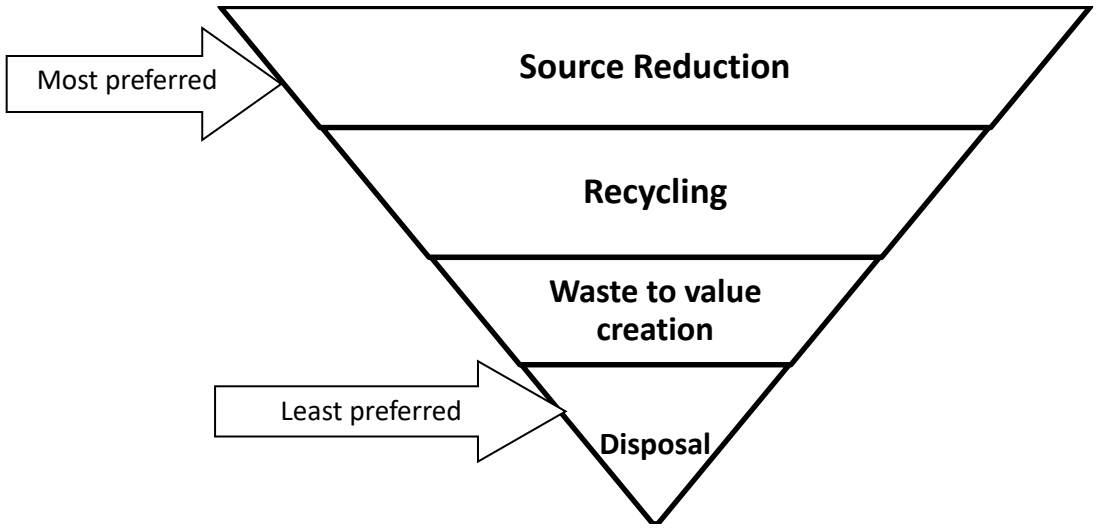


Fig 4.1 Waste Management Hierarchy

The above pyramid in the figure 4.1 begins with source reduction, because the best approach to managing solid waste is to avoid generating it in the first place. This will happen only by means of reducing the amount of waste one discards. It can be done by reusing the containers and products instead of throwing it away and increasing its use and avoiding its reach to landfill.

Importance of Waste Reduction

Reduction and reuse of wastes are the most effective ways to protect environment and have cost savings. It has a positive impact on Economy. The economy benefits through source reduction because less waste means more efficient use of resources and manufacturing processes, thereby increasing competitiveness. Manufacturers are learning that reducing solid or hazardous waste in any manufacturing process usually lowers costs. The need to use resources more efficiently and produce less waste is being felt in the marketplace.

Source reduction will benefit manufacturers, retailers and consumers. It ensures the efficient use of resources resulting in sustainable development for long term. More the increase in efficiency lesser the cost. Hence, more companies are trying to implement waste reduction methods that help in protecting environment. It decreases pressure on the environment. Waste reduction at source is also referred as prevention.

Source reduction includes:

- Process modification
- Technological intervention
- Engineering methods
- Through old case history
- Reuse of products
- Behavioural change

ReciclaIsapor ® Campaign - Brazil

In 2015 Plastivida, an association of plastics makers in Brazil launched the "*ReciclaIsopor®*" campaign to educate Brazilians about the recyclability of foam polystyrene plastic and to encourage citizens to recycle foam at drop off locations. The campaign aimed to stimulate the "responsible consumption and proper disposal, based on the dissemination of knowledge about the recyclability of the material, as well as being a sustainability action that generates environmental, social, and economic benefits."

Recycling collection bins have been installed in various locations such as select grocery stores and the Sao PauloCity Hall to receive the material brought by the public, including foam packaging used to protect home appliances and consumer electronics. Instead of becoming waste or litter, the collected foam polystyrene is reprocessed and sold to companies that manufacture new products, such as moldings, baseboards, thermo acoustic tiles, flooring, slippers, puff filling material, flower boxes, and more. According to Plastivida, Brazil recycled 34.5 percent of the foam polystyrene consumed in 2012, which generated more than 1,400 jobs and R $85.6 million for 22 recycling companies. To increase recycling beyond that rate, Plastivida participates in events, lectures, workshops, and fairs and encourages media coverage of foam polystyrene recycling.

Source: Declaration of global plastics association

Benefits of source reduction include:

1. Saving resources
2. Reducing toxicity of wastes (via use of alternatives /use of non-hazardous products, opting for eco-friendly products and recycled, refurbished products)
3. Reducing costs of management

4. Reduces GHGs emissions
5. Resource efficiency

Businesses/ Entities/Industries – They have an economic advantage by practicing source reduction. When businesses manufacture products with less packaging or packaging which is eco-friendly, their requirement for raw material for packaging is greatly reduced, which means larger profit margin and cost savings.

Consumers - Consumers can also share in the economic benefits of source reduction. Buying products in bulk, with less packaging, or items that are reusable (not single-use) frequently means a cost saving. What is good for the environment can be good for the wallet as well.

When does source reduction become vulnerable or exposed?
Source reduction becomes vulnerable or exposed if the practices are not brought into action as the government has little control over the amounts and kinds of consumer goods available in the market, nor over the packaging used for those products. Though packaging material classification is available based on its recyclability and degradability, packaging are as per the standards specified. But still at the manufacturing source level, a need for reduced and packaging based on recyclability is not available to the extent it is required and over packaging often results in increase in the volume of waste generation. Packaging plays an important role in terms of product integrity, promotion, safety and protection.

Basic Framework or Tool for Source Reduction Includes

- Capacity building and campaign for support of waste reduction and recycling – Public participation and stakeholder engagement
- Changing the very attitude of looking at waste

Possibilities for Source Reduction

- Study waste streams which includes quantitative and qualitative analysis and composition /characterization of wastes, recovery and recycling options, market availability
- Up keeping source separation, recovery, trading and incentives options and information dissemination for effective participation and implementation via networks like - forums for stakeholders.
- Facilitating small enterprises and public-private partnerships (PPP), availability of recycling centres.
- Promote residential and commercial composting (Onsite, backyard and offsite composting)
- Sell recyclables or license a private company /organization, PPP to sell the waste to create value
- Generating employment opportunities

In short, source reduction is best possible through the approach of product stewardship. Product stewardship can be defined as a concept based method that addresses the environmental and economic impacts of a product through its life cycle – everything from design and manufacturing to packaging and distribution to end of life management. To further upgrade the benefits, the concept of EPR (Extended Producer Responsibility) which emphasize on sustainability, environment and cradle-to-cradle approach.

4.2 Waste Reduction Strategies

Waste reduction strategies include - Reduce, Reuse and Recycle

Reduce

- Purchasing durable, long-lasting products.
- Using products with less packaging, packaging with high level of degradability and eco-friendly in nature. Source reduction actually prevents the generation of waste in the first place, so it is the most preferred method of waste management and goes a long way towards protecting the environment and reducing costs.
- Reduced material use in product manufacture.
- Increased useful life of a product through durability and reparability.
- Decreased toxicity.
- Material reuse.
- Reduced/more efficient consumer use of materials.
- Increased production efficiency resulting in less production waste

Examples for Waste Reduction

1. Flexible packaging waste prevention and management – concept by Smt. Almitra Patel, Member, Supreme Court Committee for Solid Waste Management includes: PE, PP, PS can all be recycled to gatta (lumps), daana (pellets) and products: Pipe, Hard plastic articles, some film tubing. Soiled mixed-films (carry bags, road litter) can be usefully shredded to improve tar roads: over 5000 km since 2004.
2. Shredded Plastic Film used for doubling road self-Life: Mixed plastic film is shredded to 2-4mm size and sprinkled onto heated mixed-stone aggregate. 30-second mixing time allows plastics to soften and uniformly coat hot stones like a baked-on primer. Molten asphalt added to this adheres well, doubles road life, reduces potholes, and improves wet strength.
3. Using only compatible thermoplastic layers.
4. Eliminating nylon and polyester layers.
5. Working with plastics recyclers
6. For toffee wrappers, mini–sachets, pesticide packaging, using compostable multifilms of BIS/ ISO 17088 / ASTM D6400-99 / EN 13432
7. Use Compostable bio-plastic barrier-films in sanitary napkins & disposable diapers

Reuse

Reusing products by repairing them, giving used items to needy groups, NGOs, marginalized and vulnerable communities or selling them will also reduce waste. Reusing products, when possible, is even better than recycling because the product does not need to be reprocessed before it can be used again. It extends its reach to landfill (avoiding waste to reach landfill).

Ways to Reuse

- Refill bottles.
- Donate unused products, containers, clothes and other day to day things.
- Reuse boxes.
- Turn empty jars into containers for storage.
- Reuse programme – Exhibition, capacity building and awareness initiative

Recycle

Recycling converts materials that would otherwise become waste into valuable resources. In addition to creating revenue, it generates a host of environmental, financial and social benefits. Materials like glass, metal, plastics and paper are collected, separated and sent to facilities that can re-process them into new materials or products, recovered to be converted into energy.

Design for Environment (DfE) and Design for Recycling (DfR) - Circular Economy

Circular economy is a model for environmentally sustainable economy, resilient in the face of resource insecurity and ecological crisis and aims for extended use of products and services. It aims for circularity in design and starting from the stage of production, consumption, return, recovery, recycle and transform.

- ✓ Redesign through innovation- reuse and recycle with transition strategies towards efficient and optimized plastic packaging can be win –win proposition.
- ✓ Replace single-use plastic bags by reusable alternatives.
- ✓ Scale-up reusable packaging in a business-to-business and consumers to business approach. Provide recycling centers hub for consumers.
- ✓ Drop box facility for consumers to drop their plastics, e-waste and other wastes of value that can be brought back into value chain.
- ✓ Plastic packaging, which often subjected to leakage into the environment, generates negative externalities, degradation of natural systems and greenhouse gas emissions that have been valued conservatively by UNEP at USD 40 billion.

What should Design for Environment (DfE) and Design for Recycling (DfR) provide?

Increase the demand for recycled plastics through voluntary commitments and or explore policy measures to support recycling. Packaging to be strategically designed for the product in order to optimize overall environmental performance

- ✓ Should be made from responsibly sourced materials
- ✓ Should be designed to be effective and safe throughout its life cycle
- ✓ Should meet market norms for performance and cost
- ✓ Should meet consumer expectations
- ✓ Should be recycled or recovered efficiently after use

Certification of circular economy products can be used to communicate the sustainability of products and services, and the reparability and recyclability of products. This would help consumers in their everyday choices. Further consideration is required on the compliance of circular economy with sustainable development and on the role of certification.

Regardless of the measures policy and decision makers plan and implement in the form of providing incentives, collecting wastes taxes, change in the way of deploying to waste collection, recycling, and processing of waste; we will never achieve truly mission of clean cities and Swachha Bharat unless there is a fundamental shift in public mindsets and behaviour towards producing less waste and also alternatives not provided for the citizens for use.

Using Products as Services

Vodafone's Red Hot
You can rent the latest phone for a year and keep on exchanging it for a newer version. Assuming Vodafone is engaged in collecting the old phone, not only does this act as material collection and pooling but, from a business standpoint, it also creates deeper customer relationships.

Tata Motors Assured
It is more than a second-hand car dealership. Cars are handpicked and refurbished in Tata workshops and then undergo a certification process. Customers are even offered financing options and warranty.

BMW's Remanufactured Parts
For BMW, product transformation can mean a 50% cost saving for customers buying remanufactured parts as compared to new ones. You get exactly the same quality specifications as a new BMW part subject to the same 24-month warranty.

Innovation in Recycling
Innovation in recycling technology is rapidly evolving and enabling the production of high-quality products with fantastic sustainability performance.

Starbucks's Recycling of Waste Coffee Grounds
Starbuck aims to turn thousands of tons of its waste coffee grounds and food into everyday products by using bacteria to generate succinic acid, which can then be used in a range of products from detergents to bio-plastics and medicines.

Extended Producer Responsibility (**EPR**)
Extended producer responsibility (EPR) is a strategy designed to promote the integration of environmental costs associated with goods throughout their life cycles into the market price of the products (OECD, 2001). It focuses on the end-of-use treatment of consumer products and has the primary aim to increase the amount and degree of product recovery and to minimize the environmental impact of waste materials.

The EPR conceptualization and thought process has the following key considerations:

- Product design shift
- Environmentally sound waste management
- Financial responsibility

- Physical responsibility
- Product responsibility

Extended producer's responsibility (EPR) is considered as main feature of E-waste (Management and Handling), wherein the producer of electrical and electronic equipment is given the responsibility of managing such equipment after its 'end of life', thus the producer becomes responsible for their products once the consumer discards them. Under this EPR, producer is also entrusted with the responsibility to finance and organize a system to meet the costs involved in complying with EPR (Johnson, *etal*, 2014).

Life Cycle Assessment

Life cycle thinking means accounting for economic, environmental and social impacts across all stages of a product or process life cycle. This perspective informs the design team of the product's life cycle impacts across a range of sustainability issues (i.e. greenhouse gas emissions, jobs created, daily average life years, etc.).

Life cycle thinking is based on and requires using some form of Life Cycle Assessment (LCA), such as:

- Environmental LCA
- Social LCA
- Life cycle cost analysis or total cost of ownership
- Streamlined LCA

The typical life cycle stages considered when evaluating the impacts of a product or service are listed below. The number of stages to include in your life cycle thinking depends on the product or process. Transportation between all stages should be included as well:

- Raw material extraction
- Material processing
- Manufacturing
- Use
- End-of-Life

How to Start a Waste Reduction Program Guideline

The best way to reduce the amount of waste produced is to look at your trash as you are throwing it out and ask yourself these questions:

- What do you throw away?
- What materials take up the most space in the trash bag?
- Can any items be reused, repaired, or donated?
- Can you reduce the number of disposable items used?
- Can you substitute products with ones that can be reused or that have recyclable packaging?

Learn what is accepted in your municipal recycling program. Then list the items in your trash that are not recyclable. The next time you go shopping, try to find recyclable alternatives to those items in your trash. If you have too many left over products, consider giving them to someone else or next time buy fewer of them.

Waste Reduction Ideas

- Use china and silverware, instead of disposal paper plates and plastic flatware.
- Use both sides of a piece of paper before recycling it.

- Pass on already read books, magazines, and newspapers to friends or coworkers, schools, libraries, nursing homes, churches, or other charitable organizations.
- Buy durable, well-made and/or repairable products.
- Use plug-in appliances, instead of battery operated ones. Single-use or even rechargeable batteries can end up in the landfill.
- Use a sponge or dishcloth instead of a paper towel to clean up a spill
- Buy the largest-size food packages that you can use without spoilage
- Avoid using plastic bags for produce purchases. Simply place produce loose in your cart or basket
- Use re-useable bags to transport items from the store to home (i.e. canvas bags)
- Consider contacting the manufacturer if your favorite brands have excessive packaging and express your concern about reducing waste
- Borrow, rent or share items that are used infrequently instead of buying them.
- Reduce the amount of mail you receive or send. Don't sign up for information you really do not want.

How to Start a Recycling Programme?

Every individual, society, community, organizations, institutions, business entities generate a large volume of waste every year. What can be done about it? While participating in local recycling programmes is considered as an excellent way to divert waste from the disposal process, the most environmentally and economically sound solution is to create less waste in the first place and secondly opt for recycling. A recycling programme planning includes the following planning steps or stages as represented in the figure 4.2.

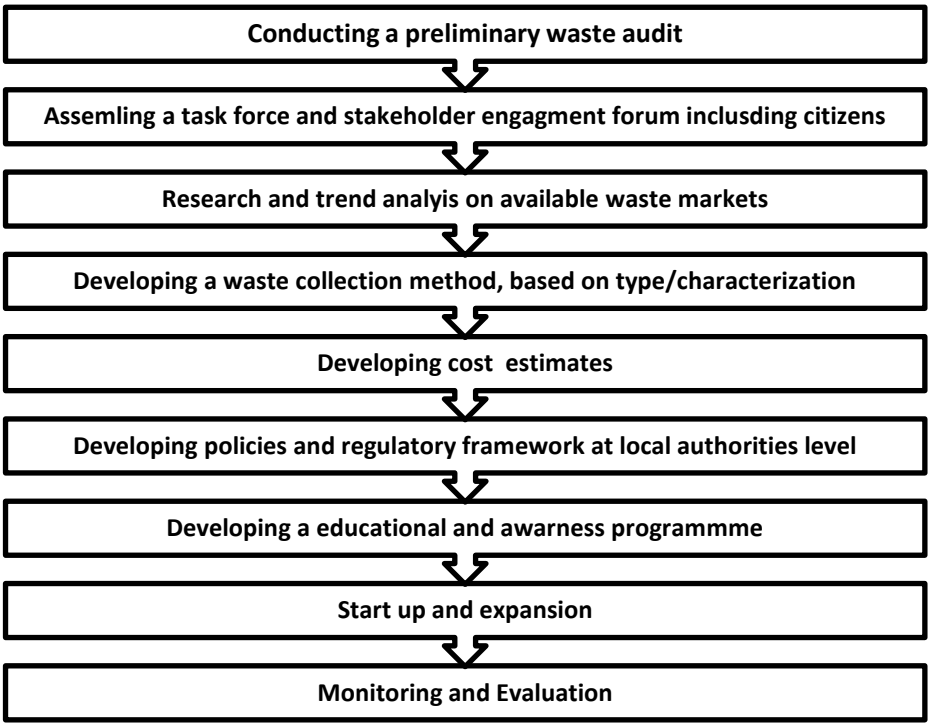


Fig 4.2 Planning Steps or Stages in Starting a Recycling Programme

4.3 Economic Benefits

The environmental benefits of recycling are well known, however the economic benefits of recycling are also significant despite the fact that they often get ignored. Recycling helps growth by generating employment opportunities. The sale of recycled products is also becoming an increasingly important component of the retail sector and commerce. There are different types of recycled products available in the market and with due to changes in technology and increased demand, today's recycled products can meet the highest quality standards, if implemented efficiently. Recycled products are also more readily available than ever before. Such products can be found in major retail stores, supermarkets, garden centers, local shops, catalogs and on the Internet. Furthermore, recycled products are affordable/cost savings. Many recycled products cost the same or less than comparable products made with virgin feedstock. By purchasing recycled products, consumers can help create long-term stable markets for the recyclable materials

As per the data status by Rajiv Agarwal, Director, Toxic Links[4],

- Plastics: 8.5 million tons per annum (consumption), 6 million tons per annum is waste generation. Number of authorized recyclers - 3500. Around 70% of plastic waste recycled in the informal sector
- Lead Acid battery. 161.7 billion INR in 2012. 4.43 million tons of waste generation. Authorized recyclers – Around 450. -In Delhi NCR 70 unorganized lead acid smelters, employing approx. 840 workers.
- Electronics industry – around $100 billion, Consumer electronics industry $9.7 billion in 2014, set to hit $20.6 bn by 2020. E-waste generation- 1.8 million tons. 138 authorized recyclers in India. About 95 % of the e-waste is being handled by the informal sector

The key economic benefits of waste reduction include:

- Avoids expensive disposal costs
- Lessens the need for costly alternative treatment of waste
- Saves on raw material and manufacturing costs

Cost Savings

Say for example a business must make a profit from waste management: If waste management costs are charged directly to the process that generates them, we shall get a true assessment of that process's profit/loss status.

Case Study: Suryapet Municipal Administration in Telangana

Suryapet municipal administration in Telangana is adopting the best practices in solid waste management in the country where they do not mix wet and dry wastes said Member, Supreme Court Committee for Solid Waste Management, Almitra H. Patel, She cited the example: Suryapet, Telangan is the only Zero- Dustbin and Zero Waste town to get ISO 14000 in 2006. Secret of success: Only Administrative will with no excuses. "TOTAL COMMITMENT" to Waste Management by both Commissioner and Councillors. Achieved by CMR Khadar Saheb in 18 months from 2002 only with own labour and no state or central funding, NO user charges to citizens, NO NGO support.

Source: almitrapatel.com

[4] https://www.oecd.org/environment/waste/Session_1-EPR-Toxics-Link1-Ravi_Agarwal.pdf

4.4 Operation on a Daily Basis

Operations in waste reduction are based starting from individual to business standpoint and strategies differ based on different waste characteristics. Operations, in this context, include all activities directly involved with making the product or providing the service and its usage in daily lives and how through optimized use, recovery and reuse effective waste reduction can be implemented across all the hierarchies. Most wastes are generated, generally have the great potential for waste reduction through reuse and recycle. The operational functionalities in waste reduction include:

- Processing
- Purchasing
- Receiving
- Delivery
- Inventory
- Personnel

Processing

It includes evaluating processing areas at the time of waste audit, by audit team and considers the following measures:

- Source reduction
- Scheduling procedures
- Waste segregation
- Maintenance

Purchasing

The way purchasing is done, helps control waste generation. It includes awareness, education and sound knowledge about what products to purchase and what packaged products are purchased.

- **Unified purchasing:** It includes routing all the purchases through one department/shop/grocery store. This makes it easier to apply uniform waste reduction policies.
- **Pre-purchase plan assessment:** Buying nontoxic (or the least toxic) material. Plan to us compactable and recyclable products
- **Minimize types of raw materials:** Reducing the number of raw materials, feedstock used as much as possible in the product line. Use of raw materials which promotes recyclability in long term upon recovery from products after end use.
- **Inventory regulator:** Purchasing or buying what is required.Over-purchasing holds the capital as well as induces losses if not disposed, stored but of no use to the consumer
- **Material Safety Data Sheet information (MSDSI):** Material Safety Data Sheets contain manufacturer's information on a material's chemical, physical, and toxicological properties as well as proper handling and storage procedures.

Receiving

In case of business entity, all materials entering the business site go through receiving procedures. Proper procedures promotes worker safety and minimize waste generating problems such as broken or leaking containers, damaged merchandise, and spills from tank and unloading. A few good practices to consider are: 1. Designated point to receive 2. Training to employees 3.Knowing your supplier 4.Inspecting the products, materials at the time of receiving.

Delivery
Well planned out delivery procedures to protect organizations, institutions, communities and societies and reducing waste. They are complementary to procedures for receiving materials.

Inventory

1. Materials Inventory: Excess inventory or reactive, toxic, or ignitable materials increases the chances of spills, exposure and worker ill health
2. Size of the container: Purchase materials in a container sized to the amount you are going to use. Transferring from large
3. Storage area: Should be clean, safe and efficient with ease of clean up.
4. Shelf life
5. Product and process changes: When a product or its process is changed, raw materials, which are already in inventory, are sometimes no longer needed. Suppliers need to from the point of cost optimization should include liability in mismanagement, incase materials return back.

Personnel
Progressive personnel responsibilities and commitments maximized waste reduction. Also in case of industry, it minimizes accidents and losses, provides a productive workforce

The reason for the emission of toxic gases while incinerating the garbage is due to presence of plastics which produces Dioxin and is highly toxic compound. Therefore the Government is controlling on plastics. Plastics are to reuse or recycling instead of throwing.

Some Innovations examples being undertaken for waste reduction:

- Paper Reduction through e-Government: The implementation of technology-based document management, electronic filing, and other online systems to replace the use of paper;
- Policy Frameworks for Sustainable Operations: Innovative municipal policies for resource conservation, holistic decision making, and protecting public and environmental health;
- Disposable Bag Policies: Examples of store-level fees on the use of disposable carry bags;
- Environmentally Preferable Purchasing Policies: Jurisdictions using their purchasing power to minimize the environmental and social impacts of their operations; and
- Biodiesel Use in Fleet Vehicles: The use of recycled vegetable oil to power fleet vehicles.

Summary

Source reduction is the key to sustainable waste management. As much as possible, we must recover resource from waste as soon as it is generated. Decentralization of waste management, as was done by Alleppey town is a good example. As is seen in the waste hierarchy, source reduction is the most preferred method of waste management. Some companies are achieving it through education programmes, while others have bade it part of their strategic plan and design. Technological design, process modification and behavioral change play a role in this. Government control on packaging plays a vital role in source reduction. More such examples are provided. Designing for environment and for circular economy are also explained here. Steps for starting a recycling programme are described along

with its potential savings and cost benefits. Concepts of life cycle assessment (LCA) and extended producer responsibility (EPR) are introduced here. They will be explained in other courses.

Additional Case Studies:

1. **EPR Perspectives and experiences from India – By Ravi Agarwal, Director - Toxics Link**
   https://www.oecd.org/environment/waste/Session_1-EPR-Toxics-Link1-Ravi_Agarwal.pdf

2. **Case Study – WithumSmith+Brown, PC (Morristown, New Brunswick, Paramus, Princeton, Red Bank and Toms River, NJ)**
   https://www.nj.gov/dep/dshw/recycling/wastewise/njwwcasestudy.pdf

3. **Case Study: Waste management: Unrealized Environmental & Economic Benefits:**https://deltainstitute.org/delta/wp-content/uploads/Delta-Institute-Waste-Management-Report-October-20141.pdf

Self-Assessment Questions

Score card based: Yes (3 points); sometimes (2 points); and No (1 point)
**Add the points to get a score card of consumption and sustainable habits

1. Do you consider the amount of packaging on an item when you buy any product?
2. Do you consider the recyclability aspect of the product you are buying?
3. Do you think about the product packaging and the waste from the product once you have used it?
4. Do you practice reusing the product containers?
5. Will you opt for recycling if opportunities to recycle are provided in your area?
6. Do you use dish cloths, sponges and cloth napkins instead of disposable paper products?
7. Will you avoid eating in places which wrap your food in lots of paper and plastic or ask that less wrapping be used for your order?
8. Do you practice composting kitchen scraps and other compostable matter?
9. Do you purchase items/products/goods in bulk?
10. Do you read consumer information /product labeling and usage information products you buy?

Further Readings

1. Making India Responsible and Environmentally Aware: https://www.youtube.com/watch?v=PekfCAAlDDw
2. Tirupati - Best in Solid Waste Management https://www.youtube.com/watch?v=ubPeQItQz-0
3. Finished Products from the Construction and Demolition Waste Recycling Plant https://www.youtube.com/watch?v=T6k46wBulXs
4. Waste Minimization by Integrated Solid Waste Management (ISWM) - Case Studies https://www.youtube.com/watch?v=y6GfnL5dC6c

Chapter 5
Waste Audit

Objective

- To give an understanding on how Environmental audit and EIA is to be performed for waste management.

Structure

5.1 Introduction to Waste Audit
5.2 Types of Waste Audit
5.2 Checklist for performance of audit of management of waste

To Do Activities

1. Open discussion on Waste Audit with the reading of the case study on Australia
2. Class room teaching on themes of Waste Audit
3. Conduct practical activity #3 as a financial audit, a performance audit or a compliance audit.
4. Classroom teaching - Explain how the results of these audits affect the performance improvement of waste management
5. Recap of Chapter. Discuss possibilities of career development, research or internship opportunities in waste management from these categories of waste.
6. Make students note their choices in their notebooks. After every chapter, they must add topics to this running list. This will help them select their study topic(s).

5.1 Introduction to Waste Audit

A waste audit is an analysis of your facility's waste stream. It can identify what types of recyclable materials and waste your facility generates and how much of each category is recovered for recycling or discarded. Using the data collected, the organization can identify the feasibility of enhancing its recycling efforts and the potential for cost savings. Waste audit will help in identifying the waste generation checkpoints so that measures to reduce can be taken. The following are the reasons for conducting waste audit:

- For establishing baseline or benchmark data.
- Characterizing and quantifying waste streams.
- Verifying waste pathways.
- Identifying waste diversion opportunities.
- Identifying source reduction opportunities.
- Assessing effectiveness and in determining ways to improve efficiency of current waste management systems.

5.2 Types of Waste Audit

Compliance Audit: The scope of audit is restricted to checking compliance of the audit entity with respect to policies/laws/ rules/regulations framed by the Parliament/state legislature. With respect to waste, compliance audit would check whether the audited entity (can be a private entity, or an agency of the government) is complying with the policies/laws/rules/regulations relating to waste (like Bio-medical Waste Management and Handling Rules, Municipal Solid waste management and Handling Rules, Hazardous Waste management rules etc.,) framed by the Ministry of Environment and Forests at the central level and Department of Environment at the state level.

Performance Audit

- Audit of Government's monitoring of compliance with environmental laws: The main aim of such audit is to assess whether the government is monitoring compliance whether the entities required to follow the applicable waste rules are doing so or not.
- Audit of the environmental impact of other Government programs: The main aim of such audit is to offer an opinion on the environmental impact of other programs/projects formulated and implemented by other Ministries/ departments/agencies other than the Ministry/Department of Environment. For example, audit of the impact of mining, building roads/dams, military etc., on the environment would fall under this category.
- Audit of Environmental Management Systems: The main aim of such audit is to offer an opinion on the implementation of Environmental Management Systems (EMS) of the audit entity and/or ISO 14001 Standards

Financial Audit

Some audit entities operate in sectors where environmental matters like waste may have material impact on their financial statements. In such entities, impact of environment related issues requires to be adequately reported upon in the financial statements. The International Auditing Practices Committee (IPAC) had defined environmental matters in a financial audit and these as applicable to waste are:

- Initiatives to prevent/abate/remedy damage to the environment as a result of improper handling and management of waste. Such initiatives may be required by environmental laws and regulations or by contract, or they may be undertaken voluntarily.
- Consequences of violating environmental laws and regulations relating to waste.
- Consequences of environmental damage done to others or natural resources as a result of improper management and handling of waste.
- Consequences of vicarious liability3 imposed by law. An example could be the present owners being held liable for environmental damage caused by the previous owners by dumping of waste.

Case Study- Waste Audit

A Large metropolitan Council in Victoria, Australia commissioned us to undertake a waste audit of a number of Council buildings and operations. The primary purposes were to measure levels of recycling based on a previous audit and then to investigate options to improve the diversion of materials to landfill – by both type and volume. This project involved collecting samples of materials from all these sites and physically sorting into a broad range of categories (27 in total). Accompanying this was investigations into the systems utilized by each site as well as staff waste management education programs. This project found that while recycling rates were consistent with the audit undertaken several years ago, there were many opportunities identified to reduce contamination of the recycling streams and reduce leakage of recyclables into the general waste – as an example; approximately 50% by volume of the general waste was in fact materials that were recyclable. Recommendations ranged from ensuring recycling bins were correctly located to introducing systems for organics (20% by volume of materials audited were organics), and other materials. Importantly, the strategies developed were individual to each site so as to ensure that the revised waste/recycling systems were sustainable and cost-effective.

Source: https://www.wasteaudit.com.au/services/customers/case-study-1/

Table 5.1 Checklist for Performance of Audit of Management of Waste

Objective	Question
Theme 1: Assessment of the quantum of waste and risks associated with it	
Whether the quantum of waste being generated in the country has been accurately assessed and whether risks to environment and health posed by waste have been identified.	1.1 Has an assessment of quantum of each kind of waste been made at the macro as well as micro level according to waste sources (like industries, households, hospitals etc.,) amounts and types (municipal solid waste, bio-medical waste, hazardous waste, e waste etc.,) to get an accurate picture of the waste being generated in the country and states.
	1.2 Has an identification and analysis of the expected parameters of significance for waste generation like increase in waste due to increase in population, due to greater economic growth, due to increase in demand for consumer goods, due to changes in manufacturing methods etc., and the composition of waste been done at central and state level.
	1.3 Has an assessment been made about the current capacity to handle waste and whether more capacity needs to be created based on the quantity of waste being generated.
	1.4 Has any entity/government identified the risks to environment as a result of improper management of waste and waste accumulation?
	1.5 Has the government identified risks to human health as a result of improper management of wastes?
Theme 2: Recognition of waste as a cause of environmental degradation	

Whether waste has been adequately recognized as a cause of environmental degradation by environmental legislation and planning documents by the country's planning authorities.	2.1 Does the legislation on protection of environment recognize waste as one of the threats to the environment in the country
	2.2 Do planning documents recognize the management of waste as a priority area for sustainable development of the country?
Theme 3: Government policies on waste minimization and waste reduction	
3. Whether policies on waste management reflect the priority of waste reduction and waste minimization in preference to waste disposal.	3.1 Has the government enacted a separate policy for waste management and does the waste policy define the hierarchy governing waste management.
	3.2 Has the government prepared an action plan for the reduction of each kind of waste.
	3.3 Has the government put in place waste prevention, reduction, and reuse and recycle strategies which will reduce the waste being generated in the country.
	3.4 Has the government taken any action on consumer information and education to promote waste minimization, specifically reduction, reuse and recycling?
	3.5 Does an environment labeling program exist and has it succeeded in its objective in promoting the use of environmental friendly products.
Theme 4: Existence of legislation for disposal of all kinds of waste	
4. Whether environmental legislation dealing with disposal of each kind of waste source exists and whether clear responsibility and penalty for violation has been incorporated in the legislations already enacted.	4.1 Does legislation /rules exist in the country for the disposal of all types of waste?
	4.2 Do all the rules/ legislation for the management of waste exists in a framework in one place for easy understanding and implementation.
	4.3 Whether the law/rules incorporate responsibility and penalty for violation (polluter pays principle) of waste laws.
Theme 5: Allocation of responsibility for the management of waste	
5. Whether the various agencies involved in the process have been identified and allocated clear responsibility and accountability for waste management and whether a mismatch/gap/overlap exists among the responsibility centres.	5.1 Has a nodal agency regarding waste management issues been identified at central and state level. 5.2 Have policy making bodies for each kind of waste been created.
	5.3 Have bodies for implementation of waste laws and rules been created.
	5.4 Have bodies been created and entrusted responsibility for monitoring the implementation of laws/ rules on waste.
	5.5 Have regulatory bodies been set up to fix standards for emissions and effluents generated by waste.
	5.6 Is there a body to assess the pollution being caused by the different types of waste.
Theme 6: Compliance to and monitoring of rules governing waste management	
6. Whether compliance to laws relating to waste is taking place and whether the	6.1 Are the municipal authorities managing and handling solid waste in accordance with the compliance criteria and procedure laid down in law.

monitoring mechanism is effective in checking non-compliance.	6.2 Is municipal solid waste being collected as envisaged under law?
	6.3 Is segregation of municipal waste taking place as envisaged under law?
	6.4 Have municipal authorities established and maintained storage facilities in such a manner as they do not create unhygienic and unsanitary conditions around it.
	6.5 Is the transportation of municipal solid waste taking place as envisaged under the law?
	6.6 Is the processing of municipal solid waste done as envisaged under the law?
	6.7 Is the disposal of municipal solid waste being done as envisaged in the law?
	6.8 Is the management of biomedical waste being done in accordance with the law?
	6.9 Has the segregation and labelling of biomedical waste prior to storage, transportation, treatment and disposal been done as per the law.
	6.10 Is the disposal of plastic waste being done as per the law?
	6.11 Is the disposal of industrial waste being done as per the law?
	6.12 Is the disposal of hazardous waste being done as per the law?
	6.13 Is the disposal of any other kind of waste for which laws have been enacted, disposed as per the laws?
	6.14 Whether monitoring mechanism was effective in checking non-compliance with the provisions of waste laws.
Theme 7: Evaluation and feedback mechanism	
7. Whether a sound system for taking effective action on the collected feedback has been evolved?	7.1 Have any evaluation studies been carried out regarding implementation of these laws.
	7.2 Have the recommendations made by independent evaluation agencies been incorporated in the Acts/rules.
Theme 8: Adequacy of funding and infrastructure	
8. Whether funding and infrastructure was adequate for the implementation of rules on waste management and whether the funds/infrastructure have been used economically, efficiently and effectively.	8.1 Are funds being provided for implementation of waste management laws/rules
	8.2 Is the funding adequate for waste management activities
	8.3 Whether need assessment for technically qualified manpower to implement and monitor waste management has been made and have these been deployed effectively
	8.4 Whether facilities to monitor pollution and environmental degradation as a result of waste exists with the pollution monitoring agency.

Waste Audit Process

- Audit planning
- Gathering background information for environment audit
- Setting audit scope
- Setting audit objectives for environment audits
- Setting audit criteria for environment audits

- Conducting field/onsite audits
- Post audit

Summary

Waste audit is of three kinds- compliance audit, performance audit and financial audit, as described in this chapter. The quantum of waste and the risks associated with it, recognizing waste as a cause of environmental degradation and compliance to government policies and laws on waste minimization and waste reduction are the themes along which waste audits are designed. To ensure proper waste management, the waste audit also takes in to consideration an evaluation and feedback method as well as the adequacy of funding and infrastructure.

Self-Assessment Questions

1. Describe the steps in the waste audit process.

Further Readings

1. Internal Waste Audit: A Best Practices Guidehttps://www.partnersinprojectgreen.com/resources/internal-waste-audit-a-best-practices-guide/

Video Links

1. Using Waste Audits to Improve Recycling & Recovery Programs https://www.youtube.com/watch?v=DVbB7mVY42Y
2. EIA waste sector lecture https://www.youtube.com/watch?v=BbKIkL9qsAM

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13. Waste Management, IANS (2016), https://swachhindia.ndtv.com/vegetable-markets-get-rs-10-lakh-setting-waste-management-plants-3722/

Annexures

1. Manual on Sampling, Analysis and Characterization of Hazardous Wastes http://cpcb.nic.in/cpcbold/upload/Publications/Publication_323_sec6_16.pdf
2. Wastes to Resource : Waste Management Handbook http://cbs.teriin.org/pdf/Waste_Management_Handbook.pdf
3. Performance audit on "management of Waste in India" https://swachcoop.com/pdf/CAG%20Audit.pdf
4. Technical EIA guidance manual for common hazardous waste treatment, storage and disposal facilities http://environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/TGM_%20Comman%20Municipal%20Sold%20Waste%20Management_160910_NK.pdf

Course 2 Biomedical and Hotel Waste Management

PG Diploma in
Waste Management & Environmental Hygiene

Mahatma Gandhi National Council of Rural Education

Hyderabad - 500004

Foreword

Biomedical waste management has assumed great significance in recent times. The rapid upsurge of HIV infection rates is an added factor. Due to the growing menace of this infectious and hazardous waste, Government of India has made proper handling and disposal of this category of waste a statutory requirement with the publication of gazette notification no 460 dated 27 July 1998. The provisions are equally applicable to all hospitals and it is mandatory for them to be well aware of the basic principles of handling, treatment and disposal of biomedical waste. Biomedical waste is defined as any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals, or in research activities, or in the production or testing of biologicals. The quantity of biomedical waste generated per bed per day varies depending upon the type of health problems, the type of care provided and the hospital waste management practices. It ranges from about 2kg in developing countries to about 5kg in developed countries. Infectious waste is almost 15% of the waste in developed countries while it is about 50% in India, requiring special handling. Hazardous biomedical waste has an inherent potential for dissemination of infection. Almost 60% of all hospital staff sustain injuries from sharps during various procedures undertaken in health care facilities. As microbiological and bio waste is highly infectious, it needs to be treated on site by autoclaving/microwaving/chemical treatment. Biomedical waste should be treated and disposed off in accordance with schedule 1 of the rules and the prescribed standards given in schedule V of Government of India gazette notification.

Hotel industry consumes lot of resources and contributes heavily to waste generation. Hotels have consistently contributed to tremendous growth in Indian GDP and also fueled the increase in number of hotels around the country. There are improper waste management practices in this industry and lack of suitable facilities and infrastructure, managerial and technical inadequacies add to the poor waste management system. The main goal of hotels should be to create sustainable business along with generating profit from waste. Proper management of waste can lead to higher profitability for hotels and save environmental pollution. A holistic framework for waste management needs optimization of each waste material in hotel industry. Most of the wastes in hotels are recyclable or compostable. Hotels can not only make environmental friendly contributions, but also make profits out of a proper recycling practice in the long term.

Waste Management is a serious issue that needs public awareness and practical and governmental attention immediately.

Dr. W G Prasanna Kumar
Chairman, MGNCRE

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This Post Graduate Diploma course on Waste Management and Environmental Hygiene is a cumulative effort of several sincere and committed visionaries and academicians. Envisioned by Shri VLVSS Subba Rao, Senior Economic Advisor, MHRD, the curriculum took shape under his keen guidance.

The sincerity with which the course curriculum was completed and published can be assessed from the fact that a prior National Consultation Workshop was held with several subject matter experts and academicians across the country, to review the contents of the course material.

The workshop was held to familiarize Central, State and Private Universities, local and social bodies with the contents of the curriculum and to discuss and share feedback on ways to improve the course curriculum. The workshop also focused on building industry–academia partnerships in Waste Management and Environmental Hygiene through an intellectual interaction. The findings and inputs of the consultation were subsequently incorporated in the course material.

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5.1 Conducting Waste Audit

5.2 Steps in Planning and Implementing a Waste Reduction and Recycling Program

Objectives

- To orient in transmission of communicable diseases and to handle risks in healthcare management
- To manage hotel wastes efficiently for higher profitability and also to curb pollution

Rationale

Waste management and environmental hygiene is the need of the hour and needs to be addressed across all sectors and communities. The course on Waste Management and Environmental Hygiene gives the student an overview of waste management including collection, transfer, transport, and disposal along with methods of processing, basic disposal facilities, disposal options, recycling, project management and GIS applications, reclamation and remediation, entrepreneurship and job opportunities in waste sector. In addition, this course provides the student with relevant information about waste markets, recycling trends, cost and affordability of waste management practices, and incentive based concepts. This course is therefore essential for the students who wish to pursue a career in waste sector as moving ahead, waste management will become an infrastructural necessity.

Competency

The course will be taught and implemented with the objective to develop required skills sets in the students so that they are able to acquire following competencies: Plan segregation, collection, transportation, recycling and disposal of wastes, know recycling trends and available waste markets, acquire skill development and know the scope and entrepreneurship opportunities in the waste management sector.

Methodology

The theory will be taught and practicality of the course will be addressed through questionnaires, self-assessment and dissertation. The course will be through class room lectures, guest lectures, field visits, audio – video learning mode, brainstorming sessions, seminars and Q&A. A lecture series will strengthen students' understanding of waste management which will help in acquiring different learning outcomes in rational and theory to practice approach. Competency that will be gained as part of course outcome includes - understanding, learning, applying and implementing skills, knowing career prospects in waste management sector, and internship and placement opportunities in.

Topics Covered

- Sources of biomedical waste
- Classification, Collection, Segregation, Pre-treatment, Transportation, Disposal
- Audit
- Health Hazards
- Capacity Building,
- Waste from Hotels and Eateries
- Treatment Methods
- Managing Food waste

Biomedical and Hotel Waste Management – An Introduction

The necessity of management in any field is imperative for a healthy environment. Wastes generated from hospitals and hotels are preposterous in magnitude and the waste management is equally deplorable. To know about management in general might help.

Introduction to Management

Management, also known as 'managing', is to administer any organization including non-profit organizations. It involves establishing goals, planning resources, setting timelines and subsequently executing them. In general, the modern organization theory refers to management as effective utilization of human resources, investments, technology and production in a company. There are multiple streams of management such as human resource management, financial management, product management, technology management, marketing management, etc., The objective of every stream is to 'manage' the resources and meet the desired objectives. The following figure represents the different streams of management and their primary responsibility:

Management and its Key Streams

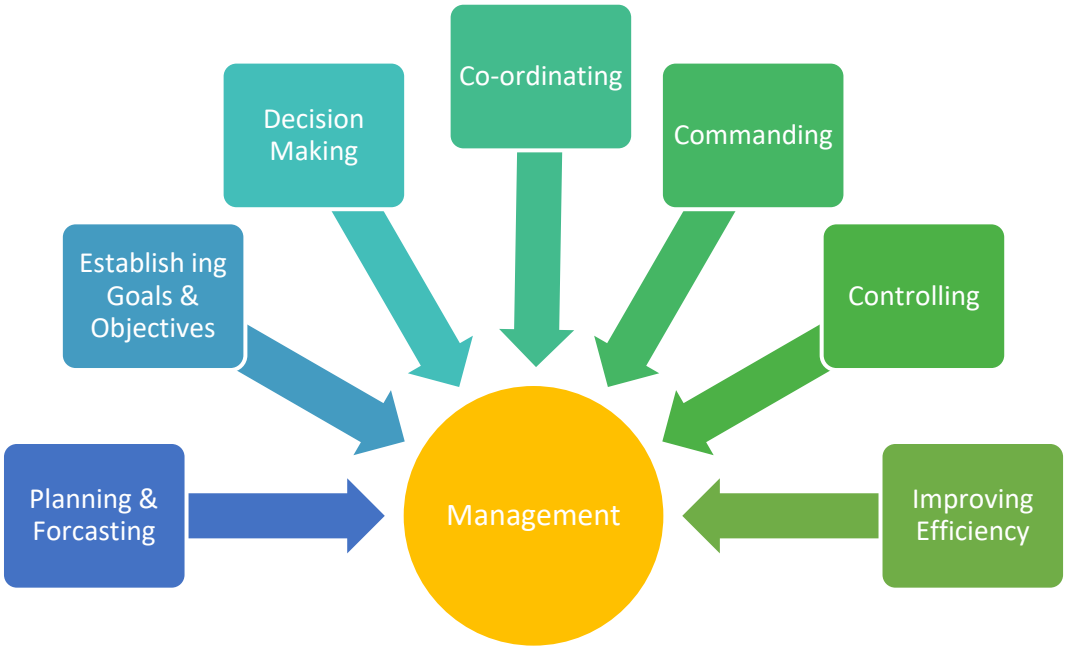
Management consists of six basic functions irrespective of the streams. It involves establishing goals, forecasting, planning, decision making, co-ordinating, commanding and controlling. The functions define the organization and its growth. Some of the functions are discussed in brief in this section.

Goals

Goals define the primary need of any management as they measure the existence of any organization or non-profit establishment. The goals (or) objectives can be divided into 'long-term' and 'short-term' goals. Long term goals are established for timeline of three or more years, whereas short-term goals can be for less than three years. However the definition of goals can be changed based on the organization, non-profit institutions etc. Managers of these organizations generally function towards strategic management and business development. They have better understanding of existence of any organization and plan for sustenance.

Planning and Forecasting

This function of management involves understanding market demand and supply. The past data of sales / revenue or training that help them to plan for future. It also provides necessary information to prepare for future requirements (or) organizational needs. Forecasting involves understanding the data, analyzing it with appropriate tools/techniques and extracting sufficient information. This will help the organization and planning team to understand the path and establish necessary course of actions to meet the objectives.



Basic Functions of Management

Decision Making

One of the key contributions of a manager is to take right decision at the right time. This is generally accomplished based on past data (or) experience. Visionary managers can articulate the future intuitively. The decisions will help the organization to move forward and accomplish success. Decisions are an important function in every managerial streams'to recruit a person' (or) 'to make financial decision' (or) 'to establish brand characteristics' etc.

Commanding

The managerial aspect of management involves commanding decisions, knowledge and justification towards success. The commanding leader can guide the team in appropriate path and motivate them to reach goals. It also helps in people management, project management and providing timeline to accomplish the objectives.

Controlling

This function refers to setting standards, measuring actual performance and taking corrective action. For any product (or) service, the process should yield desirable outcomes continuously and consistently. This is

very much applicable to production management wherein the products need to be within the specified design and measurements. Establishing the process and targeting desirable outcomes facilitate the organization to meet its objectives and accomplish its goals.

Thus management involves 'managing' (or) working on uncertainty and creating alternate course of action to sail through tough situations and succeed. As discussed earlier, management majorly involves people management in different aspects of their association such as product management, process management, and financial management, etc.

Medical care, as vital for our life and health, is equally damaging due to the waste generated from medical activities. Improper and mismanagement of waste generated in health care facilities causes a direct health impact on people involved from service providers to patients to the environmental health. Large amounts of potentially infectious and hazardous waste are generated in the health care hospitals and facilities around the world. All biomedical waste, as per its classification must be disposed safely without harming man and environment.

For the hotel/hospitality industry, daily operations generating tonnes of waste is an ongoing challenge. Along with incurring costs of waste disposal, hotels need to also allocate sufficient space for waste to be stored and sorted. The health and safety of the working personnel must be taken care of. Most of the waste created in hotels is generated from within the kitchen (organic food waste, packaging, aluminum cans, glass bottles, corks and cooking oils), or from the housekeeping department (cleaning materials and plastic packaging). Waste is created in rooms, public areas, hotel gardens and in its administration offices too, added by periodic renovation and refurbishment works.

This course deals with biomedical and hotel waste issues, categories, problems relating to handling and disposal methods, and creating environmental awareness.

Chapter 1

Biomedical Waste and Classification

Objectives

- To know about types of biomedical waste so that we know how to handle them carefully.
- To know what are the rules involved in managing biomedical waste.

Structure

1.1 Overview of Biomedical Waste
1.2 Sources of Biomedical Waste
1.3 Categories of Biomedical Waste
1.4 Legal Aspect

To Do Activities

- Visit a hospital and explain students about waste management and ask them to submit a report on the same
- Make students do group presentations by allotting topics to them
- Invite a guest speaker from a hospital who deals or takes care of biomedical waste and facilitate discussion

1.1 Overview of Biomedical Waste

Bio-medical waste can be defined as “any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or research activities pertaining thereto or in the production or testing of biological or in health camps”. It is considered as hazardous because they contain toxic substances. If the primary goal of "managing" waste from medical facilities is to prevent the accidental spread of disease, then it must first be acknowledged that there is only a small percentage of the waste stream that is contaminated and is capable of transmitting disease, and that the only documented transmission of disease from medical waste has been from contaminated sharps, syringes etc.It has an adverse effect to the health of a person or to the environment in general if not disposed properly. All such waste which can adversely harm the environment or health of a person is considered as infectious and such waste has to be managed by complying all statutory measures as given by an authored body.

Until recently, medical waste management was not generally considered an issue. In the 1980s and 1990s, concerns about exposure to human immunodeficiency virus (HIV) and hepatitis B virus (HBV) led to questions about potential risks inherent in medical waste. Thus, hospital waste generation has become a prime concern due to its multidimensional ramifications as a risk factor to the health of patients, hospital staff and extending beyond the boundaries of the medical establishment to the general population.

Hospital waste refers to all waste, biological or non-biological that is discarded and not intended for further use. Medical waste is a subset of hospital waste; it refers to the material generated as a result of diagnosis, treatment or immunization of patients and associated biomedical research. Biomedical waste

(BMW) is generated in hospitals, research institutions, health care teaching institutes, clinics, laboratories, blood banks, animal houses and veterinary institutes. The waste generated in the health care institutions essentially consists of solids and liquid, which may be hazardous, infectious and non-infectious. It has been estimated that up to 85% to 90% of the waste generated in hospitals is non-infectious (free with any body fluids, which is similar to domestic waste). It is the remaining 10% to 20% of waste that is of concern because it is hazardous and infectious. In addition, waste that is non-segregated and not treated in the right manner would cause environmental pollution affecting the health of the community.

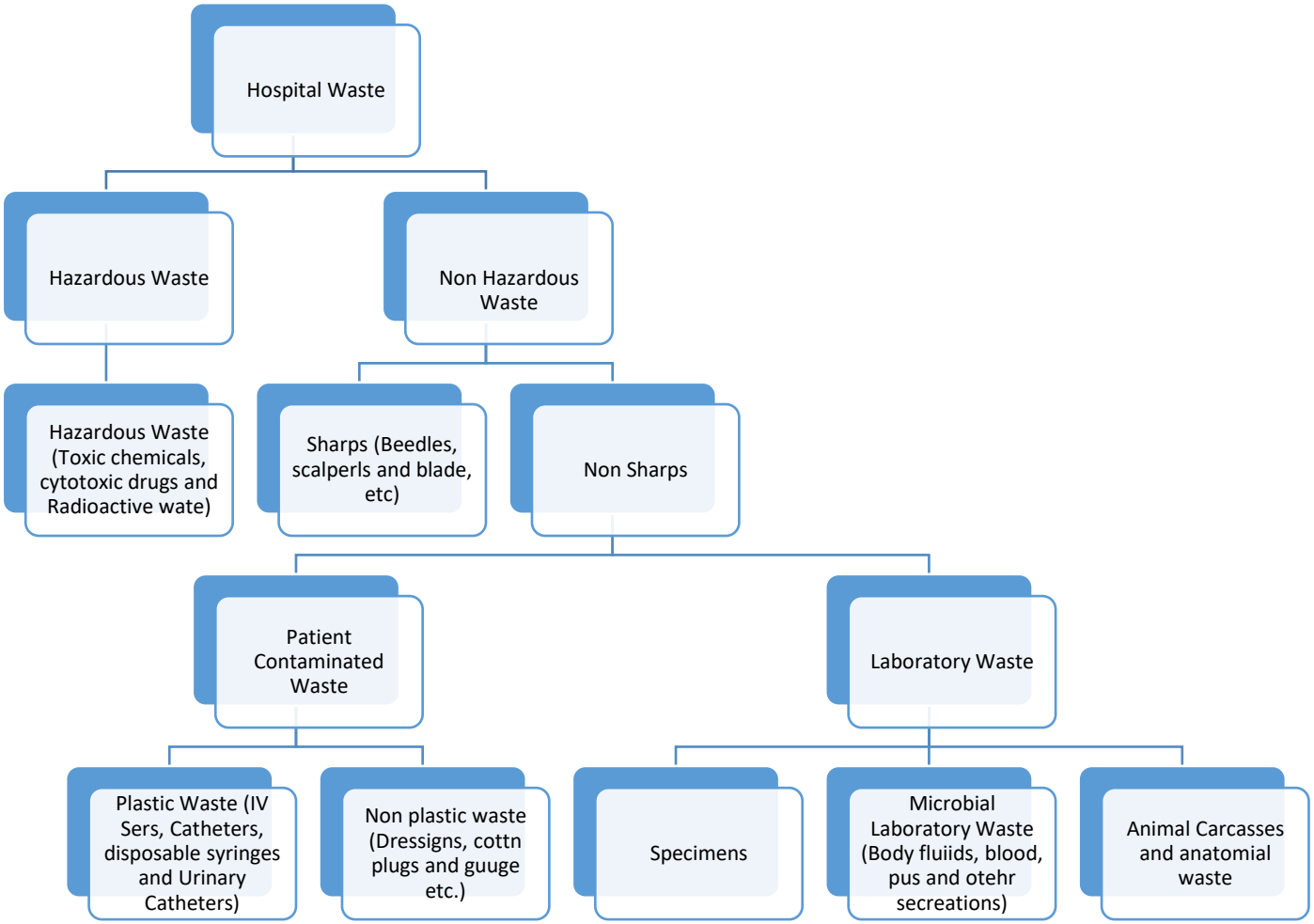


Fig 1.1 Classification of Hospital Waste[1]

[1]http://www.ihatepsm.com/resource/hospital-waste-management

1.2 Sources of Bio Medical Waste

Hospitals produce waste, which is increasing over the years in its amount and type. The hospital waste, in addition to the risk for patients and personnel who handle them also poses a threat to public health and environment. Below figures 1.2 and figure 1.3 shows major and minor sources of Bio Medical Waste respectively.

Fig 1.2Major Sources of Bio Medical Waste

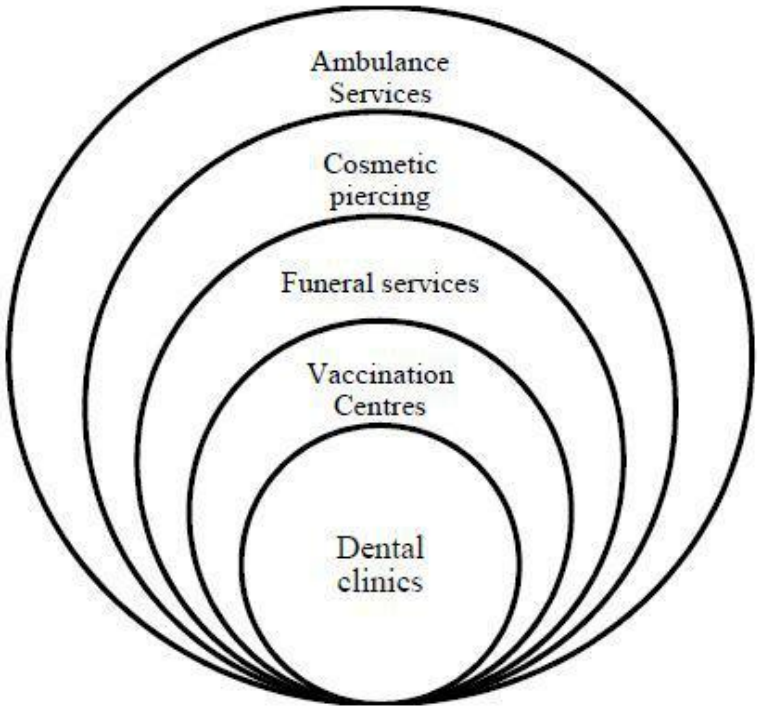


Fig 1.3 Minor Sources of Bio Medical Waste

1.3 Categories of Bio-Medical Waste

Bio Medical Waste Management Rules, 2016 categorizes the bio-medical waste generated from the health care facility into four categories based on the segregation pathway and colour code. Various types of bio medical waste are further assigned to each one of the categories, as detailed below:

Table 1.1 Schedule – I Categories Of Bio-Medical Waste

Option	Waste Category	Treatment & Disposal
Category No.1	Human Anatomical Waste (human tissues, organs, body parts)	incineration@/deep burial*
Category No.2	Animal Waste (animal tissues, organs, body parts carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals colleges, discharge from hospitals, animal houses)	Incineration@/deep burial*
Category No.3	Microbiology & Biotechnology Waste (wastes from laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biologicals, toxins, dishes and devices used for transfer of cultures)	local autoclaving/micro waving/incineration@
Category No.4	Waste Sharps (needles, syringes, scalpels, blades, glass, etc. that may cause puncture and cuts. This includes both used and unused sharps)	disinfection (chemical treatment@@/auto claving/microwaving and mutilation/ shredding##
Category No.5	Discarded Medicines and Cytotoxic drugs (wastes comprising of outdated, contaminated and discarded medicines)	incineration@/destruction and drugs disposal in secured landfills
Category No.6	Solid Waste (Items contaminated with blood, and body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material contaminated with blood)	incineration@ autoclaving/microwaving
Category No.7	Solid Waste (wastes generated from disposable items other than the waste sharps such as tubings, catheters, intravenous sets etc).	disinfection by chemical treatment@@ autoclaving microwaving and mutilation /shredding# #
Category No.8	Liquid Waste (waste generated from laboratory and washing, cleaning, house-keeping and disinfecting activities)	disinfection by chemical treatment@@ and discharge into drains.
Category No.9	Incineration Ash (ash from incineration of any bio-medical waste)	disposal in municipal landfill
Category No.10	Chemical Waste (chemical used in production of biologicals, chemicals used in disinfection, as insecticides, etc	chemical treatment@@ and discharge into drains for liquids and secured landfill for solids

1. Yellow Category

2. Red Category

3. White Category

4. Blue Category

The below table 1.1 shows the categories of Bio – wastes and the treatment methods as per in compliance with statutory methods by CPCB.

@@ Chemicals treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent. It must be ensured that chemical treatment ensures disinfection. # # Multilation/shredding must be such so as to prevent unauthorised reuse. @ There will be no chemical pretreatment before incineration. Chlorinated plastics shall not be incinerated. * Deep burial shall be an option available only in towns with population less than five lakhs and in rural areas.

The below table 1.2 shows the coulour coding and type of container for disposal of Bio- Medical Wastes

Table 1.2 SCHEDULE -II Colour Coding and Type of Container for Disposal of Bio-Medical Wastes

Colour Coding	Type of Container	Waste Category	Treatment options as per Schedule I
Yellow	Non chlorinated Plastic bag	Cat. 1, Cat. 2, and Cat 3, Cat. 6. Human Anatomical Waste Animal Anatomical Waste Soiled Waste Expired or Discarded Medicines Chemical Waste Micro, Bio-tech and other clinical lab waste Chemical Liquid Waste	Incineration/deep burial
Red	Disinfected container / plastic bag	Cat. 3, Cat. 6, Cat. 7. Contaminated Waste (Recyclable) Tubing, bottles, intravenous tubes & Sets, catheters, urine bags, syringes (without needles) and gloves.	Autoclaving/Microwaving/ Chemical Treatment
Blue/White Translucent	Plastic bag/ puncture Puncture,Leak, Tamper proof containers proof container	Cat. 4, Cat. 7. Waste sharps including Metals	Autoclaving/Microwaving Chemical Treatment and destruction/shredding
Black	Plastic bag	Cat. 5 and Cat. 9 and Cat. 10. (solid)Glassware	Disposal in secured landfill

Notes:
Colour coding of waste categories with multiple treatment options as defined in Schedule I, shall be selected depending on treatment option chosen, which shall be as specified in Schedule I.
Waste collection bags for waste types needing incineration shall not be made of chlorinated plastics.

Categories 8 and 10 (liquid) do not require containers/bags.

Category 3 if disinfected locally need not be put in containers/bags.

1.4 Legal Aspect

According to Sections 6, 8, and 25 of Environment Protection Act 1996, Central Government has made various rules, notifications and orders including the Bio –medical Wastes (Management and Handling) to perform its functions effectively.

A brief summary of the provisions are given below:

- Section 3 establishes the authority of the government to undertake various steps for protection and improvement of the environment.
- Section 5 provides for issuance of directions in writing.
- Section 6 empowers the government to make rules.
- Section 8 permits the education of individuals dealing with hazardous wastes regarding various safety measures.
- Section 10 bestows authority to enter the premises and inspect.
- Section 15 allows the government to take punitive steps against defaulters. This involves imprisonment up to five years or penalty of upto rupees one lakh or both. In case the default continues, it would then attract a penalty of rupees five thousand per day up to one year and thereafter imprisonment up to seven years.
- Section 17 provides for punishment in case of violations by government departments.

Issues Relating to Bio-Medical Waste

Improper segregation, handling and disposal of bio-medical waste will cause environmental pollution, unpleasant smell, growth and multiplication of vectors like insects, rodents and worms and may lead to the transmission of diseases like typhoid, cholera, hepatitis and AIDSthrough injuries from syringes and needles contaminated with human.Various communicable diseases, which spread through water, sweat, blood, body fluids and contaminated organs, are important to be prevented. The Bio Medical waste scattered in and around the hospitals invites flies, insects, rodents, cats and dogs that are responsible for the spread of communication disease like plague and rabies. Rag pickers in the hospital sorting out the garbage are at a risk of getting tetanus and HIV infections.

The recycling of disposable syringes, needles, IV sets and other article like glass bottles without proper sterilization are responsible for Hepatitis, HIV, and other viral diseases. It becomes primary responsibility of Health administrators to manage hospital waste in most safe and eco-friendly manner.The problem of bio-medical waste disposal in the hospitals and other healthcare establishments has become an issue of increasing concern, prompting hospital administration to seek new ways of scientific, safe and cost effective management of the waste. Keeping their personnel informed about the advances in this area is very important. The need of proper hospital waste management system is of prime importance and is an essential component of quality assurance in hospitals.

Impact of Hazardous Healthcare Waste

- Infection

- Genotoxicity and Cytotoxicity
- Chemical toxicity
- Radioactivity hazards.
- Physical injuries
- Public sensitivity
- The infectious agents enter into the body through
- Puncture
- Abrasion
- Cut in the skin
- Through mucous membranes
- By inhalation and ingestion

Most Common Infections

- Gastro enteric through faeces and/or vomit
- Respiratory through inhaled secretionsE.g. Mycobacterium tuberculosis; Measles virus;
- Streptococcus pneumonia
- Ocular infections through eye secretions E.g. Herpes virus
- Skin infection through pus
- Meningitis through Cerebrospinal fluid
- Blood borne diseases E.g. Neisseria meningitides
- AIDS
- Septicaemia and bacteraemia
- Viral Hepatitis B & C
- Hemorrhagic fevers through body fluids Lassa, Ebola and Marburg viruses
- Genotoxicity and Cytotoxicity
- Irritant to skin and eyes e.g. alkylating agent, intercalating agent
- Carcinogenic and Mutagenic e.g. Secondary neoplasia due to hemotherapy
- Chemical Toxicity
- Many drugs are hazardous
- May cause intoxication, burns, poisoning on exposure
- Radioactivity Hazards
- Radioactive waste exposure may cause headache, dizziness, vomiting, genotoxicity and tissue damage
- Visual impact of the anatomical waste, recognisable body parts
- Physical injuries
- Sharps used needles, syringes and BP or surgical blades etc

Table 1.3 Problems Associated with BMW

Organism	Diseases Caused	Related Waste Item
Viruses **Hiv, Hepatitis B, Hepatitis A, C, Arboviruses, Enteroviruses**	AIDS, Infectious Hepatitis, Infectious Hepatitis, Dengue, Japanese encephalitis, tick-borne fevers	Infected needles, body fluids, human excreta, soiled linen, Blood, body fluids
Bacteria **Salmonella Typhi,** **Vibrio Cholera,** **Clostridium Tetani,** **Pseudomonas, Streptococcus**	Typhoid, Cholera, Tetanus Wound infections, Septicemia, rhematic fever, Endocarditis, skin and soft tissue infections	Human excreta and body fluid in landfills and hospital wards, sharps such as needles, surgical blades in hospital waste.
Parasites **WucherariaBancrofti,** **Plasmodium**	Cutaneous leishmaniasis, Kala Azar, Malaria	Human excreta, blood and body fluids in poorly managed sewage system of hospitals.

Chemicals and Explosive Agents

- Use of chemicals is widespread in healthcare and includes chemicals such as:
- Cleaning agents
- Disinfecting and sterilising agents
- Laboratory chemicals
- Medical glasses
- Anaesthetic agents
- Cytotoxic drugs and pharmaceutical substances

Chemicals that have the potential to cause harm is hazardous or dangerous. Such chemicals may cause health effects, physical hazard, or affect the environment. The main means of exposure are inhalation, absorption through skin contact or a splash in the eye, ingestion via contaminated food or hands and inoculation when a sharp object such as a needle punctures the skin. Chemicals used for storing the specimens, dead bodies, and which are used during surgical practices should be carefully discarded.

Summary

The chapter provides a basic understanding of Bio-Medical Waste, its handling and disposal. It also dealt with categories of bio-medical wastes and the rules involved in managing them and the infections occurred when it is improperly handled.

Self Assessment Questions

- Discuss among yourself how you differentiate the hazardous bio-medical waste and the non-hazardous one.
- Discuss how each type of waste in the healthcare unit has to be carefully managed so as to prevent the infections.

Further Readings

- https://www.medprodisposal.com/what-is-medical-waste-medical-waste-definition-types-examples-and-more
- http://www.jlponline.org/article.asp?issn=0974-2727;year=2018;volume=10;issue=1;spage=6;epage=14;aulast=Datta
- https://www.env.go.jp/recycle/3r/en/asia/02_03-2/01.pdf
- https://www.malsparo.com/storage.htm
- Segregation of Bio Medical Waste: A case study of a South Indian Tertiary Care Hospital, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4121919/

Videos

- https://www.youtube.com/watch?v=beiHbH-3GhI
- https://www.youtube.com/watch?v=9ToD_3Zp3mA
- https://www.youtube.com/watch?v=rIm58ARkv0Y

Chapter 2

Steps Involved in Bio Medical Waste Management

Objectives

- To know in detail various steps involved in managing bio-medical waste
- To know safe methods of segregation, transportation and disposal methods
- To understand various personal safety devices

Structure

To Do Activities

- Visit any healthcare facility near your campus and see what steps are taken up by the facility to safeguard the health of its workers. Interview some of the health care personnel there and find out if they are aware of precautionary measures in handling bio-medical waste
- Ask them to submit a report on precautions taken in the hospital as primary disposal methods and how it is a very crucial step in prevention of hospital infections.

Steps Involved in BMW Management

Bio-medical waste is bio-hazard and spread infectious diseases to humans. It is the responsibility of the Health Care Facility (HCF) Management to manage by complying all statutory measures.The steps involved in Bio-Medical waste management are as follows:

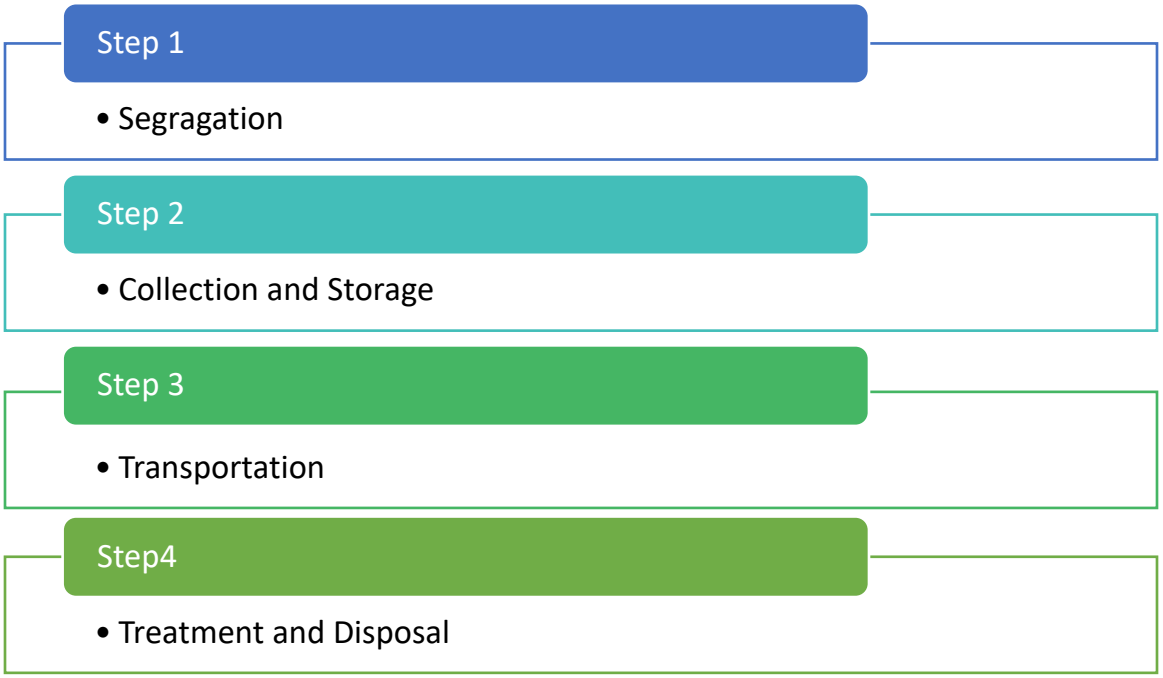


Fig 2.1 Steps in Bio Medical Waste Management

2.1 Step 1 Segregation

Fig 2.2 Segregation of Bio Medical Waste

Proper collection and segregation of biomedical waste are crucial elements in any health care centre. The quantity of waste generated at any health care centreneed to be taken care of. A lesser amount of biomedical waste leads to increase in efficiency of waste disposal, and save costs.

To protect the environment and community health, the Ministry of Environment and Forest has notified, "Biomedical waste (Management and Handling) Rules 1998/ 2000 under the Environment (Protection) Act, 1986 that compel all hospitals, clinics, nursing homes, slaughter houses and laboratories to ensure safe and environmentally sound management of waste produced by them."

Managing of waste effectively is not only a legal necessity but also a social responsibility. Some of the problems faced in the hospital waste management are lack of concern, motivation, awareness and cost factor. There is a need to create awareness on the hazards associated with improper handling of waste disposal. Keeping in view the low awareness level among different category of staff in the health care establishments regarding biomedical waste management, an effective communication strategy has to be carried out to educate the importance of managing hospital wastes. To start with, the following basic instructions need to be followed.

Waste must be segregated at the point of generation of source which means the location where wastes initially generate, accumulate and is under the control of doctor / nursing staff etc. who is providing treatment to the patient and in the process generating bio-medical waste.

- Posters / placards for BMW should be provided in the area
- Adequate number of colour code bins to be provided at source
- Specified colour code plastic bags to be provided at site

It is observed that in hospitals, the waste management practices are not complying with the standard procedures. The waste disposed off from the hospitals is both potentially infectious and hazardous. The workers who handle the waste have a great risk in the following ways:

- Accidental exposure to chemicals in waste bins
- Exposure to chemicals and other contaminants in water
- Exposure to chemical pollutants like mercury , Dioxin etc. from incineration wastes
- To avoid from such exposures, hospitals need to implement best standard practices at waste generation site.

2.2 Step 2 Collection and Storage

Collection

Fig 2.3 Guidelines for Collection of Wastes in Hospital

Some more points to be considered are collection time during the day need to be matched with the pattern of waste generation. For example, in an IPD ward where the morning routine begins with the changing of dressings, infectious waste could be collected mid-morning to prevent soiled bandages remaining in the area for longer than necessary. General waste collection must be done immediately after the visiting hours of the HCFs, as visitors coming to facility generate a lot of general waste and in order to avoid accumulation of such general waste in the HCF. The collection timings must enable the HCF to minimize or nullify the use of interim storage of waste in the departments. Bio-medical waste collected by the staff, should be provided with personal protective equipments (Refer Fig 2.4).

Gloves

Aprons, gowns, suits or other apparels

Masks

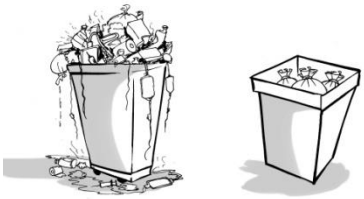
Boots

Gloves	•Heavy duty rubber gloves should be used for waste handling by the waste retrievers •Should be bright yellow in cloour •Should be washed after every use with carblic soap and a disinfectant
Aprons, gowns, suits or other apparels	•Apparel is worn to prevent contamination of clothing nd protect skin •it could be made of impermeable material such as plastic •People working in incinerator chambers hould have gowns or suits made of non- inflammable material
Masks	•It is mandatory for personnel working in the incinerator hamber to wear a mask covering both nose and mouth, preferably a gas mask with filters.
Boots	Leg coverings, boots or shoe- covers provide greater protection to skin when splashes of large quantities of infected waste have to be handled. it should be rubber soled and anti-skid type. it hsould cover the leg up to the ankle.

Fig 2.4 Personal Protective Equipments

Packaging

- Bio-medical waste bags and sharps containers should be filled to no more than three quarters full. Once this level is reached, they should be sealed ready for collection.
- Plastic bags should never be stapled but may be tied or sealed with a plastic tag or tie.
- Replacement bags or containers should be available at each waste-collection location so that full ones can immediately be replaced.
- Colour coded waste bags and containers should be printed with the bio-hazard symbol, labelled with details such as date, type of waste, waste quantity, senders name and receivers details as well as bar coded label to allow them to be tracked till final disposal.
- Ensure that Bar coded stickers are pasted on each bag



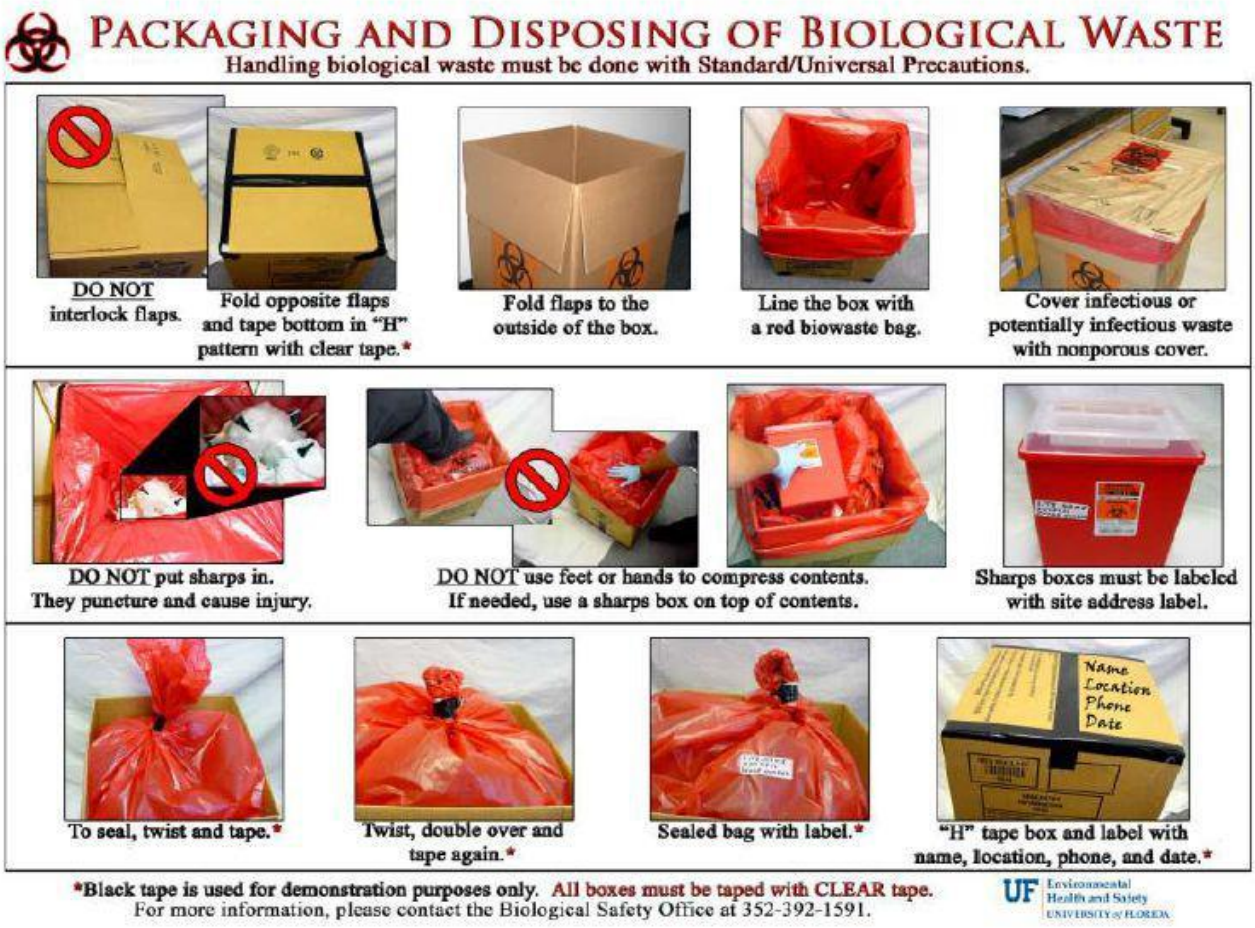


Fig 2.5 Packaging and Disposal of Biological Waste

Labeling

All the bags/ containers/ bins used for collection and storage of bio-medical waste, must be labelled with the Symbol of Bio Hazard or Cytotoxic Hazard as the case may be as per the type of waste in accordance with the BMWM Rules, 2016.For best practices, the Bio waste bags should be labelled with barcode.

Fig 2.6 Cyto-Toxic Label

Fig 2.7 Bio hazard

Bar Coding

- As per the compliance of BMW rules, 2016 barcode system is required to be adopted by the occupier as well as the operator of a common facility. This helps in:
- Tracking of waste from source of generation to final destination for final treatment and disposal
- Identification of waste in the event of source of generation in case waste is disposed of improperly;
- Helps in quantification of bio-medical waste generated, colour coding-wise waste handed over to the CBMWTF operator by the Occupier, for further treatment and disposal in accordance with the BMW Rules, 2016.
- Bar code label specific to an occupier may be pre-printed directly on colour coded bags/containers or bar coded label for pasting on the colour coded bags/ containers as prescribed under the BMW Rules, 2016shall be used.

Health Care Facilities shall procure Bar Coded Labels from the vendor (s) or the common Biomedical Waste Treatment Facility on payment of appropriate charges. At the temporary waste storage area, a representative of Health Care Facility should ensure that all the bags and containers are scanned by facility operator and also collect the waste receipt generated by the bar-code scanner unit.

Label for Transport of Bio-Medical Waste Containers / Bags should show

Date of generation .....

Waste category No .....

Waste class……

Waste description…….

Sender's Name & Address……. Contact Person……..

Receiver's Name & Address…… Contact Person……..

In case of emergency please contact, Name & address…….

Label shall be non-washable and prominently visible

Interim Storage

After collection, it must be stored in a proper place. Segregated wastes of different categories need to be collected in identifiable containers. The storage duration must not exceed for 8-10 hrs in big hospitals consisting of 250 beds and 24 hrs in nursing homes. Every container must be clearly labeled to show the ward or the room where it is kept. Also, storage area must be marked with a caution sign. Quantity of waste should be as less as possible so that waste storage, transportation and disposal is done within 48 hours. The following points need to be taken care of:

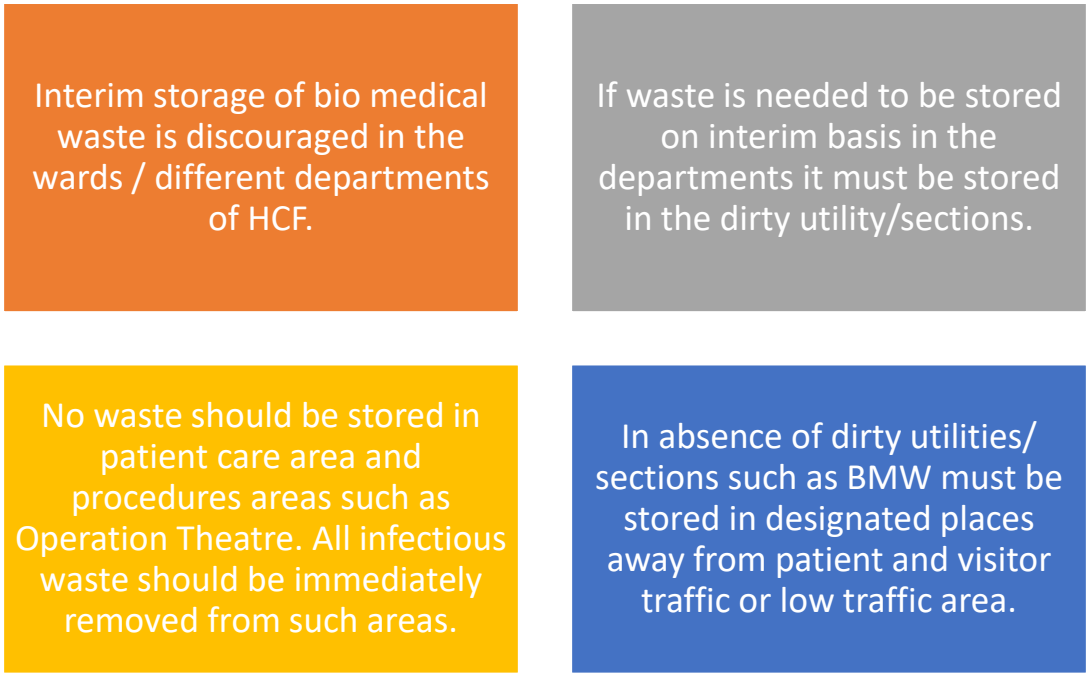


Fig 2.8 Interim Storage

2.3 Step 3 Transportation

Transportation of BMW can be divided into internal and external transportation.

Internal Transportation

Transportation Trolleys

Care should be taken while transporting bio-medical waste within the hospital from site of waste generation / interim storage to central waste collection centre. Within the premises of the hospitals, transportation must be done in closed trolleys / containers preferably fitted wheels for easy maneuverability. The trolleys or carts designated for the purpose of Bio Medical Waste collection

(BMW) must be used. Patient trolleys are not to be used for BMW transportation. Size of trolleys should be according to the volume of waste generation at HCFs.

Fig 2.9 Transportation Trolleys

It must be taken care that the route chosen for transportation has low traffic of patients and visitors, does not occur through high risk areas. Safe transportation of waste is to be undertaken to avoid spillage and scattering of waste.

Central Waste Collection Room for Bio-Medical Waste (BMW)

Each Healthcare facility should ensure that there is a designated central waste collection room situated within its premises for storage of bio-medical waste, till the waste is picked and transported for treatment and disposal at Common Bio-Medical Waste Treatment and Disposal Facility (CBWTF). Such room should be under the control of a designated person and others are not to be allowed to enter the facility.

Guidelines for Construction of Central Waste Collection Room[2]

- The location of central waste collection room must be away from the public/ visitors' access.
- The space allocation for this room must be as per the quantity of waste generated from the hospital.
- The planned space must be sufficient so as to store at least two days generation of waste.
- Central waste collection room must be roofed and manned and should be under lock and key under the responsibility of designated person.
- The entrance of this centre must be accessible through a concrete ramp for easy transportation of waste collection trolleys.
- Flooring should be of tiles or any other glazed material with slope so as to ease the cleaning of the area.
- Exhaust fans should be provided in the waste collection room for ventilation.

[2] Implementation Guidelines for Management of Healthcare Waste in Health Care Facilities as per Bio Medical Waste Management Rules, 2016, National Health Resource centrehttp://cpcb.nic.in/cpcbold/wast/bioimedicalwast/Draft_Guidelines_for_Management_of_Health_Care_Wast(as_on_21.09.2017).pdf

- It is to be ensured by the health care facility that such central storage room is safety inspected for potential fire hazard and based on such inspection preventive measure has to be taken by the health care facility like installation of fire extinguisher, smoke detector etc.
- Sign boards indicating relevant details such as contact person and the telephone number should be provided.
- The entrance of this station must be labelled with “Entry for Authorized Personal Only” and Logo of Bio Medical Waste Hazard.
- It is to be ensured that no general waste is stored in the central waste collection area.

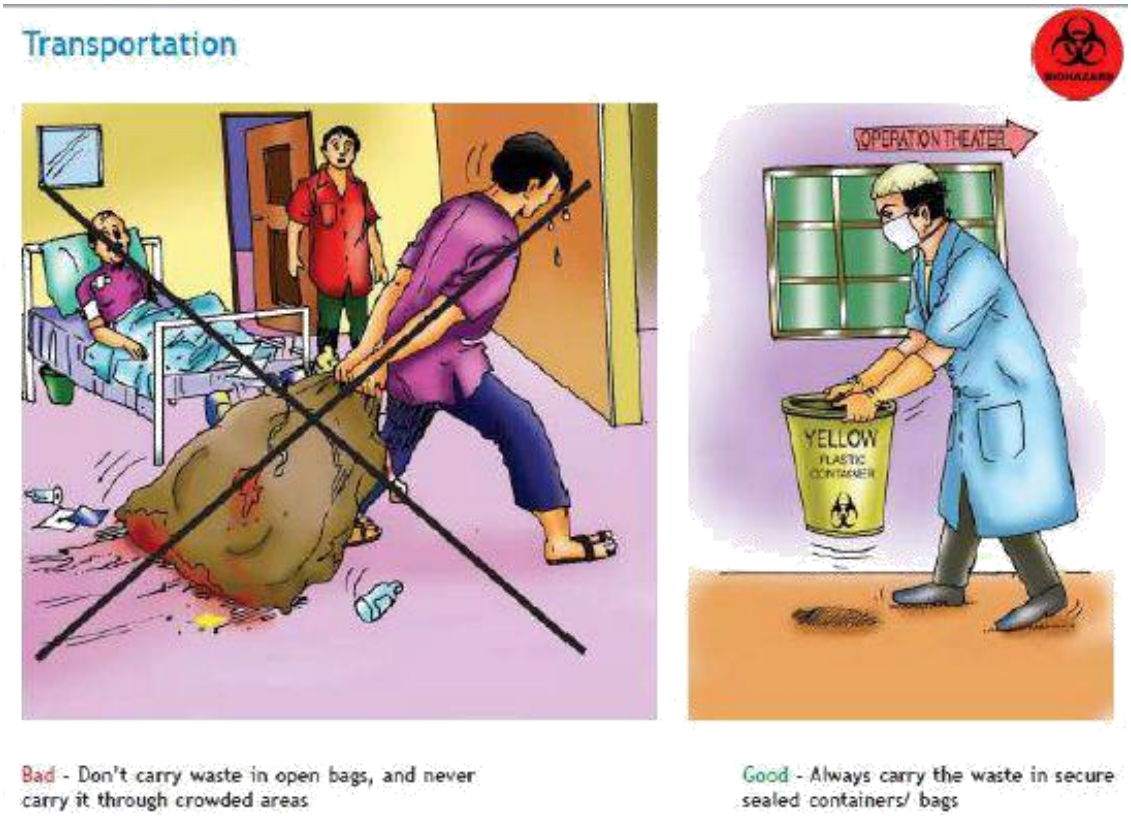


Fig 2.10 Transportation of Waste from Wards

Fig 2.11 Bio Medical Waste Collection Facility

Other Considerations for Central Waste Collection Area

- Maintain the record of waste generated and share it with authorized recyclers.
- Health care facility must ensure protection from the animals. They must ensure that there is no stray animal in the health care facility premises and cattle traps have been installed at the entrance of the health care facility.
- Pest control measures need to be taken to ensure protection against the pests in the central storage area on a regular basis.

Handing Over the Bio-Medical Waste to CBMWTF[3]

Health Care Facility must follow the following steps while transporting the waste to Common Bio Medical Waste Treatment Facility (CBMWTF):

- Ensure that all the bags containing BMW are lifted by facility operator
- All the bags or containers containing bio- medical waste, to be sent out of the premises must also be labelled as per BMW Rules and also labelled with unique bar code.
- Collect or receive a receipt generated from bar-code scanning system.
- The HCFs must ensure that there is no secondary handling of the waste i.e. the waste is handed over to the CBMWTF directly from HCFs central waste collection room.
- The health care centre should immediately notify the prescribing authority if the waste collection agency or CBMWTF does not collect the waste within agreed time, which must not exceed beyond 48 hrs.

[3] Implementation Guidelines for Management of Healthcare Waste in Health Care Facilities as per Bio Medical Waste Management Rules, 2016, National Health Resource centrehttp://cpcb.nic.in/cpcbold/wast/bioimedicalwast/Draft_Guidelines_for_Management_of_Health_Care_Wast(as_on_21.09.2017).pdf

Safe Transportation

The waste can be pre-treated by autoclaving / microwaving / hydroclaving / Chemical disinfection on-site. The pre-treated waste shall be placed in yellow colour bag and sent to the common bio-medical waste treatment facility (CBMWTF) for final disposal. It should be transported through registered and authorised BMW transporters.

Fig 2.12 Transportation of Waste from HCF to the Common Bio-medical Waste Treatment

All the vehicles used by the CBMWTF operator shall not be sub-let or contract vehicles should not be used by the CBMWTF operator. All the vehicles owned by the CBMWTF operator intended only for collection of biomedical waste from the member health care facilities. They should be registered under the Motor Vehicle Act with the respective RTO/Transport Department and such vehicle numbers should also be registered with the respective SPCB/PCC for the purpose of collection of biomedical waste from the member health care facilities. The bio-medical waste collected in designated coloured containers shall be transported to the CBMWTF in a fully covered vehicle. Such vehicle shall be dedicated for transportation of bio-medical waste only. Depending upon the volume of the wastes to be transported, the vehicle may be a two or three-wheeler, light motor vehicle or heavy-duty vehicle. In either case, the vehicle must possess the following:

- Transportation vehicle shall be fitted with GPS to track the movement of the vehicle.
- Separate cabins shall be provided for driver/staff as well as for placing the designated colour coded bio-medical waste containers.
- Two wheeler registered under the Motor Vehicle Act shall be permitted for collection of bio-medical waste only from the clinics or dispensaries located in places where the lanes are narrow and not easily accessible to four wheeler vehicles.
- Such two wheeler vehicle (s) should have a provision of a suitable fixed waste collection box marked with bio-hazard symbol, contact details, proper lid, emergency spill collection procedure, first aid box and manifest record in accordance with the BMW Rules.
- The base of the waste cabin shall be leak proof to avoid pilferage of liquid during transportation.
- The waste cabin may be designed for storing waste containers in tiers and also should be provided with a lighting provision.
- The waste cabin shall be designed in such a way that it is easy to wash and disinfect.

- The inner surface of the waste cabin shall be made of smooth surface to minimize water retention.
- The waste cabin shall have provisions for sufficient openings in the rear and/or sides so that waste containers can be easily loaded and unloaded.
- The vehicle shall be labeled with the bio-hazard symbol (as per Schedule IV of the BMW Rules) and should display the name, address and contact telephone and mobile number of the CBMWTF.
- The vehicle driver should carry always valid registration of the vehicle obtained from the concerned transport authority and also carry valid pollution under control certificate issued by the authorized certificate issuing agency.
- Depending upon the area to be covered under the CBMWTF, the route of transportation shall be worked out. The transportation routes of the vehicle shall be designed for optimum travel distance and to cover all member healthcare units of the CBMWTF.

The CBMWTF operator should ensure online and real time tracking & monitoring provisions (GPS provision) should be given access with passwords to the SPCB/PCC and CPCB to cross check the movement of the transportation vehicles on any time by the SPCB/PCC/CPCB.

As far as possible, the transportation shall be carried out during non-peak traffic hours. If the area to be covered is very large, a satellite station may be established to store the biomedical waste collected from the adjoining areas. The wastes so stored at satellite station may then be transported to the CBMWTF in a big vehicle. It shall be ensured that the total time taken from generation of bio-medical waste to its treatment, also includes collection and transportation time, and shall not exceed 48 hours.

Record Keeping

Every health care facility must maintain and update day wise, category wise record of Bio Medical Waste generated from the facility. Category wise quantity of waste generated from the facility must be recorded in Bio Medical Waste Register being maintained at central waste collection room under the supervision and authority of one designated person.

A weighing machine as per the specifications given in CPCB guidelines for bar code system needs to be kept in central waste collection room or with a designated person responsible for handing over the waste to CBMWTF, for weighing the quantity of Bio Medical Waste.The following records need to be maintained (to be kept atleast for five years) relating to:

- Bio-medical Waste Generation (Ward-wise as well as Centralized)- for compilation of Annual Report.
- Pre-treatment of Lab, Microbiology, Blood Bags and the Blood samples. - Wastes treated and disposed through recyclers approved by SPCB/PCC (as applicable).
- Daily Waste disposed through CBMWTF
- Accidents and remedial measures taken
- Immunization of Health Care Workers
- Trainings organized to the HC Staff
- Health status of the workers (Induction and once in a year)
- Minutes of the meetings of the Committee c constituted by the HCF

- Annual report submitted by June 30th of every year (By the HCFs) for the preceding calendar year to SPCB/PCC

Common Biomedical Waste Treatment Facility

The facility will have the following equipment

1. Incinerators
2. Auto claves
3. Microwave equipment
4. Shredders
5. Chimney
6. Effluent treatment plant
7. Vehicle Washing equipment
8. Water pumps, storage, air compressors
9. Generator for electricity

This list shows the essential equipment required to dispose of the plastic bags in which the waste is kept. The list of colour bags shows the guidelines to follow in waste disposal by the health workers, including doctors, nurses and cleaners.

Updating Of Information in Website

Every healthcare facility as prescribed under BMW Rules, 2016 shall develop a separate page/web link in its website for displaying the information pertaining to their hospital. The following information should be uploaded and updated:

- Contact Address and details of the Healthcare Facility
- No. of beds
- Details of Authorisation under BMW Rules, 2016;Consent under Water (Prevention and Control of Pollution) Act, 1974 and Air (Prevention and Control of Pollution) Act, 1981
- Total quantity of biomedical waste generation (in kg/day)
- Mode of disposal of bio-medical waste (through CBMWTF or through captive treatment facility)
- Name and address of the CBMWTF through which waste is disposed off (as applicable)
- In case, HCF is having captive treatment facility, - Biomedical waste treated (in kg/day) - Details of treatment equipment (Nos. and capacity of each treatment equipment in kg/day) - Operating parameters of the treatment equipment as per BMW Rules, 2016
- Record of bio-medical waste generation (category wise)
- No. of trainings conducted on Biomedical Waste Management in the current year
- Stats of immunization of Health Care Workers involved in handling of BMW

2.4 Step 4 Treatment and Disposal of BMW

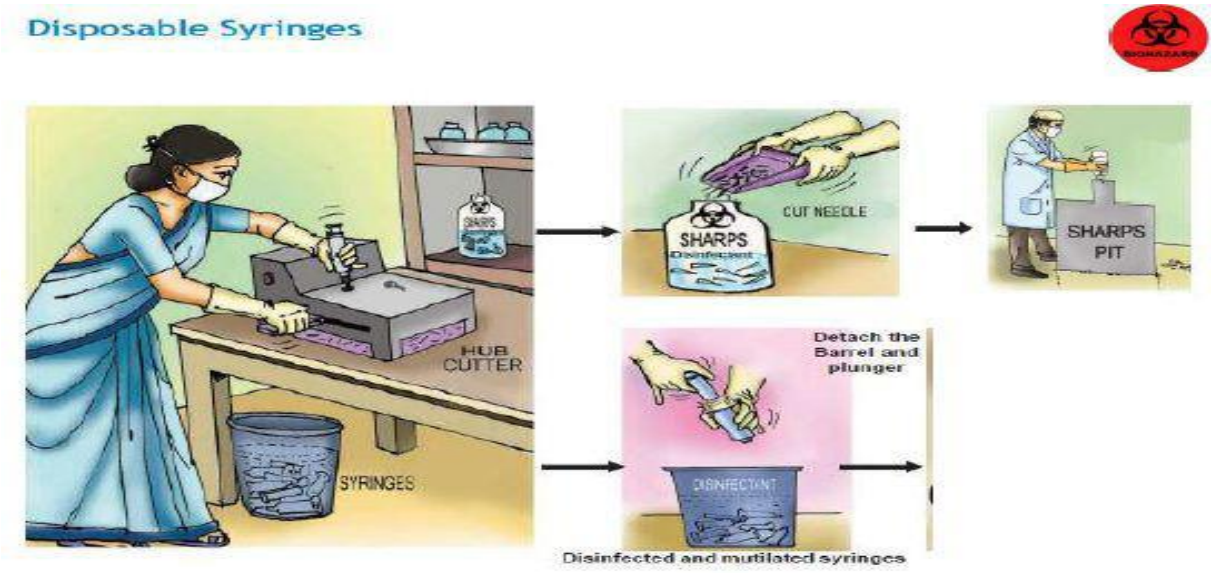


Fig 2.13 Treatment and Disposal of Medical Wastes

Central Facility for Hospital Wastes Treatment

It is difficult for every hospital, nursing home or polyclinic to install all the treatment and disposal equipment and plants. The quantities of various categories of wastes generated in a single hospital are usually not too large and often its treatment system remains idle. A Central Facility however can be easily established to treat and manage all kinds of biomedical wastes being generated in a city or within any other administrative boundary. For this purpose appropriate equipment should be installed in line with waste characteristics and legal requirements. Collection, segregation and suitable treatment of each category of wastes can then be carried out under expert supervision. Final disposal of the residues should be on a secured landfill. A well-equipped laboratory, a computerized database centre and a specialty library should form an integral part of this Central Facility.

Ideally this facility should be administered by a private agency or an NGO. The fee to be charged from hospitals should be a function of the type and quantity of wastes generated by it. A Central Facility will be a great incentive to the small and large hospitals alike, as they will be spared the huge initial cost incurred in the purchase of land and equipment.

Incineration

This method was used in 1990s and before. New EPA regulations have brought in new methods. However, incineration is still the only way to treat pathological wastes like human tissue, blood, or body parts. The advantage of this method is that pre-treatment is not required and is suitable for low heating volume above 2000 Kcal/Kg for single chamber & 3500 Kcal/Kg for double-chamber. The waste should be less moistured as less than 30% and also combustible. Large capital and operating costs are the disadvantages of this method.

Fig 2.14 Incineration

Inertisation

The process of waste inertisation includes solidification and stabilisation. Stabilisation is the process used for reduction of hazard potential of the waste by converting the contaminants into their least soluble, least immobile, or least toxic form. Solidification physically binds or encapsulates the waste in a monolithic solid of high structural integrity. Thus solidification may be used for powders, liquids or gases.

Autoclave

Autoclaves are closed chambers are used for sterilizing medical equipments using both heat and pressure and sometimes steam. This method has been used for nearly a century to sterilise and reuse the medical instruments. It destroys micro-organisms that is present in medical waste before disposal in a traditional landfill. It can also be used to process up to 90% of medical waste.

Fig 2.15 Auto Clave

Encapsulation

This helps in immobilizing the pharmaceuticals in a solid block within a plastic or steel drum. Drums must be cleaned before use. It should not consists of explosives or hazardous materials. Drums have to be filled 75% capacity with solid and semi-solid pharamaceuticals and the remaining space is to be filled by pouring cement or cement/lime mixture, plastic foam or bituminous sand**.** For ease and speed of filling, the drum lids should be cut open and bent back. Care should be taken to avoid cuts to hands when placing pharmaceuticals in the drums. Once the drums are filled to 75% capacity, the mixture of lime, cement and water in the proportions 15:15:5 (by weight) is added and the drum filled to capacity.

A larger quantity of water may be required sometimes to attain a satisfactory liquid consistency. Steel drum lids should then be bent back and sealed, ideally by seam or spot welding. The sealed drums should be placed at the base of a landfill and covered with fresh municipal solid waste. For ease of movement, the drums may be placed on pallets which can then be put on a pallet transporter.

Microwave

It is a process which disinfects the waste by moist heat and steam generated by microwave energy.

Shredder

Shredding is a process by which waste is de shaped or cut in to smaller pieces, so as to make the waste unrecognizable. It helps in prevention of reuse of non-infectious Biomedical waste and also acts as identifier that the waste is safe to dispose off.

Plasma Pyrolysis

This technology is the disintegration of organic compound into gases and non- leachable solid residues in an oxygen-starved environment. Plasma pyrolysis utilizes large fraction of electrons, ions and excited molecules together with the high energy radiation for decomposing chemicals.

Gas/Vapor Sterilization

Gas/vapor sterilization uses gaseous or vaporized chemicals as the sterilizing agents. Ethylene oxide is the most commonly used agent, but should be used with caution since it is a suspected human carcinogen. Because ethylene oxide may be adsorbed on the surface of treated materials, the potential exists for worker exposure when sterilized materials are handled

Thermal Inactivation

Thermal inactivation involves the treatment of waste with high temperatures to eliminate infectious agents. This method is usually used for large volumes. Liquid waste is collected in vessel and heated by heat exchangers or steam jacket surrounded the vessel. The types of pathogens in the waste determine the temperature and duration of treatment. After treatment, the liquid waste can be discharged into the sanitary sewer in a manner that complies with State, Federal and local requirements. This method requires higher temperatures and longer treatment cycles than steam treatment.

Central Storage for HCFs Having Captive Treatment and Disposal System

For the health care facilities which are having captive treatment facility for treatment and disposal of biomedical waste through incinerators, autoclaves/microwaves, shredders etc. within its premises must ensure that waste generated from the HCF is stored in this central waste collection area till it is transported to reception area of captive waste treatment facility within the premises.

For HCFs having its own treatment and disposal facility through use of deep burial pits i.e. Primary Health Centres (PHCs) which doesn't fall under coverage area of any CBWTF, interim Storage area used for daily waste collection will serve as Central Waste Collection Area. The collected waste is needed to be store in this place before it is disposed of by the deep burial pits as per the specifications given under the BMWM Rules, 2016.

Source Reduction

- Build awareness on hazards before purchase
- Purchase smallest quantity needed, and don't purchase hazardous materials if safe alternative exists
- Limit use and access to trained persons with personal protective gear
- Use Engineering Controls such as Ventilation, Hoods for Select Hazards
- Get Rid of Unnecessary Stuff
- Don't accumulate unneeded products
- Don't let peroxides and oxidising agents turn into bombs

Fig 2.16 Mercury Free Thermometer

2.5 Communication about Workplace Hazards

- Job description
- Posters on doors
- Labels on hazards
- Give feedback on use of Personal Protective Equipments (PPE) and disposal evaluation
- Role model safe use and disposal
- Contact point who is responsible

Fig 2.17 Labels on Hazards

Best Practices for Managing Bio Medical Waste

The following best practices are to be followed by responsible personnel at Medical centers:

- Comply with statuary methods as per CPCB
- Separate biomedical waste from non-hazardous medical waste. Train staff not to put non-regulated waste into bio hazard bags and containers, since this causes overspending.
- Sort medical waste by type. Waste should be sorted into biomedical waste (pathological, infectious, sharps), radioactive, chemical, pharmaceutical, and non-hazardous.
- Color-code all biomedical waste. Biohazard waste should go in red biohazard bags and containers. Sharps go into puncture-resistant red biohazard containers.

Steps for Bio Medical Waste Management for Out Reach Activities

- Segregate biomedical waste at the point of generation i.e. during the outreach activity
- Collection and packaging of waste in colour coded and bar code labelled bags/containers
- Transportation of waste from outreach activity site to HCF or make arrangement with nearby CBWTF to collect the waste directly after completion of outreach activity.
- Treatment & disposal at HCF or CBWTF

Best Operating Procedures

- To develop infrastructure for safe disposal and recycle of hazardous wastes
- Health care facilities need to be able to tie into a municipal system of proper waste management to ensure that they are meeting their mission of providing for the public health.
- HCFs to train the staff at units to avoid hazard exposures
- Proper PPEs to offer to operators for safety concern.

Summary

The Chapter dealt with step by step methods in handing Bio Medical waste from proper segregation to primary treatment to storage and internal transportation and then safe ways of external transportation and then the disposal methods. The chapter also dealt with ways of source reduction or prevention and the various means of communicating the messages to healthcare workers by using specific labeling.

Self Assessment Questions

- Discuss different steps involved in biomedical waste management.
- What are some of the precautionary measures to be taken while handling biomedical wastes?
- Communication is key for creating awareness among health workers. Discuss some of the ways to communicate the message to the health workers.

Further Readings

- Labelling for external communication & Storage - https://www.malsparo.com/storage.htm
- https://practicegreenhealth.org/topics/epp
- https://www.malsparo.com/minimization.htm
- http://www.who.int/en/news-room/fact-sheets/detail/health-care-waste
- http://parisara.kar.nic.in/pdf/WasteMgmt.pdf
- http://www.biomedicalwastesolutions.com/medical-waste-disposal/

Videos

- https://www.youtube.com/watch?v=qsclvnPvr18
- https://www.youtube.com/watch?v=iaDBE4-OlJs

Chapter 3

Management and Administration

Objectives

- To know the occupational safety methods and who is responsible for its implementation
- To know the duties of various Regulatory Bodies
- To understand training needs to manage a health care facility

Structure

3.1 Measures for Waste Minimization
3.2 How can a Hospital become Zero Waste?
3.3 Stakeholders of Waste Management
3.4 Training and Awareness

To Do Activities

- Invite guest speaker from the hospital and discuss on the training programs organized by them for the health care personnel.
- Ask students to do a small study in groups on any hospital nearby and submit a report on the same.

3.1 Measures for Waste Minimization

Hospital management committee should be formulated consisting of Head of the Institute as Chair and with representation of members from all major departments. The committee should be responsible for implementing hospital specific plan for waste management and its supervision, monitoring, and implementation. Reports such as annual reports, accident reports should be submitted to concerned authorities as per BMW rules.

- To minimize waste
- Purchase of reusable items made of glass and metal should be encouraged
- Choose non PVC plastic items
- Adopt procedures and policies of waste management
- Establish effective and sound recycling policy

Responsibility of the Healthcare Facility

It is the overall responsibility of the in- charge of the HCF to take all necessary steps to ensure that biomedical waste is handled without any adverse effect to human health and the environment and in accordance with the BMWM Rules, 2016. He/she has to ensure that the BMW generated from the Health Care Facility is properly segregated, handled, stored, packaged, transported and disposed of, as per these guidelines to ensure successful implementation of BMWM Rules, 2016.

As per the provisions under BMW Management Rules, 2016, the following responsibilities have been bestowed upon Healthcare facilities -

- To ensure that all the legal requirements related to the Bio Medical Waste Management are complied with and are regularly updated.
- To ensure that annual reports and accidents reports are submitted to SPCB in a timely manner.
- To ensure that biomedical waste is handled without any adverse effect to human health and the environment.
- To make a provision within the premises for a safe, ventilated and secured location for storage of segregated biomedical waste at central storage area.
- To ensure that there shall be no secondary handling, pilferage of recyclables or inadvertent scattering or spillage by animals.
- To ensure that biomedical waste from central storage area or the premises shall be directly transported to the common biomedical waste treatment facility for the appropriate treatment and disposal

Occupational Safety

It is the responsibility of the in charge of the healthcare facility to ensure the occupational safety of the healthcare workers and other staff involved in handling of Bio medical waste in the healthcare facility.

As per Bio Medical Waste Management Rules, 2016 occupational safety of the staff has to be ensured.

- Providing adequate and appropriate Personal Protective Equipment (PPE) to the staff handling Bio Medical Waste. Use of PPE while handling of Bio Medical Waste must be encouraged and must be monitored regularly to ensure occupational safety of staff.
- Conducting health check-up of all the employees at the time of induction and also at least once in a year.
- Ensuring that all the staff of the health care facility involved in handling of BMW is immunized at least against the Hepatitis B and Tetanus.
- Taking remedial steps in accordance to any accident occurred, leading to any harm to the employee, during the handling of Bio medical waste

Comprehensive Health Checkup

- Comprehensive Health Check-up includes following but not limited to;
- Present Complaints (If any), with duration
- Vaccination History (especially with respect to Hepatitis B and Tetanus Toxoid)
- Past Medical History
- Past Surgical History
- General Physical Examination
- Dental Examination

Systemic Examination including Cardiovascular System, Respiratory System, Central Nervous System, Gastrointestinal System, Uro Genital System, Gynae and Obstet. (in case of females), Musco-skeleton System, EYE and ENT.

- Lab Investigations including: Hb, TLC, DLC, RBS, Blood Urea, S. Creatinine, Urine, Stool etc.
- Radiological Investigations: Chest X ray, USG (If needed), CT or MRI (if needed)
- Inference with Diagnosis

3.2 How can a Hospital become Zero Waste?

Every hospital should strive towards zero waste philosophy. In order to reach there, hospital needs to redesign products and materials in such a way that every material can be reused and no material to be sent to disposal facility. Objectives for reducing and/or eliminating waste from a health care facility should include the following:

- Measure the amount of waste in each category and identify associated costs.
- Complete an assessment of waste as a "non–value-added" component of hospital Determine targets and goals for prevention and management.
- Establish an environment for managing waste that is regulatory compliant and safe from physical and health hazards for staff and patients operations so that it can be systematically analyzed and functionally approached.
- Reduce all risks for occupational illnesses and injuries.
- Define and understand waste categories and definitions including the regulatory components, policy and management aspects,
- Ultimate disposition of all streams.

Measure the amount of waste in each category and identify associated costs.
Develop an education process that covers all personnel, from the purchasing agent to the environmental services employee, regarding the risks associated with each waste stream.Maintain oversight by establishing administrative and engineering controls to track, measure, report, and sustain goals, staff satisfaction, safe work practices, and feedback.Develop an ongoing communication process to engage staff and promote participation in the waste reduction programs.

3.3 Stakeholders of Waste Management

- Occupier
- Operator
- Regulatory Body
- Ministry of Environment, Forest and Climate Change

Occupier

"Occupier" means a person having **a**dministrative control over the institution and the premises generating biomedical waste, which includes a hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathological laboratory, blood bank, health care facility and clinical establishment, irrespective of their system of medicine**.**

Bio Medical Waste Management Rules,2016 are applicable to all persons who generate, collect, receive, store, transport, treat, dispose, or handle bio medical waste in any form including hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathological laboratories, blood banks, AYUSH hospitals, clinical establishments, research or educational institutions, health camps, medical or surgical camps, vaccination camps, blood donation camps, first aid rooms of schools, forensic laboratories and research labs. The duties of various stake holders information has been taken from Tool Kit on Biomedical Waste Management Rules, 2016[4].

[4]http://www.npcindia.gov.in/wp-content/uploads/2017/08/Tool-Kit-on-Bio-Medical-Waste-Management-2016.pdf

Table 3.1 Duties of Occupier

Management 	Take necessary measures to handle Bio-medical waste to avoid adverse effe to human health and the environment
	Segregation of bio-medical waste in colored bags or containers in the manner specified in Schedule I of the BMW Rules, 2016
	Phase out use of chlorinated plastic bags , gloves and blood bags within two years from the date of notification of the rules;
	Review and monitor the activities related to bio-medical waste management
	Report major accident
Storage of Waste 	Provision within the premises for a safe, ventilated and secured location for storage of segregated and disinfected biomedical waste

Table 3.2 Capacity Building Program on Implementation of Waste Management Rules, 2016

Training 	Provide training to all its health care workers and others, involved in handling of biomedical waste at the time of induction and there after at least once every year;
Safety of workers 	Immunize all its health care workers and others, involved in handling of bio-medical waste for protection against diseases including Hepatitis Band Tetanus that are likely to be transmitted by handling of bio-medical waste.
	Ensure occupational safety of all its health care workers and provide requisi personal protective equipment;
	Conduct health check up at the time of induction
Bar Coding 	Establish a Bar-Code System for bags or containers containing bio-medical waste to be sent out of the premises or place for any purpose within one year from the date of the notification of these rules;
Wastewater Management 	Ensure segregation of liquid chemical waste at source and ensure pre-treatment or neutralization prior to mixing with other effluent generated from health care facilities;
	(1) The effluent generated or treated from the premises of occupier or operator of a common bio medical waste treatment and disposal facility, before discharge into the sewer should conform to the following limits-
	PARAMETERS — PERMISSIBLE LIMITS
	pH — 6.5-9.0
	Suspended solids — 100 mg/l
	Oil and grease — 10 mg/l
	BOD — 30 mg/l
	COD — 250 mg/l
	Bio-assay test — 90% survival of fish after 96 hours in 100% effluent.
	Treatment of generated liquid effluent in accordance with the Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974);
Monitoring, Reporting & data collection 	Make available the annual report on its web-site
	Inform the prescribed authority immediately in case the operator of a facil does not collect the waste.
	Develop system to review and monitor and maintain the record
	Maintain the operating condition of in-house Incinerator as per standa operating condition mentioned in schedule II
	Handover of segregated or pre-treated waste to CBMWF located within KMs distance for safe treatment and disposal in accordance with the BM Rules, 2016;
	Maintenance of records for a period of five years.

Emission

Existing incinerators to achieve the standards for treatment and disposal of bio-medical waste as specified in Schedule II for retention time in secondary chamber and Dioxin and Furans within two years from the date of this notification.

S no	Parameter	Standards	
1	2	3	4
		Limiting concentration in mg Nm3 unless stated	**Sampling Duration in minutes, unless stated**
1	Particulate matter	50	30 or 1NM3 of sample volume, whichever is more
2	Nitrogen Oxides NO and NO2 expressed asNO2	400	30 for online sampling or grab sample
3	HCl	500	30 or 1NM3 of sample volume, whichever is more
4	Total Dioxins and Furans	0.1ngTEQ/Nm3 (at 11% O2)	8 hours or 5NM3 of sample volume, whichever is more
5	Hg and its compounds	0.05	2 hours or 1NM3 of sample volume, whichever is more

Operator

Operator of a common biomedical waste treatment facility means a person who owns or controls a common Biomedical Waste Treatment Facility (CBMWTF) for the collection, reception, storage, transport, treatment, disposal or any other form of handling of biomedical waste

Fig 3.1 Duties of an Operator

Table 3.3 Duties of Operator of a Common BioMedical Waste Treatment Facility

Channelization of waste	Take all necessary steps to ensure that the bio-medical waste collected from the occupier is transported, handled, stored, treated and disposed of, without any adverse effect to the human health and the environment in accordance with the rules and guidelines issued by the Central Government or Central Pollution Control Board from time to time;
	Ensure timely collection of bio-medical waste from the occupier as per rules
	Inform the prescribed authority immediately regarding the occupiers which are not handing over the segregated bio-medical waste in accordance with these rules;
	Common bio-medical waste treatment facility shall ensure collection of biomedical waste on holidays also;
Bar Coding 	Establish bar coding and global positioning system for handling of bio-medical waste within one year;
Training 	Provide training for all its workers involved in handling of bio-medical waste at the time of induction and at least once a year thereafter;
	Assist the occupier in training conducted by them for bio-medical waste management;
Safety of workers 	Undertake appropriate medical examination at the time of induction and at least once in a year and immunize all its workers involved in handling of bio-medical waste for protection against diseases, including Hepatitis B and Tetanus, that are likely to be transmitted while handling bio-medical waste and maintain the records for the same;
	Ensure occupational safety of all its workers involved in handling of bio-medical waste by providing appropriate and adequate personal protective equipment;
	Report major accidents including accidents caused by fire hazards, blasts during handling of biomedical waste and the remedial action taken and the records relevant thereto, (including nil report) in form i to the prescribed authority and also along with the annual report;
	Maintain a log book for each of its treatment equipment according to weight of batch; categories of waste treated; time, date and duration of treatment cycle and total hours of operation;

Treatment of waste 	Allow occupier , who are giving waste for treatment to the operator, to s whether the treatment is carried out as per the rules;
	After ensuring treatment by autoclaving or microwaving followed by mutilation or shredding, whichever is applicable, the recyclables from the treated bio-medical wastes such as plastics and glass, shall be given to recyclers having valid consent or authorisation or registration from the respective state pollution control board or pollution control committee;
	Supply non-chlorinated plastic colored bags to the occupier on chargeable basis, if required;

Maintain records 	Maintain all record for operation of incineration, hydro or autoclaving for a period of five years;
	Shall display details of authorization, treatment, annual report etc on its web-site;
	Upgrade existing incinerators to achieve the standards for retention time in secondary chamber and dioxin and furans within two years from the date of this notification.

Duties of Regulatory Body

Table 3.4 Duties of State Pollution Control Board or Pollution Control Committee

▪ Inventorisation of Occupiers and data on bio-medical waste generation, treatment & disposal.	▪ Compilation of data and submission of the same in annual report to Central Pollution Control Board within the stipulated time period.
▪ Grant and renewal, suspension or refusal cancellation or of authorization under these rules (Rule 7, 8 and 10).	▪ Monitoring of compliance of various provisions and conditions of authorization.
▪ Action against health care facilities or common biomedical waste treatment facilities for violation of these rules (Rule 18).	▪ Organizing training programmes to staff of health care facilities and common bio-medical waste treatment facilities and State Pollution Control Boards or Pollution Control Committees Staff on segregation, collection, storage, transportation, treatment and disposal of bio-medical wastes.

▪ Undertake or support research or operational research regarding bio-medical waste management.	▪ Any other function under these rules assigned by Ministry of Environment, Forest and Climate Change or Central Pollution Control Board from time to time.
▪ Implementation of recommendations of the Advisory Committee.	▪ Publish the list of Registered or Authorized (or give consent) Recyclers.
▪ Undertake and support third party audits of the common bio-medical waste treatment facilities in their State.	

Table 3.5 Duties of Ministry of Environment, Forest and Climate Change, Government ofIndia

▪ Making Policies concerning bio-medical waste Management in the Country including notification of Rules and amendments to the Rules as and when required.	▪ Providing financial assistance for training and awareness programmes on bio-medical waste management related activities to for the State Pollution Control Boards or Pollution Control Committees.
▪ Facilitating financial assistance for setting up or up-gradation of common bio-medical waste treatment facilities.	▪ Undertake or support operational research and assessment with reference to risks to environment and health due to bio-medical waste and previously unknown disposables and wastes from new types of equipment.
▪ Constitution of Monitoring Committee for implementation of the rules.	▪ Hearing Appeals and give decision made in Form V against order passed by the prescribed authorities.
▪ Develop Standard manual for Trainers and Training.	▪ Notify the standards or operating parameters for new technologies for treatment of bio medical waste other than those listed in Schedule- I

Table 3.6 Duties of Central Pollution Control Board

▪ Prepare Guidelines on bio-medical waste Management and submit to the Ministry of Environment, Forest and Climate Change.	▪ Co-ordination of activities of State Pollution Control Boards or Pollution Control Committees on biomedical waste.
▪ Conduct training courses for authorities dealing with management of bio-medical waste.	▪ Lay down standards for new technologies for 25 treatment and disposal of bio-medical waste (Rule 7) and prescribe specifications for treatment and disposal of bio-medical wastes (Rule 7).
▪ Lay down Criteria for establishing common biomedical waste treatment facilities in the Country.	▪ Random inspection or monitoring of health care facilities and common bio-medical waste treatment facilities.
▪ Review and analysis of data submitted by the State Pollution Control Boards on bio-medical waste and submission of compiled information in the form of annual report along with its observations to Ministry of Environment, Forest and Climate Change.	▪ Inspection and monitoring of health care facilities operated by the Director General, Armed Forces Medical Services (Rule 9).

Table 3.7 Duties of Municipalities or Corporation, Urban Local Bodies and Gram Panchayat

▪ Provide or allocate suitable land for development of common bio-medical waste treatment facilities in their respective jurisdictions as per the guidelines of 27 Central Pollution Control Board.	▪ Collect other solid waste (other than the biomedical waste) from the health care facilities as per the Municipal Solid Waste (Management and Handling) Rules, 2000 or as amended time to time.
▪ Any other function stipulated under these Rules.	▪

Table 3.8 Duties of Ministry of Defense

▪ Grant and renewal of authorization to Armed Forces health care facilities or common bio-medical waste treatment facilities (Rule 9).	▪ Conduct training courses for authorities dealing with management of bio-medical wastes in Armed Forces health care facilities or treatment facilities in association with State Pollution Control Boards or Pollution Control Committees or Central Pollution Control Board or Ministry of Environment, Forest and Climate Change.
▪ Publication of inventory of occupiers and biomedical waste generation from Armed Forces health care facilities or occupiers	▪ Constitution of Advisory Committee for implementation of the rules.
▪ (v) Review of management of bio-medical waste generation in the Armed Forces health care facilities through its Advisory Committee (Rule 11).	▪ Submission of annual report to Central Pollution Control Board within the stipulated time period (Rule 13).

3.4 Training and Awareness

As per Bio Medical Waste Management Rules, 2016 have been revised it is mandatory for all the employee of the healthcare facility to be trained on handling of biomedical waste management and handling as per BMW Rules, 2016.

- Staff education programmes should include:
- Information on, and justification for, all aspects of the health-care waste policy
- Information on the role and responsibilities of each hospital staff member in implementing the policy
- Technical instructions, relevant for the target group, on the application of waste management practices.
- One of the best ways of learning is through practice, and hands-on training of small groups of personnel should be considered where appropriate.

Testing the participants at the end of the course,by means of simple true/false or multiple-choice questions, often provides an incentive for learning, and allows the course organizers to assess the knowledge acquired by participants.

Education and Training of Health Care Personnel

All hospital personnel, including senior medical doctors, should be convinced of the need for a comprehensive health-care waste management policy and the related training, and its value for the health

and safety. This should ensure their collaboration in the implementation of such a policy. Separate training activities should be designed for, and targeted to, four main categories of personnel:

- Hospital managers and administrative staff responsible for implementing regulations on health care waste management
- Medical doctors
- Nurses and assistant nurses
- Cleaners, porters, auxiliary staff, and waste handlers.

Medical doctors may be educated through senior staff workshops and general hospital staff through formal seminars. Since action is needed at management level, by those producing the waste as well as by the waste handlers, training of all of these categories of personnel is equally important.

Training Schedule

As per the BMW Rules, 2016 the minimum requirements for health care facilities is to conduct the training on BMW activities at least annually for all the staff of the facility and also whenever a new staff is inducted into Health Care Facility. It is preferable for each health care facility to create a training calendar for imparting the training on Bio Medical Waste Management Handling and training must be provided as per the formed training plan.

Trainers

As per the BMW Rules, 2016 it is the responsibility of the SPCB/PCC SPCB and CBMWTF to impart training on BMW Management in the health care facilities. SIHFW may take the responsibility to provide induction training to the newly recruited healthcare staff. For In house trainings trainers can be arranged from SPCB/PCC SPCB or CBMTF or already trained employee of the healthcare worker can take up the role of trainer.

Training Material

It is a requirement of BMW Rules, 2016 to have a standard training module for imparting the training in the healthcare facilities. For this purpose, these guidelines can be used as training material for imparting the training or any other relevant material published by approved authorities like SPCB/PCCSPCB, State Guidelines can be used as training material.

Training Records

Health care facilities need to ensure that all the training records pertaining to the Bio Medical Waste Management including the induction training records and in service training, for all the staff is needed to be kept for proving compliance. Attendance records of each training needs to maintained and signed by the trainees with name and designation. HCFs need to maintain, compile and provide details of trainings provided for BMW handling to State Pollution Control Board (SPCB)/Pollution Control Committee (PCC). These details have to be submitted along with the annual report to the prescribed authority i.e. SPCB/State Pollution Control Board/PCC, on or before 30th June of every year. The training details include:

- Total Number of trainings conducted along with the date of imparting the training
- Total number of participant of each training
- Attendance Record
- Total Number of staff trained on BMW Handling

- Total number of staff trained on BMW handling at the time of Induction
- Total number of staff, not undergone any sought of training on BMW Handling.

Training Effectiveness

Training on personal protective equipments, immunization, post-exposure prophylaxis, medial surveillance and personal hygiene must be provided to ensure effective practices of waste management. To assess the effectiveness of the training, the staff can be evaluated by observing whether they are following rules and regulations or through a test mock/verbal or written.

Summary

Hospital management should form a committee and entrust responsibility of proper management of biomedical waste. Training must be provided to all levels of personnel in the hospital. Effective implementation of rules by surprise visits and inspection by appropriate authorities and fixing the accountability of each and every person involved in management of Biomedical Waste is essential. If Hospital Management wants to protect our environment and health of community, Hospital Management must treat this as an important issue in the interest of community.

Self Assessment Questions

- Discuss the steps to be taken by a hospital to become a zero waste facility.
- Discuss the type of training programs to organize for effective handling of Biomedical waste

Further Readings

- http://envfor.nic.in/sites/default/files/5.%20Waste%20handlers%20manual_FLIP%20CHART.pdf
- http://toxicslink.org/docs/bmw/bmw-training-m/slides_pps/NEW-BIO-MEDI-MANUAL-ENGLISH.pdf
- http://www.who.int/water_sanitation_health/medicalwaste/159to166.pdf
- http://www.cpreec.org/pubbook-biomedical.htm

Videos

- https://www.youtube.com/watch?v=gj8T3yuOxEw
- https://www.youtube.com/watch?v=eD9PSwX3tMU

Chapter 4

Hotel Waste Management

Objectives

- To know the types of hotel waste produced and ways to handle them
- To know how this initiative can save economy of the hotels
- To know how the hospitality industry across world is taking up the CSR task through case studies

Structure

4.1 Overview of Hotel Waste
4.2 Types of Waste in Hotels
4.3 Steps of Effective Waste Management in Hotels
4.4 Benefits of Waste Reduction

To Do Activities

- Visit a restaurant and understand types of food waste they generate and how they manage effectively in minimizing the same.
- Ask students to prepare a note on the visit and submit
- Do a case study analysis of any hotel.

4.1 Overview of Hotel Waste

Hotels are chief consumers of resources, and also huge generator of waste. There is a tremendous growth in the Hotel Industry. WTTC report on "Travel and Tourism Economic Impact 2017 India[5]" shows that India is contributing to 6.9 % to the world GDP. Thus, a number of international players in hotel industry have started their ventures in India. Hotel industry has both opportunities and challenges; wastage of food at mass level is one of them. The levels of food waste from hotels and restaurants must be handled scientifically or otherwise it would lead to environmental impact.

Since hotels use a very high number of natural resources from energy to food, it is essential that sustainable practices must be adopted. Managing huge amounts of waste generated is one of the major concerns to be addressed. In a hotel, major part of revenue is generated from the kitchens of different outlets which mean a large amount of food waste is generated. The generation of this waste and managing it is not only a financial problem but also environmental problem too. Since the waste produced in hotel is bio degradable in nature, it requires large landfills to discard the resources. It increases the cost of managing food wastes and it impacts environment by producing methane gas which is a contributor to greenhouse effect. It also leads to the destruction of flora and fauna in the nearby areas because of the toxins released by the waste.

[5]https://www.wttc.org/-/media/files/reports/economic-impact-research/countries-2017/india2017.pdf

With the objective of providing best services and profit maximisation, the industry is forced to provide with high quality and quantity or variety of food portions to survive the competition. In the process, it leads to large amount of food getting wasted. Similarly, when the customer leaves the food in the plate due to high portion or any other reason, it is again deposited as waste. There is cost involved in disposal and transport of waste and in labour. The hotel industry needs to look into efficient ways of reducing cost.

Food waste in Hotel industry is a burning issue to be handled with. Proper guidelines and training has to be provided for efficient ways of managing wastes in Hotels. There is a huge requirement to develop a holistic framework for waste management. In hotels most of the food wastes are compostable. The effective waste management not only helps the organization to work for an eco-friendly environment but also helps them to earn profit out of it.

Waste management is such a critical issue which requires the attention of public as well government authorities. Currently, there are improper waste management practices in hotels and lack of infrastructure, underestimates of waste generation rates, inadequate management and technical skills, improper collection, and route planning are responsible for poor collection and transportation of municipal solid wastes.

The reasons can be

- Lack of appropriate planning.
- Purchase and preparation of too much food.
- Errors in industrial processing and following food safety policies
- Managerial, financial and technical constraints
- Over-preparation of food in restaurants, hotels and the food service industry
- Over-merchandizing and over-ordering in food stores and supermarkets
- Consumer behaviour

Most restaurants, hotels and the food service industry have a tendency of over-preparing food. While the intention is good, especially in expectation of high customer volume, over-preparation often leads to wastage.

Table 4.1 Causes of Food Waste

<table>
<tr><th colspan="2">CAUSES OF FOOD WASTE</th></tr>
<tr><th>Pre-consumer</th><th>Post-consumer</th></tr>
<tr><td>Unidentified demand</td><td rowspan="2">Large portion sizes</td></tr>
<tr><td>Overstocking</td></tr>
<tr><td>Inefficient production</td><td rowspan="3">Inefficient service model</td></tr>
<tr><td>Poor communication</td></tr>
<tr><td>Staff behaviour</td></tr>
<tr><td>Unskilled trimming</td><td rowspan="3">Customer's menu acceptance</td></tr>
<tr><td>Over-merchandising</td></tr>
<tr><td>Food Safety</td></tr>
</table>

There are two main kinds of waste discarded in hotels.

Organic Waste (Wet Waste): cooked and uncooked food, fruits and flowers (which are natural products) decompose quickly.

Inorganic (Dry Waste): manmade or manufactured products include plastics, rubber, metal, glass, cloth, paper, and packaging. If these different types of wastes are kept unmixed, each of them can be reused or recycled if they are collected and managed separately.

Considering the significant role of the hotel industry in terms of waste generation(half a pound to 28.5 pounds[6] of trash per day per room) and the fast growth of the industry, adopting a number of environmental best practices with quantifiable measures, including areas of benchmarking and auditing, financial analysis to facilitate informed decision making, and operational training, becomes important due to certain factors such as increasing regulation and rising utility costs (Goldstein and Primlani, 2012). This study helps to understand the waste generation and its management for estimating the monetary benefits of recycling for the industry and the environment. Findings of this study support the instrumental stakeholder theory.

The expansion in hospitality sector operations is complemented by an expansion in its waste management operations. More waste usually translates into a greater environmental footprint and therefore more harm to the ecosystem. For example, a hotel guest is estimated to generate up to 1 kg of waste per day on an average (International Hotel Environmental Initiative, 2002), and this amounts to millions of tons of waste being generated worldwide annually. Therefore, the importance of studying the hotel waste management in order to minimize the waste cannot be overemphasized.

Fig 4.2 Waste Management in Hotel[7]

[6]http://www.ijsrp.org/research-paper-0916/ijsrp-p5792.pdf
[7]http://www.atf-2015.com/waste-management-in-new-built-hotels/

There are few guidelines for managing waste based on the priority. They are

Reduction of Waste at the Source Point

Waste management program would help in reducing the level of waste generation and increase efficient utilization of materials, energy and water resources. In hotels, owners often pay twice for the waste; firstly in the form of packaging and secondly for their disposal. Many stuffs/items of waste are also valuable in nature, can be recycled into other items. Hotel owners may make money from their generated wastes. Around 30% of a hotel's solid waste can be sorted, reused, recycled and recoverable in nature (International Tourism Partnership Report, 2008). Therefore, it's a need of an hour to manage the waste of a hotel industry for protecting and conserving 25 natural resources and the environment.

The first and foremost option for any waste reduction is reducing the generation of waste at source. To begin with the hotelier must do a preliminary research on the culture of food habits, customer preferences, in flow of the customers, their tastes and food standards of the regional demand and plan accordingly. Also, the locality, place, type of city must be considered while planning the location of a hotel. That will also have an impact on the quantity and quality of food to be prepared. This preliminary research would help the hotelier in reducing waste generated.

Good waste management can make good business sense. Minimising waste can provide competitive advantages to a hotel in a few ways: Improved Resource Efficiency & Reduced Disposal Costs. Hotels consume and pay for resources (raw materials, consumables, energy, water, manpower) that translate into sales revenue. Waste management enables you to identify the sources, types and quantities of waste you produce. The process will help you identify areas where simple actions can be taken to minimise waste, save money and achieve long lasting sustainable waste management. Waste is generated as a by-product and cost money to treat or dispose of. This is represented as shown below.

- Raw materials & consumables
- Energy & water
- Manpower & time Business Process Services & Products
- Solid/liquid waste
- Wasted energy

Reuse

Hotels should ensure that the wastes that are generated in the form of liquid and solids can be reused. For e.g. water used for cleaning utensils, washing hands can be recycled and used for gardening. Food waste can be used for composting and will become natural fertilizers for plants. Methane is emitted from rotten substances, where waste can be salvaged and used to produce bio gas. Care should be taken to see if the waste generated can be reused before disposal.

Recycle

It involves converting the waste in to a marketable or reusable product. For e.g. the used oil in the hotels are sent refineries and is recycled and sold as a second grade product in the market for reuse. Recycling is the least favorable method and is used only if reduce and reuse options are not applicable. Three major steps for recycling are:

- Collection of solid waste
- Processing and manufacturing of the products into reusable products

- Purchasing of the products which are made up of reprocessed materials, and can be reutilized.

Recycling programs for hotels are focusing on collection of recyclable materials from waste stream of different areas of the hotel. Before boarding on a waste-segregation programme, the type of material can be collected from local waste and recycling contractors. In many countries, recycling and waste management programmes are relatively well advanced; waste may be separated into various categories. Implementing recycling actions for items wherever practically possible must be done. Sometimes, local conditions may inhibit the many actions of recycling. For example, many countries lacking infrastructure for recyclable elements coming from waste streams like plastic bottles.

The steps outlined are not difficult and can be fulfilled by the hotel industries for managing their waste. But, the hotels do require a commitment of the management and staff to manage their waste.Theymust spare time for implementing the waste management strategies. If a hotel is green hotel, then the message should pass to all potential guests that the hotel management, staff, and corporation all believe that environment conservation and protection is an important factor during the hotel operations. This message can play a powerful role.

4.2 Types of Waste in Hotels

Multiple types of waste tend to be generated at individual locations. The relative percentage of each of these different waste types also varies by type of food (Refer Fig 4.1). Solid waste is a key concern in the hospitality industry. Typically, a hotel guest can produce 1 kg of waste a day that accumulates to thousands of tonnes of waste annually. Small hotel operators show little interest in reducing / recycling waste due to lack of awareness on waste management, and also because of belief that it is too expensive and time consuming. The below table 4.1 shows different types of non-hazardous waste generated in the hotels.

Table 4.2 Types of Non-Hazardous Waste in the Hotel Industry (adapted from Zein et al., 2008)

Non-Hazardous Waste Type	Components	Source
Household Wastes	Food / Kitchen waste, used or dirty paper and wrapping, plastic wrapping or bags, composted wrappers	Hotel's different departments
Cardboard	Packing	Hotel's purchasing and other departments
Paper	Printed documents, brochures, menus, maps, magazines, newspaper	Administration, reception, guests room, restaurants
Plastic	Bags, bottles (hat did not contain hazardous material), house hold goods, individual portion wrappers for various products	Kitchen, restaurants, bars, guest room
Metal	Tin cans, jar lids, soda cans, food containers, mayonnaise, mustard and tomato puree tubes, aluminium packing	Kitchen, restaurants, bars, guest room
Glass	Bottles, jars, flasks	Kitchen, restaurants, bars, guest rooms
Cloth	Table cloth, bed-linen, napkins,	Kitchen, restaurants, bars,

	clothes, rags	bathrooms, guests
Wood	Wooden packing pallets	Purchasing department
Organic waste	Fruit and vegetable peelings, flowers and plants, branches, leaves, grass	Kitchen, restaurants, bars, guests, room, gardens

Fig 4.2 Percentage of Wastage of Food in Hotels[8]

Food waste from hotels comes from a variety of sources such as

- Spoiled or out of date food
- Peelings & trimmings
- Inedible by-products, e.g. bones, coffee grounds, tea leaves
- Kitchen error
- Plate waste

There will be food waste even in the best-run kitchens**.** The objective must be to reduce the quantity of food wasted at source than planning for disposal of waste**.** If the materials are used with care, it can save lot of money. Decreasing the cost of waste disposal is very crucial factor to be considered. It can start with:

- Using refillable dispensers for soaps, shampoos, and conditioners
- Using washable cloth products and dishware instead of disposable ones
- Using water filters instead of plastic bottles

[8]Topen (2014), http://www.greenhotelier.org/know-how-guides/reducing-and-managing-food-waste-in-hotels/

- Reducing and reusing supplies packaging materials
- Reducing the number of paper products
- Switching to LED lights

4.3 Steps for Effective Waste Management in Hotels

Waste management is also known as waste disposal. It is an activity / action required to carry out from inception to disposal.

Characterization and Quantification of Waste in the Hotel Industry

It is important to categorize the types and quantity of waste produced by every department of the hotel industry so that it is managed properly. For example, office waste (like papers, documents, brochures), household waste (jars, bottles, cardboard), organic waste (vegetable and fruit peels, flowers) can be segregated in color-coded bins for easy and hassle-free waste management.

Understanding Waste Hierarchy

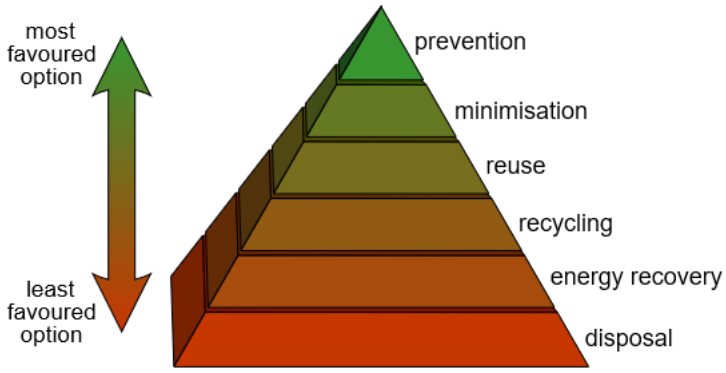


Fig 4.3 Waste Hierarchy[9]

As the saying goes, “Prevention is better than cure”, the above figure (Fig 4.2) on waste hierarchy shows the most favoured option to be followed in any hotel industry which means prevention is better than disposal. It provides option to manage waste by prevention, minimization, reuse, recycle, recovery and disposal which prevent a lot of waste from going to the waste stream.

- Prevention means minimising / avoiding the amount of waste generated. Some of the things to follow could be,
- Don’t buy things that you don’t need
- Buy products with better packaging which can be refilled or reusable
- Choose products that use the least hazardous materials
- Materials should be re-used to the greatest possible through substitution and postponing.

Recovery is the most important part of the whole process because some value of the material can be retrieved through recycling. The last step is disposal which generally involves landfill and incineration of waste.

Data Analysis

[9]http://www.ijsrp.org/research-paper-0916/ijsrp-p5792.pdf

Hotel industry generates a lot of waste and most of the time it is sent to the landfills without being treated properly. The first step in managing the data analysis of waste is to perform waste audit. Waste audit is identifying the process of productivity from waste management practices in hotels.

Step 1 Carry out a Waste Audit

The most important step is waste audit which may be done at any time without the need for external help. This step involves critical manual checking at all the areas of a hotel producing waste. At this level, measures can be taken for efficient utilization of waste. A checklist can also be prepared for self-evaluation of the waste. Tools like the Environmental Walkthrough can also be developed especially for small scale hotels in order to provide exact and useful information regarding the saving of water, energy and other useful materials.

Another tool is small hotel environmental assessment that involves analyzing and understanding the situation by a team. The specialized team reviews all the facilities, operation procedures, baseline performance and prepare a comprehensive list of best alternative practices. The team also submits a report on the best practices and opportunities for reducing, restoring, recycling and reusing waste and also provides a list of guidelines for implementation.

Step 2 Set Priorities and Goals

After self- evaluation and identifying source and type of waste generated, quantify the recyclable materials that are currently discarded. Create a list of items disposed at each location, disposal method used, and the quantities involved.

After self-evaluation and identification of alternative practices for improving waste management in a hotel, priorities must be set right to implement most attractive measures by following the schedule and action plan with assigned responsibilities and also by setting target dates.

Step 3 Continuous Improvements and Investments

After implementation of waste management practices, it must be monitored and evaluate if the set standards are different from the implementation of practices. If there is a gap identified, corrective measures to be taken to improve the efficiency of the system. Hotel industry can save their huge amount of money by purchasing reusable products. Initially, it might incur costs but in the long run it will offer substantial savings. The important benefit of waste reduction is saving money and conservation of natural resources.

Case Study: When leftovers don't go into the trash[10]

"Feeding India" is an NGO that collects excess food from all sorts such as individuals, weddings, restaurants, corporate offices, caterers, canteens and households and feed the food to less privileged or orphans. The volunteers collect the food; check the quality by tasting it two times. Once, when collecting the food and second, before donating it to the needy. It serves 10, 000 to 15,000 meals across the country daily. On some days it may go up to 45000.

[10]https://www.thehindu.com/news/cities/mumbai/when-the-leftovers-dont-go-into-the-trash/article17745964.ece

Feeding India runs three vans to collect and donate food from set locations each day to serve food. In many regions 24/7 refrigerated vehicle moves around the city collecting and donating excess food. Their Volunteers are called 'super heroes' and 'hunger heroes'. While super heroes regular paid workers (seven in number), hunger heroes only participate in volunteer drives and events. They have around 3500 volunteers with its presence in 40 cities across the country serving 3.5 million meals. If we have many such NGO's in the country, it would reduce wastage of food in large quantities and it reaches the needy.

Summary

Managing of wastes in hotel is a big challenge and huge concern to be dealt with. Since the preparation of food depends on the inflow of customers, demand of the customers, planning must be done carefully by analyzing the trends. Hoteliers have to carry out a study to understand the culture, tastes and market of customers and plan accordingly to minimize the waste of food.

Self Assessment Questions

- What are the different types of waste a hotel could generate?
- Discuss the measures to be taken for minimizing the waste
- Rich people buy more food and cook more food than they need. Why is this? Is enough work being done to understand the underlying dynamics behind this?
- Let's look at an example of how our motivations conflict – the wish to avoid wasting money or good food may be overshadowed by a desire for convenience because we lead busy lives. We might have good intentions but we fail to act on them. Are we mentally capable of prioritising such concerns when confronted with immediate life challenges?

Further Readings

- https://wastewise.be/2014/04/appetite-for-reduction-behaviour-change-and-food-waste/ , Accessed on Nov 28, 2018, @ 18:00
- https://hospitalityfoodwaste.wordpress.com/2013/04/17/food-waste-in-the-hospitality-industry/ , Accessed on Nov 28, 2018 @ 18:00

Video Links

- Waste Management in the Hospitality Industry https://study.com/academy/lesson/waste-management-in-the-hospitality-industry.html , Accessed on Nov 28, 2018 @ 15: 30
- Managing Waste In The Hospitality Industry https://www.youtube.com/watch?v=nDL-Dd39GFg, Accessed on Nov 28, 2018 @ 15:35
- How one hotel is reducing food waste, https://www.youtube.com/watch?v=6gEdzt5D0AU, Accessed on Nov 28, 2018 @ 15:40

Chapter 5
Waste Audit in Hotels

Objectives

- To know the importance of waste audit in hotels
- To know how to conduct waste audit and tools needed for it

Structure

5.1 Auditing of Waste in Hotels
5.2 How to Perform a Waste Audit
5.3 Tools Used to Conduct Waste Audit
5.4 Identification of Process of Profitability from Waste Management Practices in Hotels
5.5 Restaurant Food Waste Reduction Ideas

To Do Activities

- Visit a nearby hotel or restaurant and conduct a waste audit and submit a report on the same
- Invite a guest speaker from Hotel Industry and facilitate interaction with students

5.1 Auditing of Waste in Hotels

Hotel industry generates a lot of waste and most of the time it is sent to the landfills without being treated properly. The first step in managing the data analysis of waste is to perform waste audit. Waste Audit is identifying the process of productivity from waste management practices in hotels.

A first step towards a waste management program is waste audit. Auditor will investigate the audit sheet waste which is classified into recyclable, compostable and inert waste. Recyclable wastes are those which can be processed by alternative techniques or procedure and convert into by-products or any useful material. Compostable wastes like food waste, leftover foods, kitchen waste, etc. are recycled in the form of composting and converted in to manure for gardening. Finally, inert waste like laminated plastic products or mixed waste that are not in the position to convert it in to any valuable item are directly sent to the landfills. Audit was conducted randomly, without any prior notification given to these hotels to ensure unbiased information is obtained and avoid any deliberate action by hotels to manage their recycling status.

How to conduct a Waste Audit?[11]

Fig 5.1 Conducting Waste Audit

First step to a waste management program is a waste audit. During a waste audit, the auditor investigates the sources, composition, weight, volume, and destinations of the waste. By learning more about the trash the hotel generates, one can be better informed about the products that contribute to waste and be better prepared to more efficient disposal, saving money and improving green hotel's environmental performance.

How to Start a Waste Reduction & Recycling Program[12]

First step in waste reduction and recycling program is preparing a checklist to evaluate the environmental impact of frequently used products in the Hotel. Checklist will also facilitate in identifying the best disposal method of waste. Table 5.1 shows checklist format for hotel waste.

[11]Shroeder (2016) http://www.seradesign.com/2016/02/waste-audits-the-dirty-work-of-office-sustainability/
[12]https://www.ecogreenhotel.com/green_hotels.php

Table 5.1 Hotel Waste Checklist

Product Used	Reduce	Reuse	Recycle	Replace		Product Used	Reduce	Reuse	Recycle	Replace
Aerosols						Leaves / grass clippings				
Air Conditioner						Light bulbs				
Aluminium appliances						Magazines and books				
Batteries						Matches				
Bedding						Mattresses				
Bleach						Menus				
Bleach Bottles						Metal items				
Brochures						Mirrors				
Cans (aluminium)						Motor oil				
Cans (tin)						Newspapers				
Card						Office equipment				
Carpet remnants						Oil (kitchen)				
Cleanser						Oil(engine)				
Computer Paper						Oven cleaner				
Cooking oil						Packaging				
Corrugated boxes						Paints and solvents				
Detergent boxes						Paper cups				
Dishes						Paper towels				
Disposable pens						Pencils				
Dry cleaner						Pens				
Electrical equipment (e.g. hairdryers, vacuum, cleaners, irons, kitchen equipment, etc.)						Pesticides / herbicides				
Electronic equipment (computers, TVs, mobile phones, etc.)						Photocopying paper				
						Plastic bags				
						Plastic bottles				
						Plastic buckets				
						Plastic shower curtains				
Facial tissues						Pots and pans				
Fertilisers						Printed matter				
Fine paper						Room booklets				
Food (meat waste)						Shampoo				
Food (non—meat waste)						Shoe bags				
Food Packaging						Stationery				

Furniture						Styrofoam				
Glass bottles						Tissue Paper				
Laundry bags						Toxic and hazardous materials				
						Window envelopes				
						Wood				

After identifying the checklist of products that impact environment, following eight basic steps need to be planned and implemented for waste reduction and recycling program in hotels:

Fig 5.2 Steps in Planning and Implementing a Waste Reduction and Recycling Program

5.2 How to Perform a Waste Audit[13]

To ensure proper management of waste and recycling efforts are carried out, performing multiple waste audits at different seasons during the year is crucial. Here are a few things to note:

1. Ensure proper safety measures. Provide thick gloves to sorters, and make sure everyone has had a tetanus shot. Be sure to inform and educate the hotel's staff on health and safety matters.
2. Ensure proper confidentially measures. The waste stream may contain personal and private information that should be kept confidential.

[13] https://www.hotelnewsresource.com/article52505.html

3. Enlist staff from each hotel department and form your waste reduction team. The help of housekeeping, custodial staff, and waste haulers is invaluable to a successful waste audit. These personnel can assist in gathering your hotel's waste and can also provide logistical insights about your recycling and waste management system.
4. Keep the timing of the audit a secret. By keeping the timing of a waste audit secret, you ensure that the waste you analyze is a truly representative sample of the waste your green hotel generates at a particular time of year. If people are informed in advance of the date of a waste audit, they may increase their recycling efforts or otherwise alter their behavior.
5. Collect waste. Work with waste haulers, staff, and concessions managers to collect the waste. Make sure that everything collected is clearly labelled by date and location.
6. Sort waste. Sort the collected waste by type, noting paper; cardboard; recyclable and non-recyclable plastics, glass, and metals, food waste, batteries, and so on. Make sure to note recyclable materials that have not been diverted for recycling.

Analyze results and make recommendations. What is the composition of your hotel's waste stream? How much can a hotel increase its recycling? By what methods can an eco-friendly hotel increase its recycling? How can waste be collected more efficiently? What are the opportunities to reduce waste generation? How can a sustainable business save money by altering its waste management systems? The below table 5.2 shows a format for conducting Waste audit.

Table 5.2 Basic Audit Form[14]

Waste Item	Approx Annual Quantity		Current Disposal Route	Current Disposal costs per annum (Rs.)	Reduce	Reuse/ Recycle	Replace	Action	Cost (Rs)	Approx Annual Saving (Rs)
	Kg	litres								
Total										

[14]http://www.greenhotelier.org/wp-content/uploads/2014/09/4-Waste-for-web-1-1.pdf

5.3 Tools Used to Conduct Waste Audit

Warm Model

Due to increase in consumption pattern, life style, food habits and culture in India, the organic or compostable wastes in hotels are higher. Since it is usually not segregated at source, it becomes unfit for composting. Thus wastes composted generate low or poor quality of compost. It is because of this reason, the various wastes to energy (WTE) or combustion plants are either shut down or operate at a loss.

Waste materials like aluminium cans, steel cans, all type of papers, cardboard and plastics are easily recycled among hotels in India. Remaining wastes like inert materials and mix waste (non-segregated waste) mainly wet waste, goes to the landfill. In WARM model, the first step is to calculate baseline scenario. It is used to calculate the emission according to current practice of waste disposal. Next step in WARM model is alternate scenario which is suggestive in nature, and shows that if the waste is utilized/managed properly by recycling, composting or combustion depending on the type of waste, can lead to reduction in total emission.

$$\frac{\text{Daily generation (in kgs)} \times 365}{1000} = \text{Emission generation ratio}$$

WARM tool recognizes 54 material types as shown in the table below. Warm model is periodically updated as and when new material categories and revisions are made to existing numbers and methodology.

Table 5.3 Types of Material Recognized by WARM[15]

Aluminum Cans	Food Waste (non-meat)	Mixed Recyclables
Aluminum Ingot	Food Waste (meat only)	Newspaper
Asphalt Concrete	Fruits and Vegetables	Office Paper
Asphalt Shingles	Glass	Personal Computers
Beef	Grains	Mixed Plastics

[15]https://www.epa.gov/warm/basic-information-about-waste-reduction-model-warm

Branches	Grass	PET (polyethylene terephthalate)
Bread	HDPE (high-density polyethylene)	Phonebooks
Carpet	LDPE (low-density polyethylene)	PLA (polylactic acid)
Clay Bricks	Leaves	Poultry
Concrete	LLDPE (linear low-density polyethylene)	PP (polypropylene)
Copper Wire	Magazines/Third-Class Mail	PS (polystyrene)
Corrugated Cardboard	Medium Density Fiberboard	PVC (polyvinyl chloride)
Dairy Products	Mixed Metals	Steel Cans
Dimensional Lumber	Mixed MSW (municipal solid waste)	Textbooks
Dry wall	Mixed Organics	Tires
Fiberglass Insulation	Mixed Paper (general)	Vinyl Flooring
Fly Ash	Mixed Paper (primarily from offices)	Wood Flooring
Food Waste	Mixed Paper (primarily residential)	Yard Trimmings

Equivalency Calculator

Equivalency calculator is a tool developed by United States Environment Protection Agency (USEPA). This tool was used to show the optimum utilization of GHG emission to other sector. It may be useful in communicating the greenhouse gas reduction strategy, reduction targets, or at reducing greenhouse gas emissions. It is useful in communicating the GHG reduction strategy and in reducing GHG emissions.

It calculates the emissions of passenger vehicles, gasoline and oil consumed tanker trucks, propane cylinders, burning rail cars, emissions from waste sending to the landfill and emissions from power plants.

Cost Benefit Analysis

Cost benefit analysis, helps in analyzing the potential of waste management and its positive implementation to the hotel industry and also to the environment.

Net benefit = Benefit - Cost

Methods of Waste Treatment

There are various methods for waste treatment according of the nature of waste. There are:

1. Treatment of recyclable waste

2. Treatment of compostable waste

Treatment of Recyclable Waste

Paper waste is treated with repulping technique to convert paper and paperboard products. Plastic waste are treated with the help of Extruder Machine, Injection moulding, Blow moulding, Film blowing and depolymerisation Process (the plastic is melted and chemically broken down) and Fluidized bed reactor to convert into bottles and jar. Metal waste is treated with the help of Ferrous metal shears. Garden waste and food waste is treated with the process of composting and converting in to manure. Textiles waste is treated with the help of remanufacturing process, Lyocell process, Patagonia process and Textile incineration to convert into reusable cloths. Glass waste is treated with Cullet- Glass crusher. Metals waste is treated with the help of Ferrous metal shears. Garden waste and food waste are treated with the process of composting and convert manure from it.

Treatment of Compostable Waste

Hotel organic waste can be reduced by composting as a best alternative. It is a biological process of decomposition of organic wastes within certain condition like proper ventilation, temperature, moisture and carbon and nitrogen ratio. Compost is useful manure and perfect soil conditioner. Composting is basically depending on the nature of waste and its decomposition process. There are two methods of composting describes i.e., aerobic and anaerobic. Apart from that another form of composting is vermin composting, in which various species of earthworm are used to convert organic waste into manure.

Model and Framework Development

A holistic framework is developed to educate hotel industry about the effective waste management is a revenue source. The framework helps in saving costs on local vendors and labor costs for handling waste. Hotel waste management is classified in to profitability aspect and sustainable aspect. Treatment of waste in hotels is a crucial issue to be dealt with. Thus it is mandatory for hotel industries to develop a complete framework which helps in optimizing the waste generated in the industry and also reduces environmental impact.

Monitoring and Benchmarking Progress

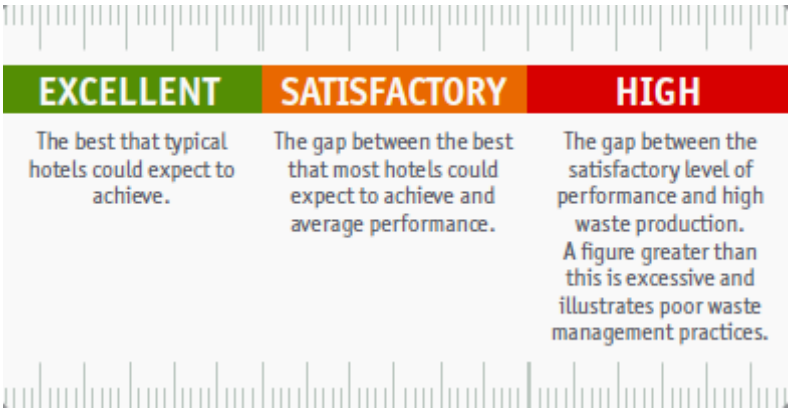
Monitoring the results of completed actions and ongoing efforts are important. Establish check points to monitor the success of the each action either daily or weekly or monthly. Benchmarking can help identify opportunities for savings in the hotel and will enable to compare performance against that of similar hotels. An example of a waste benchmark for a luxury hotel in Europe with reasonable recycling facilities might be between 0.6 and 1.2kg of waste per guest per night. To calculate simple waste benchmarks:

- Calculate the volume (litres) or weight (kg) of non-hazardous waste sent to landfill over the last full calendar year. You can find this information on your waste disposal bills, from your waste contractor, or you may need to conduct your own survey.
- Exclude any materials that are separated on-site and recycled but include wastes that are not segregated on site but are recycled by a contractor at a later date.
- Divide the total volume or weight by the number of guest nights spent at the hotel over the past calendar year.

Table 5.4 Waste Benchmarks for Luxury Hotels[16]

Hotel profile	Parameter	Benchmark value for waste produced		
		EXCELLENT	SATISFACTORY	HIGH
Luxury serviced hotels	litres / guest night	< 3.0	< 5.0	< 7.0
	kg / guest night	< 0.6	< 1.2	< 2.0

The above table shows waste benchmarks for luxury hotels. The results fall into three categories as below: excellent, satisfactory and high.



It is recommended that weight (kg) is measured for greatest accuracy.

[16] http://www.greenhotelier.org/wp-content/uploads/2014/09/4-Waste-for-web-1-1.pdf

5.4 Restaurant Food Waste Reduction Ideas

To track food waste in a restaurant there are two main factors to consider, how much food is being wasted and the number of customers coming to the restaurant. By gathering data of these two variables we can understand the bigger source of waste. Three important waste types in a restaurant are Pre-Consumer waste, Post-Consumer waste and Disposables.

Pre-Consumer Waste
It is the waste which can be controlled by ordering, storing, preparing and cooking the ingredients as per requirement and not in surplus. The inventory needs to be evaluated and the ingredients have to be properly stored to maximize their shelf life.

Train staff with proper preparation techniques to reduce waste. Keep the stock organized by using stickers with packaging dates clearly written.

Leftover food can be offered to staff or donate to food banks and the food scrap can be used for animal feed.

Post-Consumer Waste
Consumers in restaurants would not eat all the food that they order and the leftovers typically end up being discarded for disposal. Simply put, Post-Consumer waste is the waste that individuals routinely discard either in a trash can or in a dump by incinerating or pouring down the drain. Below are some of the effective methods hotels could use in reducing Food Waste.

- Changing the menu
- Making hotel purchases wisely
- Educating the staff
- Investing in high-quality kitchen equipment

- Changing serving quantities
- Conducting inventory checks in the restaurant regularly
- Restaurant Waste Recycling
- Encourage guests to take the leftover food with them

Disposables

Disposables are the items which are intended to be thrown away after a single use. Plastic bags, plastic containers, plastic cutlery are the disposable items mostly used in a restaurant which create unnecessary wastage and pose a significant environmental problem. To reduce usage of disposables try to use biodegradable items wherever possible.

Use reusable dishware for serving food. Eliminate excess packaging. Provide training to staff on optimal usage of disposable items. Separate garbage from the food materials and do composting. Plastic bottles, cans, glasses, plates, cardboard and glass waste can be recycled and reused to reduce environmental pollution. Assess food waste regularly so that you can monitor trends and implement any necessary changes.

Food waste is organic and can be completely recycled. It is one of the important renewable energy resources and the most common transport to landfills for composting. Plastic bottles, cans, cardboard boxes, wooden pallets and paper materials can be either reused or recycled. Making a contract with a local company for recycling may earn money from waste generated and can even get a free service of waste transport. And finally buying products made from recycled materials will support recycling programs and contribute to the sustainability of life.

Summary

Waste production from hotel industries is one of the major issues in India because waste is not treated well. Therefore, develop a holistic framework for waste management has important role in the optimization of each waste material in hotel industry. Most of the wastes in hotels are recyclable or compostable. The study shows that hotels can not only make environmentally friendly contributions, but also make profits out of a proper recycling practice in a long-term. Waste elimination at source and recycling can saves GHG emission to a large extent. Therefore, it can decrease pollution and slow down global warming, which is a major problem mankind is facing nowadays.

Proper waste management strategy shows that a thorough literature review along with expert's interviews done by researcher, waste audit form for the calculation of waste volume can be prepared. Then the impact of waste on environment was calculated with the help of WARM Model and equivalency calculator. And the next most important analysis is cost benefit. And the last step is to develop the best framework or model which explains the value of profitability and sustainability. Waste Management is serious issue that needs public awareness and governmental attention immediately.

Self Assessment Questions

Discuss in teams the tools used to conduct waste audit.

Further Reading

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- $19,000 saving in food cost- https://www.unileverfoodsolutions.com.au/chef-inspiration/chef-training-and-resources/managing-food-waste/waste-reduction-a-success-story.html

Video Links

- $19,000 saving in food cost - https://www.unileverfoodsolutions.com.au/chef-inspiration/chef-training-and-resources/managing-food-waste/waste-reduction-a-success-story.html , Accessed on Nov 28, 2018 @ 16:00

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