Introduction to Waste Management

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Introduction to Waste Management

Waste disposal leads to direct and in direct environmental impacts, such as land occupation, resource depletion, amplification of global warming due to methane and other greenhouse gas emissions, waters intoxication due landfilling, as well as acidification and toxic effects from emissions to air in the case of incineration.

Direct impacts of waste represent a significant but comparatively small share of climate change, while resource depletion among similar effects is linked to indirect environmental impacts. This is mainly because indirect results of wastes are linked with the extraction and processing of different resources to produce different types of products while focusing on the output rather than the input in many industries. This shows how indirect impacts of incorrect management of waste can be more devastating and present the highest potential compared to its counterpart.

Waste management is defined as: the different approaches and procedures designed and implemented to identify, control and handle the different types of waste from generation and until disposal. Full implementation of waste management processes, including waste prevention and reuse, and recycling wherever possible, has and can further help avoid considerable environmental impacts when assessed from a life-cycle perspective – considering direct effects such as emissions and indirect effects such as resource depletion.

From a material resource-efficient perspective, disposal options such as landfill and incineration do not represent best practice for separately collected recyclables and mixed Municipal Solid Waste, it is important to quantify the impacts associated with such disposal operations, in order to quantify the environmental, economic and societal benefits realized through the adoption of proper waste management practices, which you will be introduced to in this text.

There are multiple governmental and international organizations that are meant with regulating and managing different aspects of the waste management sector, some of these are:

1. Municipalities and Environmental Governmental Agencies: work together to create legislation and benchmarks for waste management in facilities, while handling municipal waste management as well as hazardous waste treatment in their operations.
2. US Green Building Council worked on standardizing Waste management of construction waste as well as the daily operations of facility through their Leadership in Energy and Environmental Design LEED program.
3. International Standards Organization ISO and the European Union EU are both involved in creating frameworks and regulation for waste management among many

other fields. This is mostly represented by the ISO14001 (Environmental Management Standard) and EMAS (Eco Management and Audit Scheme)

All these entities share common goals which are:

1. Improve resource efficiency.
2. Reduce waste.
3. drive down costs.
4. Increasing Competitive advantage in supply chain
5. Meet legal obligations.
6. Increase customer trust.
7. Improve and manage a consistent environmental impact.

All in all, this represents the basis on which waste management approaches can be built on, this text will allow you to develop a further understanding of what goes into waste management and should a low you to grasp the full potential benefits of waste management, across different commercial, industrial, and residential applications.

Sustainability and Waste Management

This chapter will introduce you to the concept of sustainability and present you with its role across the field of waste management. Sustainability is defined by meeting our needs to complete a certain task or activity in an efficient and productive manner that benefits the implementer and does not negatively affect the environment around us, in an approach that allows us to better utilize resources in three key areas, they are: economy, environment, and society.

I. economic impact, is represented in the financial benefits of adopting different plans in the operations involved at achieving a certain task.
II. Environmental impact, involves the effect outputted from the activities we perform, this comes in the form of emissions, non-natural or non-native products outputted to the planet’s ecosystem.
III. Societal impact, targets the effect of our activities on humans' quality of life. this involves their access to resources, employment and as well as the presence of a healthy ecosystem for them to live in.

For example: back in 2012, the third sector in the UK benefited by an estimated 430 million Pounds through the reuse of different commercial and residential waste. this process supported the creation of 11,000 full-time equivalent jobs and reduced market need for intensive water consuming and GHG producing industries such as clothing. Additionally, in calculating waste generated from the clothing industry alone. Each household‘s waste of clothing per year accounts to 1000 bathtubs and the carbon emissions from driving a modern 5 passenger car for 10000 Km.

Sustainability is deeply rooted within waste management as some consider it to be the basis on which it is built on. governing this relation is the concept of the 3rs of waste management and what will further be introduced as part of the environmental pyramid.

The three Rs of sustainability are reduce, reuse and recycle, and they can be utilized across our waste management operations by follow three key recommendations, which are:

I. Waste Reduction, is most preferable to us as it provides the best sustainable outcome of the 3 R's of waste management.
II. Waste Reuse, whenever we find an inevitable source of waste, we look at opportunities to reuse, either for the same purpose or for another. this provides us with moderate sustainable payback.
III. Waste Recycling, is the least preferable as it provides the least sustainable returns.

Note: These three represent positive areas of investment. And should not be confused with the profitability of these approaches, for example recycling some materials could use up to ten times the energy it took to originally create them, but at the same time it can be highly feasible and profitable for an independent business. While, in parallel, reducing the need for such waste if that were possible would have saved the original cost in addition to the recycling cost.

Types of Waste

A waste is any solid, liquid, or contained gaseous material that is being discarded by disposal, recycling, burning or incineration. It can be a byproduct of a manufacturing process or an obsolete commercial product that can no longer be used for intended purpose and requires disposal.

Waste can be categorized on many different bases, for the purpose of the applications displayed through this text, we will focus on three of the most prominent approaches to categorizing wastes and are demonstrated in table 1 below.

Characterization	Types of waste
Based on physical properties, effects etc.	a) Solid wastes: Wastes in the form of solid i.e. local, commercial, and industrial waste. b) Liquid wastes: Wastes in the form of liquid or watery. i.e. oils, chemicals, polluted water from ponds or rivers etc.
Based on the biological properties of wastes:	a) Biodegradable wastes b) Non-biodegradable wastes
Based on the effects of waste on human health and environment:	a) Hazardous wastes: Dangerous substances emitted from the commercial, industrial and agriculture or economical use, which are unsafe to use for further purpose. b) Non- hazardous wastes: Safe wastes emitted from the commercial, industrial and agriculture or economical use, considered harmless to use for further purpose.

Table 1 Waste categorization approaches.

The most known type of waste, which will be focused on during this text will be Municipal Solid Waste as it accounts for most of the waste outputted to dumpsites and has a high potential to be managed. Municipal solid wastes (MSW) include commonly known trash, and consists of daily use items, which we throw away after use such as batteries, paints, appliances, newspapers, food scraps, bottles, clothing, furniture, and packaging.

As for its sources, MSW is generated from industries, hospitals, schools, and houses. MSW is a biomass waste type consisting of glass, food wastes, metals, textiles, wood, plastics, and paper. The methods most commonly used for management of MSW are open dumping and landfilling. Both methods have side effects such as environmental contamination, methane gas generation which promote global warming and labor issues.

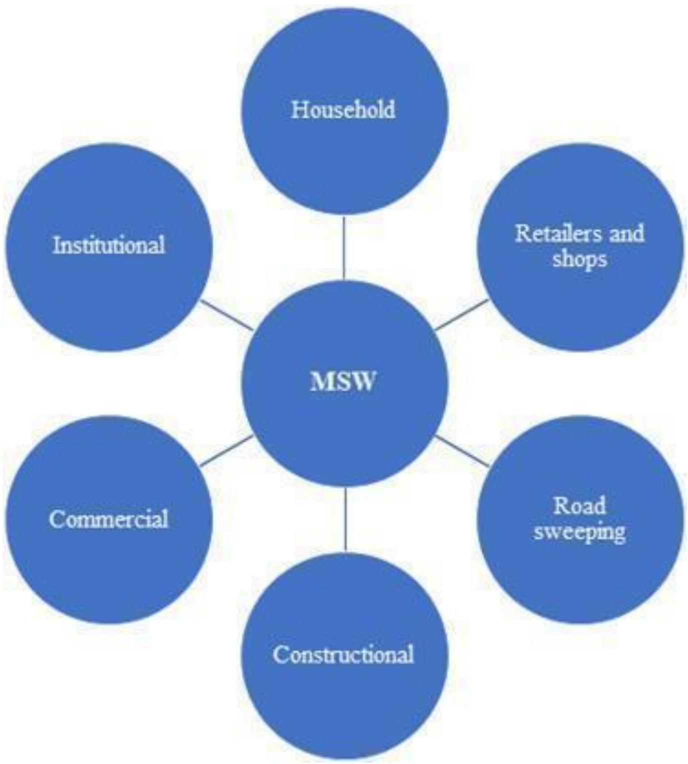


Figure 1 Sources of MSW.

The presence of chemical bonding between C–H–O, MSW allows for energy generation whenever these bonds are broken, this characteristic presented the potential for extracting methane from the biodegradable components in MSW, and further use it for the purpose of generating electricity.

In 2016, urban population generated 2.01 billion tons solid waste with each person contributing approximately 0.74 kg/day. With increasing urbanization, the annual generation of wastes is expected to increase by 70% from 2016 to 2050. The waste generation is expected to increase from around 2 billion tons from 2016 to 3 billion tons by 2050 (World Bank, 2019). Annually, 1.9 billion tons of MSW is generated with each person contributing 218 kg MSW to this grand total. This shows the great potential of putting MSW into use, rather than using traditional landfilling and dumping approaches.

Waste Management Principles and Procedures

This chapter will introduce some of the administrative guidelines that govern the different processes involved in waste management. These guidelines will be translated in later chapter into technical measures for the design and assessment of waste management plans.

These guidelines will be based on the different approaches that are used in environmental science planning and auditing, which are known as the Beat Environmental Management Practice BEMP. BEMP represents the techniques, measures and actions that allow organizations to minimize their impact on the environment in all aspects under their direct control. These practices involve multiple disciplines, including waste management. To begin with, for any facility that generates waste, there are two main practices to look for:

1. Establishing waste management priorities throughout the operations and activities of the implementing facility. And this should be based on an understanding of potential Environmental, Health, and Safety (EHS) risks and impacts while in parallel, considering waste generation and its consequences.
2. Establishing a waste management hierarchy that considers prevention, reduction, reuse, recovery, recycling, and finally disposal of wastes.

The practices demonstrated in this text should be conducted following set procedures which conform to the 3Ra of waste management and the waste management hierarchy, and they include:

I. Avoiding or minimizing the generation waste materials is the most preferable approach.
II. Where waste generation cannot be avoided, we always look for ways minimize it.
III. Wherever it cannot be minimized we look for ways to recovering and reusing it.
IV. wherever waste cannot be recovered nor reused. We must ensure that we either properly recycle it or dispose of it in an environmentally sound manner.

BEMPs and waste management practices have been recently increasingly linked to the concept of Zero Waste, which can be implemented within our waste management structure. Zero Waste is an approach that at managing waste in in a way where none of the wastes generated from our facility would be sent for disposal such as landfilling, open dumping or incineration. Rather than that, it is either reused or inputted into other processes.

After establishing the basis of our waste management practices, we start designing a specific waste management model that addresses issues linked to waste minimization, generation, transport, disposal, as well as the required monitoring process needed to ensure proper implementation of our plans.

In this model we identify how facilities that generate waste should characterize their waste according to: composition, source, types of wastes produced, generation rates, in addition to any local regulatory requirements.

Additionally, the effective planning and implementation of waste management strategies should include the following six key focus areas, which are:

1. Review of new waste sources during planning, siting, and design activities, including during equipment modifications and process alterations, to identify expected waste generation, pollution prevention opportunities, and necessary treatment, storage, and disposal infrastructure.
2. Collection of data and information about the process and waste streams in existing facilities, including characterization of waste streams by type, quantities, and potential use.
3. Establishment of priorities based on a risk analysis that takes into account the potential Environmental, Health and Safety risks during the waste cycle and the availability of infrastructure to manage the waste in an environmentally sound manner.
4. Definition of opportunities for source reduction, as well as reuse and recycling
5. Definition of procedures and operational controls for onsite storage
6. Definition of options / procedures / operational controls for treatment and final disposal

Finally, it is integral as we have said to incorporate a consistent planning criterion in the waste management plans design phase. We have until now covered how this process needs to be initiated.

In this chapter, we will start with identifying the phases of waste management, starting from its generation up until disposal, this will include:

Section 1: Generation, Collection and Storage.
Section 2: Transport, Treatment, and Disposal.
Section 3: Monitoring and Evaluation.

GENERATION, COLLECTION, AND STORAGE

In this section, we will tackle three integral stages of the waste management hierarchy, which are:

1. Generation
2. Collection
3. Storage

Waste Generation Prevention Processes should be designed and operated to prevent, or minimize, the quantities of wastes generated, and hazards associated with the wastes generated in accordance with the following strategy:

1. Substituting raw materials or inputs with less hazardous or toxic materials, or with those where processing generates lower waste volumes. An example of this would

be the replacement of toxic cleaning materials with sustainable and safe ones. For example, Using Certified Green Seal products, which is a labeling for environmentally friendly cleaning products.

2. Secondly, we can also minimize hazardous waste generation by implementing strict waste segregation to prevent the mixing of non-hazardous and hazardous waste during storage. Because any contact between nonhazardous and hazardous waste results in contamination, thus increasing the amount of hazardous waste which need to be properly managed and processed. Which is surely considered a losing bargain.
3. Applying manufacturing process that convert materials efficiently, providing higher product output yields, including modification of design of the production process, operating conditions, and process controls. An example of this would Be in the form of reducing wasted materials in production line for fabric cutting through certain design solutions.
4. Instituting good housekeeping and operating practices, including inventory control to reduce the amount of waste resulting from materials that are out-of-date, off specification, contaminated, damaged, or excess to the facility's needs.
5. Instituting procurement measures that recognize opportunities to return usable materials such as containers. Which respectively prevents the over ordering of materials. This can be utilized in reusing packaging materials, and containers for compatible materials as well as furniture.

As for waste collection, methodologies differ inside a facility but in most cases, they are based on three main levels, they are:

Level 1: Station Collection (per office / room / workstation / single production line).
Level 2: Level Collection (per floor / Apartment / Zone).
Level 3: Facility Collection and Storage (within a building).

The design for each of these levels will be further in chapter six which will tackle the design and assessment of waste management plans.

Moving on to storage, waste should be stored in a manner that prevents the mixing or contact between incompatible wastes and allows for inspection between containers to monitor leaks or spills. Examples include sufficient space between incompatibles or physical separation such as walls or containment curbs, and there are a few guidelines to be kept in mind when we design storage plans:

1. Store waste in closed containers away from direct sunlight, wind, and rain, and consider the wind profile for the area of storage in case it was exposed.
2. Secondary containment systems should be constructed with materials appropriate for the wastes being contained and adequate to prevent loss to the environment.
3. Secondary containment should also be included wherever liquid wastes are stored in volumes greater than 220 liters. Keeping in mind that the available volume of

secondary containment should be one of two. Either at least 110 percent of the largest storage container, or 25 percent of the total storage capacity (whichever is greater in that specific location).

4. Provide adequate ventilation where volatile (hazardous) wastes are stored. Hazardous waste storage activities should also be subject to special management actions, which should be conducted by employees who have received specific training in handling and storage of hazardous wastes.

The waste management plans should also take into consideration the following parameters whenever hazardous waste streams are present in a facility:

1. Provision available information on chemical compatibility to employees, including labeling each container to identify its contents.
2. Limiting access to hazardous waste storage areas only allowing employees who have received proper training while clearly identifying (label and warning signs) in the area, including documentation of its location on a facility map or a site plan.
3. Conducting periodic inspections of waste storage areas and documenting the findings
4. Preparing and implementing spill response and emergency plans to address any accidental release.
5. Avoiding underground storage tanks and underground piping of hazardous waste. Due to its high risk of contamination.

TRANSPORT, TREATMENT AND DISPOSAL

On-site and Off-site transportation of waste should be conducted to allow for processing, as well as preventing or minimizing spills, releases, and exposures to employees and the public. All waste containers designated for off-site shipment should be secured and labeled with the contents and associated hazards, be properly loaded on the transport vehicles before leaving the site and be accompanied by a shipping paper (manifest) that describes the load and its associated hazards.

In conjunction with the waste collection levels inside facilities, transportation begins with municipal waste collection. In this regard we see that Municipal waste handling is mostly based on 4 main levels, they are:

Level 1: Collection Center.
Level 2: Distribution Center.
Level 3: Treatment.
Level 4: Disposal.

These levels need to be taken into consideration when following up on the transportation of waste from handling services.

Next, the treatment of waste. This could be in the form of Recycling and Reuse In addition to the implementation of waste prevention strategies, the total amount of waste may be significantly reduced through the implementation of recycling plans within our waste treatment approaches, which should consider the following elements:

1. Evaluation of waste production processes and identification of potentially recyclable materials
2. Identification and recycling of products that can be reintroduced into the manufacturing process or industry activities within the area of operation.
3. Investigation of external markets for recycling by other industrial processing operations located in the neighborhood or region of the facility (e.g., waste exchange)
4. Establishing recycling objectives and formal tracking of waste collected for processing.
5. Providing training and incentives to employees in order to meet objectives of proper Treatment and Disposal If waste materials are still generated.
6. Finally, we need to ensure that the waste handling service should be properly equipped to treated and dispose of waste in a manner that ensures meeting sustainable goals set in our plans.

For the waste handling service provider, we need to keep in mind that Selected management approaches should be consistent with the characteristics of the waste and local regulations, and may include one or more of the following:

- On-site or off-site biological, chemical, or physical treatment of the waste material to render it nonhazardous prior to final disposal.

- Treatment or disposal at permitted facilities specially designed to receive the waste. Examples include composting operations for organic non-hazardous wastes; properly designed, permitted, and operated landfills or incinerators designed for the respective type of waste; or other methods known to be effective in the safe, final disposal of waste materials such as bioremediation.

Commercial or Government Waste Contractors, as waste managers we need to validate that they represent the best option for us to achieve our waste management plan goals, this is done by ensuring that they have two main things, they should:

1. Have the technical capability to manage the waste in a manner that reduces immediate and future impact to the environment.
2. Have all required permits, certifications, and approvals, of applicable government authorities.

Finally, waste managers should consider Installing on-site waste treatment or recycling processes in case no proper waste handling service is available and as a final option, construct facilities that will provide for the environmental sound long-term storage of wastes on-site or at an alternative appropriate location up until external commercial options become available. An example of this would be nuclear power generation waste storage.

MONITORING

There are several guidelines that you need to be sure to follow during the implementation of any waste management plan, and most of them will be greatly utilized in the assessment stage for existing waste management plans which will be discussed in chapter 6.

Monitoring of activities associated with the management of hazardous and non-hazardous waste should include many stages of observation of active waste management operations and includes inspection, audits, tracking and characterization of waste management operations. These include:

1. Regular visual inspection of all waste storage collection and storage areas for evidence of accidental releases and to verify that wastes are properly labeled and stored.
2. Regular audits of waste segregation and collection practices as seen in our plans.
3. Tracking waste generation trends by (type and amount of waste generated) preferably by facility departments for us to be able to assess the achievement of different goals.
4. Adapt to new inputs through Characterizing waste at the beginning of generation of a new waste stream, and periodically documenting the characteristics and proper management of the waste.
5. Keep manifests or other records that document the amount of waste generated and its destination, to allow for assessment and comparison between different conditions of operations.

Accordingly, whenever significant quantities of hazardous wastes are generated and stored on site, monitoring activities should include:

1. Inspection of vessels for leaks, drips, or other indications of loss.
2. Identification of cracks, corrosion, or damage to tanks, protective equipment, or floors
3. Verification of locks, emergency valves, and other safety devices for easy operation (lubricating if required and employing the practice of keeping locks and safety equipment in standby position when the area is not occupied).
4. Documenting results of testing for integrity, emissions, or monitoring stations (air, soil vapor, or groundwater).
5. Documenting any changes to the storage facility, and any significant changes in the quantity of materials in storage.

As for Monitoring records for hazardous waste collected, stored, or shipped should contain Name and identification number of the material(s) collected, stored, or shipped. This includes three things:

   1. Name and identification number of the material(s) composing the hazardous waste, including:

   a. physical state (be it solid, liquid, gaseous or a combination of one).
   b. Quantity (in kilograms or liters, and number of containers).
2. Strict Waste shipment tracking documentation that includes:
   a. quantity and type.
   b. date dispatched, date transported.
   c. date received, as well as the.
   d. record of the generation facility.
   e. handling and processing service provider.
3. Document Method and date of storing, repacking, treating, or disposing at the facility, cross-referenced to specific manifest document numbers from the WMP.

You might feel that these administrative guidelines are not relevant to your facility's requirement in specific, and therefore you need to keep it mind that by the end of this text, you should be able to design the proper waste management plan for your specific facility in focus, and from there decide on the proper regulation with regard to each stage of the hierarchy from generation to disposal.

Labeling and Recycling of Products

Labels represent a great way of communicating information, and this extends to the information that are related to our work as waste managers. In this chapter, we will overview some of the most significant labels that can be stamped on products and will allow you to understand them to make use of them in the future. These labels could include instructions on separating components, a resin identification code (RIC) to differentiate plastic grade, a company's standpoint on recycled products or certain disposal warnings.

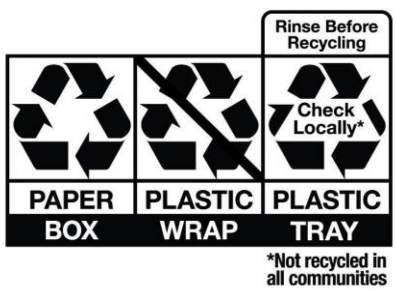
1. The Mobius Loop

Which represents a triangle composed of three arrows looping back on themselves in clockwise direction. This symbol is used to deliver multiple messages regarding recycling conditions and opportunities for different types of products and could be used to indicates that a product can be recycled as well as the presence of any recycled content within a specific product. It can be used as a general reference for recyclability of a product.

Figure 2 - Illustrations of the Mobius Loop.

As seen in the figure it can be used to provide consumers with information on their ability to recycle a substance in general or in each community or region. The following examples represent the different used of the mobius loop.

a. to indicate if different components of a single product can be recycled and provide guidance on how they should be recycled.



Example. We have a label for a product's packaging material. As seen in the figure, it shows us how the paper box that the product shipped in can be recycled as a cardboard we might assume and informs us that the plastic wrap is non-recyclable, which could mean that it is a type of non-recyclable plastic. And finally, that the plastic tray might be recyclable depending on the availability of a facility in the region were in and informs that in case of recycling we need to rinse the plastic tray.

b. to identify compostable products alongside relevant symbols

This shows us how the mobius loop can be used to indicate biodegradable and compostable contents. To differentiate between the two. Biodegradable labeling means that it can be disposed of in nature as it can naturally dissolve in soil, while compostable labeling means that it can be used to create compost which can be later used for fertilizing soil.

It can also be replaced or used alongside the US composting council's composting label shown.

c. The simplified Mobius loop for identifying plastics (resin identification code)

The mobius loop can also be used to classify different types of plastic by numbers from 1 to 7 according to (weight/grade and composition). Keep in mind that when we see this symbol, it does not always mean that the plastic can be recycled. *It is merely an identification aid*.

Figure 3 - Resin codes for plastic products.

As for the recycling of these plastics, as a useful rule of thumb, the lower the number, the more likely it is that a particular plastic product can be recycled, and for that both resin codes 1 and 2 are among the most recycled materials. Moreover, Plastic 3 or PVC is widely recycled too, but further down the list it becomes harder to fully recycle plastics – for example in the 4th category, thin single-use plastic bags are better targeted through initiatives like the minimum carrier bag.

Plastic becomes harder to recycle as you go down the list. Mainly, because it is not economical or environmentally effective to recycle some forms of plastic and accepting them all without distinction can make recycling efforts much more difficult for the other types of plastic too.

For example, plastic films, plastic wrapping, and thin plastic bags run the risk of clogging processing machinery if they are collected along with larger, heavier, and more rigid recyclable plastics such as PVC. which is why it is important not to put them in plastic recycling bins unless you know they are acceptable. And target them through reduction strategies if they cannot be reused.

Some of the other symbols which can also be present on different products. such as the green dot, the wheeled bin and the FSC logo symbols.

2. The Green dot Symbol

The green dot, which represents two arrows looping into one another, is mostly used as a reference for consumers that the manufacturer contributed resources towards package recycling at some point.

3. The Wheeled Bin Symbol

the wheeled bin symbol indicates that the product cannot go in a normal waste or recycling bin, most likely because it is electrical or hazardous.

4. the Forest Stewardship Council (FSC) logo

We also have the Forest Stewardship Council logo identifies the product as wood-based from well-managed forests in accordance with FSC rules and regulations.

Figure 4 - Example of the usage of the FSC logo.

This resembles a brief of product labels which relate to our managerial needs. Keep in mind that These labels help us identify different opportunities for handling the waste their products generate, thus contributing to our waste management plan.

Waste Management Plans for Facilities.

The design of waste management plans as well as carrying out assessments carries out huge significance in ensuring the correct implementation of the guidelines we have established during the previous chapters. This chapter will tackle the design and assessment for facilities waste management plans and is divided into two sub-section.

DESIGN

The design of the waste management plans for facilities mainly focuses on the generation, collection and storage of waste which was covered in section 4.1.

In this Section, we will put each of these stages into implementation and show you how you can utilize them to design your own waste management plan. Beginning with major requirements for your waste management plan and moving into the administrative steps to design it.

Before designing our plan, there are certain parameters which we need to identify in order to help us manage the waste and recycling needs of our facility. these are 7 parameters, which should help make our design adaptive to the region we are implementing it in as regulations, infrastructure and waste management services defer from region to region. They include:

1. Land use details.
   Identify land use details, including the facility's land and building specifications. This involves documentation of the land size, building's number of floors, operation of the facility (industrial, residential and commercial), as well as the number of units and their specification (apartments by size, stores, offices or production zones).
2. Waste systems.
   Define waste handling systems. Including the different technologies for handling waste, would they be mandatory or not. This could include chutes, compactors (which help compress waste to smaller sizes and are mostly used when waste volumes are in excess of 25000 liters per week), and similarly, glass crushers, automated waste management systems, and onsite food processing systems.
3. Collection frequency.
   Identify collection frequency, from the facility's end, and include schedules for collection by the respective municipality, or collection service provider.
4. Collection location and bin storage.
   Design collection location and bin storage, through identifying the location of level 1, 2, and 3 collection spots throughout the facility. This is always based on the major locations for waste generation with relevance to different types of waste.

5. Waste management drawings.

    Drawing Up to Scale waste management designs by overlaying schematics of preliminary waste handling plans over building blueprints. This is meant to show the path that the waste would travel throughout the facility's levels of waste handling.

6. Collection contractors.

    Define waste contractors which are represented by municipal waste handling services in most countries. This is done by identifying the service provider's capacity, scope of operations as well as the present options for waste processing and set the goals for recycling and reuse.

Now, after finishing the initial screening for our design, we begin the design for our plan by following the below eight steps. Following these steps will help to accelerate **your work**, this is what you will need to do:

1. Determine type and volume of recycling and garbage that will be generated onsite.
   This is done by creating tables that define the following (type of waste, source of generation, quantity, and finally processing and handling requirements depending on its type).

2. Determine reduction, reuse and recycling opportunities and targets.
   this begins by substituting materials purchased where processing generates lower waste volumes as well as Instituting procurement measures that recognize opportunities to return usable materials such as containers and packaging material. This process involves researching possible options for reuse of items either internally through the facility or external. Then identify recycling opportunities depending on availability of services and manufacturer specifications. This ends with documenting data in tables which contain waste type and quantities, in addition to their reduction, reuse and recycling opportunities.

3. Calculate the number and type of containers required.

   Your WMP must include the number of bins and their sizes. It is preferred to collect larger bins at level 3. as this decreases the number of bins to be stored or collected and reduces truck movements and the time taken for collection.
   This is usually carried out by using benchmarks for outputted waste from different industries such as the benchmarks shown in the table.

   For example, suppose we have a restaurant, it is safe to build the baseline for our level 3 waste storage around 860 liters (representing 660 mixed and 200 recyclable) and then move on to breaking down each type into its source of generation.
   From there we move down to level 2 collection bin sizes depending on the zones we have, and these would range from 120l to 200l for a commercial facility and could go

up to 500 l for an industrial facility. As for level 1 collection, we usually focus on the types of waste generated from the station itself and these translate into 20-60 liter bins for commercial facilities.

Outlet type	Garbage	Recycling
Retail (non-food)	50L/100 m² floor area/day	50L/100 m² floor area/day
Restaurant	660L/100 m² floor area/day	200L/100 m² floor area/day
Supermarket	660L/100 m² floor area/day	240L/100 m² floor area/day
Café	300L/100 m² floor area/day	200L/100 m² floor area/day
Take-away / café (pre-packaged food only)	150L/100 m² floor area/day	150L/100 m² floor area/day
Office	10L/100 m² floor area/day	10L/100 m² floor area/day
Education	1.5L/student/day	0.5L/student/day
Religious/social	50L/100 m² floor area/day	10L/100 m² floor area/day
Serviced apartment	35L/apartment/week	35L/apartment/week

Table 2 – waste generation baseline for a number of residential commercial facilities.

4. Calculate level 3 and level 2 collection and storage space required.

   In Calculating the space for level 3 collection and storage. we use the following equation:

$$Collection\ Space = N_{Containors} \times A_{containor} \times f_{maneuver}$$

   $N_{Containors}$: Number of containers.

   $A_{containor}$: Individual container footprint.

   $f_{maneuver}$: Maneuver factor, and represents the space required to move the containers inside the storage zone and is between (2-2.25).

   Example: if we have 6 containers for our facility and a 3*1m footprint for each, and a limited space so we utilize a maneuvering factor of 2, we are left with needing a level 3 collection area of 36 square meters.

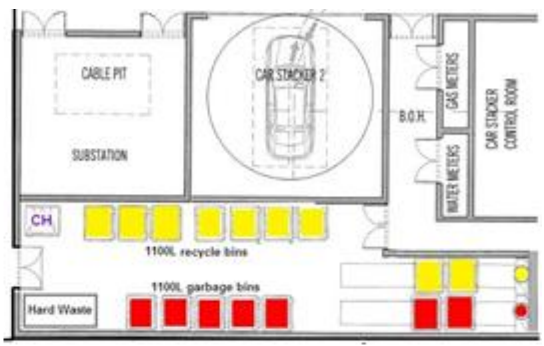


Figure 6 – Level 3 collection area design.

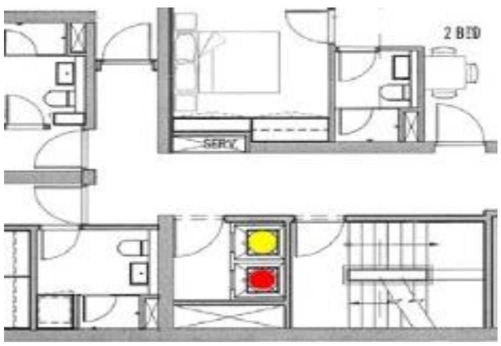
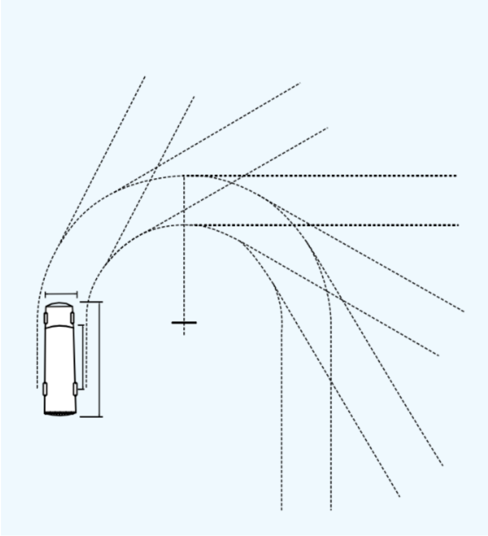


Figure 5 – Level 2 collection area.

   The figures above respectively show a level 3 collection layout situated in the service level, alongside the parking lot and service meters, and a level 2 collection space for a residential building with adequate separation from other areas.

5. Determine access route for collection vehicles and turning radius.



Using your municipal or waste collection service provider's guidelines which should be included in the plan. You should Design entry and exit scenarios for an easy and proper access and loading environment for the waste, and this depends on the facility's activities and the dimensions of the collection vehicle.

For example, a facility with considerable customer interaction should consider concealing the loading and waste storage access points from the entrance. Additionally, the route design should be conducted as seen in the picture. As we said utilizing the available access points and the proper loading and storage location for each facility and waste.

6. Designate collection/loading area.

   Choose final location and bin allocations for the level 3 collection area. taking into consideration its loading capability for our waste handling service's collection trucks.

7. Develop and submit a waste management overlay plan while keeping in mind that it contains the following from previous steps:
   a. generic floor schematics showing garbage and recycling disposal points.
   b. waste infrastructure and storage areas including any chutes, carousels, compactors, bins, bin lifters, hard waste, charity bins and green waste areas.
   c. a Clear diagram of movement of each material from disposal, storage and collection points including any gradient/slope or stairs.
   d. bin presentation location (on-street or on-site) with bin alignment shown for each individual bin showing size and material type
   e. Swept path diagrams illustrating sufficient access to collection points for all vehicles required to collect from the facility.
   f. You should finally keep in mind to check different requirements mentioned in section 4 regarding including the policies enforced in your area and taking them into account.

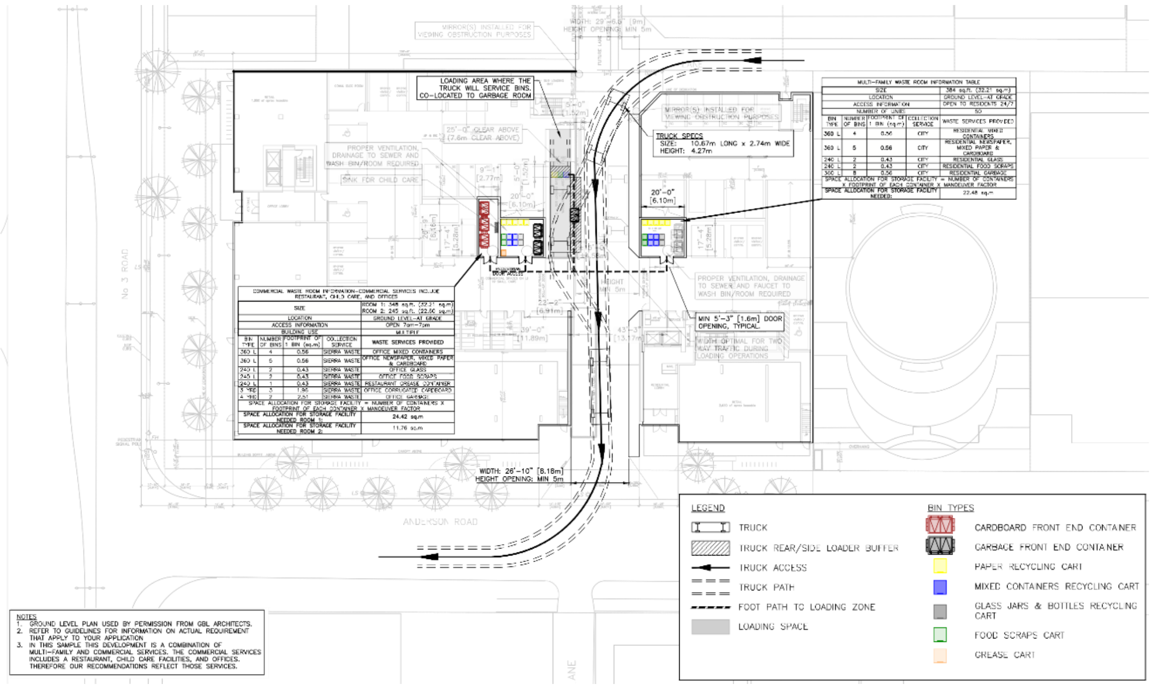


Figure 7 – example of roadside waste loading and collection design for a facility.

ASSESSMENT

waste assessment usually begins with assessment visits and reporting to the facility in focus. These preliminary assessments should utilize checklists that are meant to navigate through the official assessment plan which will be demonstrated in this section.

You should Keep in mind that checklists such as the one in the box, are built on the BEMP introduced in chapter 4 as well as the design guidelines seen in this the previous section. However, their content differs depending on the relevance of their different items for each specific region or application.

The assessment approach which will be proposed in this course relies on four key areas of assessment, which are:

Area 1: Compliance Assessment

Area 2: Assessment of Targets

Area 3: Viability Assessment

Area 4: Credibility Assessment

***Example** of what we usually look for in preliminary assessments are:*

- *Definition of type, source and quantities of municipal waste generated.*
- *Presence of a well-defined waste management hierarchy*
- *Existence and identification of hazardous waste on site*
- *Existing waste collection schemes*
- *Readiness for new future waste streams*

each of these areas for assessment will be demonstrated in the following sections.

Compliance Assessment

This section will introduce you to the Compliance check and the coherence check.

1) Compliance Check

in a compliance check we are looking to identify gaps between your existing control environment and what is required. We identify gaps and presence of definition, type and source of the following: municipal waste generated / waste amounts / future waste streams/ existing waste collection schemes / major disposal and recovery installations / waste shipments / special arrangements / assessment of the need for new collection schemes / additional waste handling infrastructure / capacity of future disposal and major recovery installations / location criteria for site identification / closure of existing waste installations / description of waste policies / planned waste management technologies or methods / policies for waste posing specific management problems and finally self-reporting of evaluation of WMP implementation.

2) Level coherence

Level coherence checks are well organized and purposefully designed to facilitate waste management without the need for modification or repetition. the term refers to the alignment of the WMP across all departments and areas of implementation.

In case waste management planning is carried out at different administrative levels (large facilities), What we look at in the coherence check include General waste management policies , strategy / type, quantity and source of waste, estimation of waste amounts, developments and forecasts / existing waste collection schemes and assessment of new collection schemes / major disposal and recovery installations / planning for additional waste infrastructure (including capacity planning) / closure of existing installations / location criteria for site identification / shipments of waste / special arrangements (at least for waste oils and hazardous waste) / coverage of the relevant waste streams at different administrative levels: municipal waste, packaging waste, biodegradable waste, hazardous waste, batteries and accumulators.

Assessment of Targets

We then move on into the second stage which is the assessment of targets, in this phase we look to identify the targets set in the waste management plan for reduction or waste prevention, as well as reuse, recycling and output to dumpsites. These targets can be additionally divided into their respective environmental, economic, and societal impacts while prioritizing one over the other, depending on the main goal of the assessment.

Assessment of targets takes into account 11 areas of assessment, which are: separate collection / preparing for re-use and recycling of municipal waste / pre- treatment of municipal waste before handling / packaging waste / construction and demolition waste / biodegradable waste / WEEE / batteries and accumulators / waste oils / hazardous waste / ELVs as well as other targets specifically mentioned in the WMP.

Viability Assessment

We look into the viability of each WMP being assessed in order to address any issues or areas which lack management and monitoring. Generally, viability assessments involve reviewing general information of the WMP, waste streams and policy instruments.

1) General information

What we mean by reviewing general information is that we evaluate whether the following basic information on the WMP are mentioned or not. These are: application period and legal adoption / review period / competent authority for drafting WMP as well as the competent authority for implementing WMP.

2) Waste streams

Through this criterion, we evaluate whether information on relevant waste streams is included or not:

a. For Municipal waste we review:
   1) the definition, type and source of municipal waste generated.
   2) waste amounts.
   3) trends in waste increase over last years.
b. As for All other waste streams including (packaging waste, biodegradable waste, hazardous waste, batteries /accumulators, waste oils, End of life vehicles, construction waste, industrial waste). They should be separately assessed, but share the same items mentioned a.1.

3) Policy instruments assessment

involves defining whether sufficient information on applied and planned policy instruments is included and documented or not. This includes identification of set of instruments (environmental, economic, and legal instruments which represent policies and regulations enforced in the area of operations) as well as the evaluation of usefulness and suitability of these instruments to the WMP.

Credibility Assessment

Our last area for assessing WMPs is the credibility assessment, which look at the credibility of the assumptions made, and targets set in the plan itself. In doing this we look into the waste model, the robustness of data, the inner logic of data and the waste prevention plan.

1) Waste model

Beginning with the waste model, this is done by conducting Comparisons between anticipated treatment infrastructure and targets as included in the WMP with a given benchmark such as the European Waste Modelling Tool on Waste Generation and Management scenarios or the US EPA's estimations for waste generation and relevant impacts.

2) Robustness

Evaluating the robustness gives us an idea whether the WMP includes sufficient information on data sources and how assumptions were made. This includes: timeliness of data on municipal waste generation / time-lines for waste generation / primary data and information sources on municipal waste generation and data and information sources for status-quo of waste collection and treatment facilities.

3) Inner logic

In this we evaluate whether conclusions (recommendations) and the future planning as laid down in the WMP are consistent and coherent with the data we mentioned in our robustness assessment. In doing the inner logic assessment we focus on: waste data / identification of main problems in connection with waste data provided in the WMP as well as the measures we propose to address these problems.

4) waste prevention plan

We conduct specific evaluation of the coherence of the waste prevention plan in the WMP by measuring Consistency of baseline data and indicators with quantitative data collected through the waste management operations. Basically, comparing between data of waste without management with the data of waste managed before and after prevention policies.

After establishing how each are of assessment is carried out, we combine the outputs to form the final shape of the overall assessment for a given WMP, as seen in the figure below.

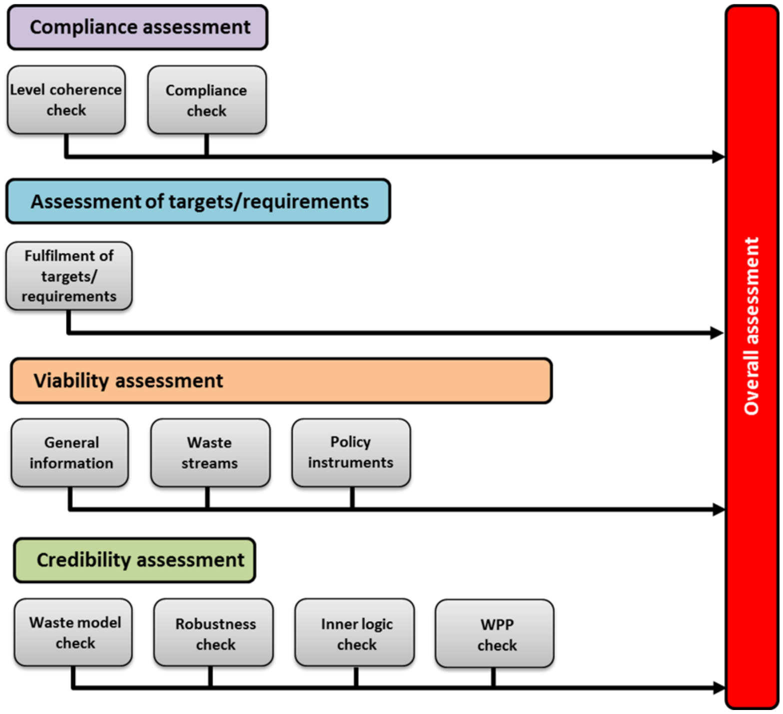


Figure 8 – areas and criteria for assessment of WMPs.

We begin by assigning marks for each criteria of assessment, representing the coherence check, compliance check, quality of targets, general information, waste streams, policy instruments ‹waste model, robustness, inner logic and waste prevention plan.

we then add each mark to make up the overall mark of each area of assessment representing. Compliance, targets, viability, and credibility. For the overall rating of the WMP, the final marks of each area provide a reference to the following approach to assess the result of the assessment. And the results must be categorized as follows:

- Substandard. If it does not pass the compliance assessment
- Adequate. If it passes only the compliance assessment it is considered adequate.
- Satisfactory, Good or Exceptional. passes all for areas mentioned before, relative to its score.

Municipal Waste Management

back in section 4.2 we discovered how transport, treatment and disposal of waste begin where normal facility waste management operations end. Additionally, chapter 6 introduced facility waste management plan design and assessment, it is most appropriate to continue into introducing municipal solid waste is management through waste handling service providers.

As it was previously demonstrated through this text, municipal waste management hierarchy is mostly based on 4 key levels. These levels are:

Level 1: Collection.
Level 2: Distribution.
Level 3: Treatment.
Level 4: Disposal.

The 4 sections of this chapter will introduce you to the core principles governing each of these four levels.

LEVEL 1: COLLECTION AND COLLECTION CENTERS.

The process of waste collection begins when the generated waste is thrown into appropriate containers and ends when they are picked up and emptied by collection vehicles. A collection system is therefore defined as a combination of technology and human activities and is characterized by:

- The equipment used for collection (such as collection vehicles).
- The applied method of identifying them and picking them up.

The collection stage includes the collection of all household, industrial, and commercial waste including the collection of recyclable waste separated at the source whenever possible and the picking up of these wastes from the place of their collection.

The stage of waste collection and transportation plays a central but often underestimated role in the waste management system. After all, it accounts for 60 - 80% of the total cost of waste disposal and thus any improvement in its organization and implementation would result in considerable savings.

An efficient and optimal implementation and organization of waste collection must take the following factors into account: dimension of the collection area, its structural, economic and social settings, area specific legislation and laws, user demand, and the combination of appropriate collection systems and technology.

As for Methods for picking up waste There are three different methods used to pick up the waste:

1. simple container emptying
2. container exchange
3. one-way loading

Additionally, a non-systematic collection can be performed for picking up bulky waste and other items such as furniture and hazardous materials.

Each collection method has compatible or dedicated container systems and vehicles with the appropriate loading technology and crew arrangement.

1. Simple container emptying is primarily used for the pick-up of household and small quantities of commercial waste and uses a variety of standardized containers. The content of the container is emptied mechanically into the collection vehicle and then the container is returned for refill.
2. Container exchange is suitable for waste of high density, such as construction and development waste, as well as for low-density waste from sources that generate large quantities of waste, such as manufacturing or industrial sites, hotels, offices, or multi-story buildings. In this method, full containers are exchanged with identical but empty containers at their place of installation. The full containers are taken along and emptied at a treatment facility and can then be used elsewhere. For economic reasons, these containers (which could include roll-off container or a skip container system) have generally larger capacities but can be carried by multiple vehicles.
3. One-way method is where waste is picked up lose or in containment such as bags or sacks which get disposed of together with the waste. The collection process is rather easy because there are no emptied containers to be returned and the containment vessel don't need to be cleaned. However, to get these containment bags into the collection trucks usually involves much of manual work which places considerable physical demands on the collection personnel. Because of this and due to limited strength of the material, quite small volumes can be collected with these enclosures while become waste themselves.

LEVEL 2: DISTRIBUTION CENTERS

The transportation (distribution) stage includes the transportation of the collected waste to processing and disposal facilities including the necessary transfers or intermediate storage.

After the collection and pickup, the waste materials need to be transported to the facilities for waste treatment and disposal. This could entail transportation over short or long distances. For transportation over short distances the same vehicles that picked up the waste should be used. Keep in mind that for you to use these vehicles also for the long-distance transportation is not economical since they are optimized for the pick-up processes and do have rather limited loading capacities and usually additional personnel on board. For long distance we recommend building distribution centers to help systemize waste transfer in bulk.

Different technologies for distribution of waste after collection fall under two categories, they are:

1. Fixed body transportation

This involves Waste transportation in fixed bodies using long- distance transporters and it starts with open loading the waste into the container by means of conventional loading equipment such as wheel loaders, cranes or over a dumping ramp.

For a waste transfer station, it is recommended to transport certain wastes in a compressed state through large semitrailer trucks with a closed body. How is this done? At the waste transfer site, these trucks are loaded with the waste which then gets compacted inside the body with the help of stationary compactors or thru a compacting mechanism integrated into the semitrailer itself.

Figure 9 – fixed body waste transport.

2. Swap body transportation

The second technology is the swap body transportation which represents the best way to avoid emissions during the reloading and transportation processes. The advantage of this system lies in the exchange of full container bodies against empty ones as the only operation during the reloading. For a number of systems, there is even no need for additional reloading equipment such as cranes.

Figure 10 – swap body waste transport.

LEVEL 3: TREATMENT

Waste consists of many different materials and disposal to landfills would mean a loss of certain valuable resources as well as a number of negative impacts (in the form of land and material resources as previously mentioned through the course) and this is where waste treatment comes in. and we do it to the point where practical limits prevent any further feasibility. Treatment operations allow us to make use of operations such as material and energy recovery and shall be applied with landfilling always being the last option of disposal.

Treatment operations are basically aimed at diverting the different recyclable materials that are still contained in the residual waste. Through treatment we are meant to process waste in a way that allows us to recycle them and best utilize their material, material properties and/or energy content. Further goals of the treatment are the discharge, demobilization or even destruction of potentially harmful substances from the residual waste stream, as well as the reduction of the volume of the waste stream expected for final disposal and finally the stabilization of the waste before it is discharged to landfills.

Treatment operations are generally categorized into three categories, they are:

1. waste processing / material recovery,
2. waste pretreatment / stabilization
3. waste incineration /industrial co-combustion.

The following sub sections will briefly introduce the prominent characteristics defining each of the three categories.

1. Waste processing/Material recovery

Waste processing includes sorting, recycling, and composting. Recycling and the utilization of waste material are key elements towards waste minimization as an essential goal of waste management. Within this, direct material recycling takes a high preference. On the other hand, sorting can be done right on the spot where the waste is generated. The biggest benefit of sorting from the source is by reducing municipal operational costs in sorting after collection and this can be incentivized through tax reductions for facilities. Finally composting provides a great opportunity for utilizing organic content which has many impacts on the environment as well as accompanying costs of transportation, and volume of wastes handled.

2. Waste pre-treatment/stabilization

This category includes the different processes meant to reduce the toxicity of different wastes and the benefiting of some of their resources. An example of this is thud solidification of liquid hazardous materials.

3. Incineration/Industrial co-combustion.

Incineration is considered the most effective and reliable option for the management of nonrecyclable waste, and its processes utilize industrial outputs to obtain energy from the waste. It also acts as a way of reducing impacts of the waste itself. An example of this is thermal waste treatment through incinerators with energy recovery and heat extraction.

LEVEL 3: DISPOSAL

The traditional and widespread practice of waste disposal in landfills is more and more replaced by advanced waste treatment processes. Introduction of energy recovery from the waste materials, the segregation of recyclables and the reduced volume of solid waste that must be deposited have incentivized lower waste to landfill approaches. The move away from landfilling is a necessary step for sustainable waste management but requires a consequent thinking in material loops and strict legal enforcement.

Even if wastes will increasingly be utilized and treated in a way that very little remains from them as non-usable residues, landfills are and for further decades, will remain the last resort for an ultimate disposal of waste and waste residues in an environmentally safe and controllable manner.

In order for this to be achieved, three different categories of landfills are prescribed as the standard for many municipal waste management plans, they are:

– Category 1: Landfills for non-hazardous waste.

– Category 2: Landfills for inert waste.

– Category 3: Landfills for hazardous waste.

1. The first category is the landfill for non-hazardous wastes like mixed domestic and commercial waste without higher concentrations of environmentally harmful or hazardous substances. This landfill category is the most extensively used method for the deposition of the residuals, which remain after the treatment of household and commercial wastes. It should be considered that a pre-treatment of materials, especially of the organic fraction, cannot eliminate the generation of greenhouse gases in the landfill body. It is for these reasons that landfills must be created with the necessary precautions and equipment to collect and treat these emissions and prevent hazardous substances from penetrating into the soil and aquifers.
2. The second landfill category is landfill for inert wastes. This kind of landfill has been defined as a place where mineral wastes or waste of completely inert character are deposited. As such, facilities use these landfills especially for the disposal or storage of excavated soil, mining material and C&D waste of inert nature (stone, concrete, sand and mixtures of it).
3. The third category is the landfill for hazardous wastes. This landfill type is exclusively reserved for waste material which carries a potential risk or contains substances which can be harmful for the environment. For these reasons special protection and aftercare measures must be imposed for the establishment and operation of such landfills. Generally, landfills intended for hazardous wastes must be engineered with dual liners and related containment systems to protect the land and groundwater.

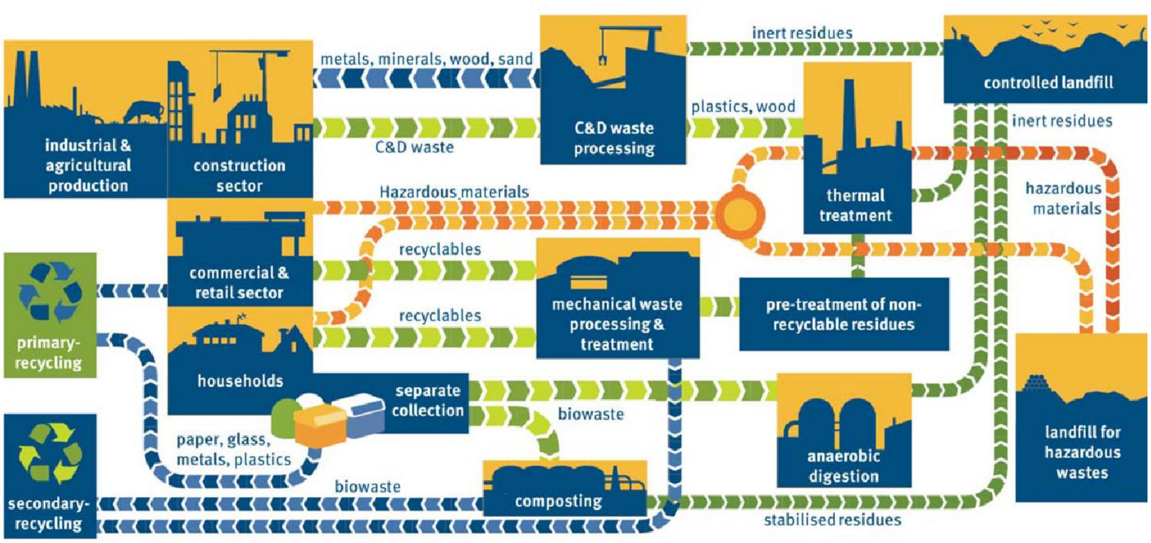


Figure 11 – municipal waste life cycle.

Environmental Management Regulation

Environmental externalities refer to the economic concept of uncompensated environmental effects of production and consumption that affect consumer utility and enterprise cost outside the market mechanism.

As a consequence of negative externalities, private costs of production tend to be lower than its "social" cost. It is the aim of the "polluter/user-pays" principle to prompt households and enterprises to internalize externalities in their plans and budgets.

Usually Targets and regulations are either fixed through standards provided through legislative frameworks (such as in the European Union) or by the national law but they can also be determined by the strategic planners and decision-makers of a company. And in this process is where governments and international regulators come in.

Their contributions help us account for externalities and adopt environmental guidelines for waste management. In this lesson we will give a brief about two examples for entities which's work revolve around defining and regulating the waste management field. In specific, we will investigate the government's role as well as the work that the International Standardization Organization does for environmental management.

GOVERNMENT INSTITUTIONS AND WASTE MANAGEMENT

To begin with, the governmental roles which are involved in waste management for each country can be distributed across three levels: local government, government agencies, and national government.

Local Governments

Local governments must provide waste management services, which include waste removal, storage, and disposal services. This is mostly done through Municipalities which must work with industry and other stakeholders to extend recycling at municipal level. Municipalities must provide additional bins for separation at-source and are responsible for diverting organic waste from landfill and composting it.

As for regulation, municipalities may set local waste service standards for waste separation, compacting, management and disposal of solid waste, amongst others.

Government Agencies

Government Agencies, mostly represented by an environmental protection agency and are the primary regulatory authority for waste activities, except for activities for which the national authority must approve. It must promote and ensure the implementation of the national norms and standards. Their powers include setting provincial norms and standards, declaring a priority waste, listing of waste management activities, registering waste transporters, requesting the preparation of industry waste management plans and identifying contaminated land.

National Governments

National governments are mostly represented by the ministry of specialty and are ultimately responsible for ensuring that the national Waste plans are implemented and that the various local government bodies are operating in the most appropriate and effective way. In terms of mandatory provisions, among many things, they are responsible for:

- Establishing the National Waste Management Strategy.
- Setting national norms and standards.
- Establishing and maintaining a National Contaminated Land Register.
- Establishing and maintaining a National Waste Information System.
- Preparing and implementing a National Integrated Waste Management Plan.

INTERNATIONAL STANDERDIZATION

The most prominent body that operates in the waste management policy creation is the ISO (International Organization for Standardization). Additionally, it overseas the accreditation of multiple organizations that operate in the fields of environmental and waste management. Its purpose is to facilitate and support national and international trade and commerce by developing standards that people everywhere would recognize and respect. ISO achieves this purpose through the participation and support of its members from 164 national standards bodies.

Consequently, these standards tend to have worldwide support. And for the purpose of this course, we will focus on the ISO 14000 family. The ISO 14000 family of standards are developed by ISO Technical Committee ISO/TC 207. In this family we have the ISO 14001 which provides requirements and guidance for environmental systems. Other standards in the family focus on specific approaches such as audits, communications, labelling and life cycle analysis, as well as environmental challenges such as climate change.

The main purpose of ISO 14001 is to define the requirements for the Environmental Management Systems and provides guidance for its implementation. Key elements of this standard include:

- Environmental policy
- Planning
- Implementation and Operation

- Checking and Corrective Action Management review

The main outcome of Implementing the ISO 14001 is that it provides a systematic way for controlling the environmental impact of a facility. It also provides the structure for an organization to attain a very good level of environmental performance that shows the complete commitment of an organization in controlling the impact of waste, pollution and energy consumption.

The other key benefits of implementing ISO 14001 include:

- Cost Savings, due to increased environmental efficiency.
- Cutback of environmental responsibilities.
- Cutback of environmental risk.
- Increased organization ability to compete in the global marketplace.

There are many other entities which have programs which can help you assess, and develop your waste management plans and operations, including the Green Building Council, EDGE and other international regulatory organizations.

Waste Management Economics

This Chapter will introduce you to waste management economics and its components. Through it well display the different economic benefits which can be realized through the management of waste.

CIRCULAR ECONOMY

In order to better understand the workings of environmental and waste economics, we will begin by introducing the concept of circular economy. Circular economy basically resembles an approach that identifies everything as healthy food for something else, the same way nature runs itself. plants use carbon dioxide and nutrients to grow and produce oxygen. while Animals use oxygen and create CO_2 and nutrients. Nothing is wasted in this closed loop system.

Circular economy is usually opposed to linear economy which we have been running for many years and involves taking in inputs for processes and disposing of the outputs without acquiring any of their potential.

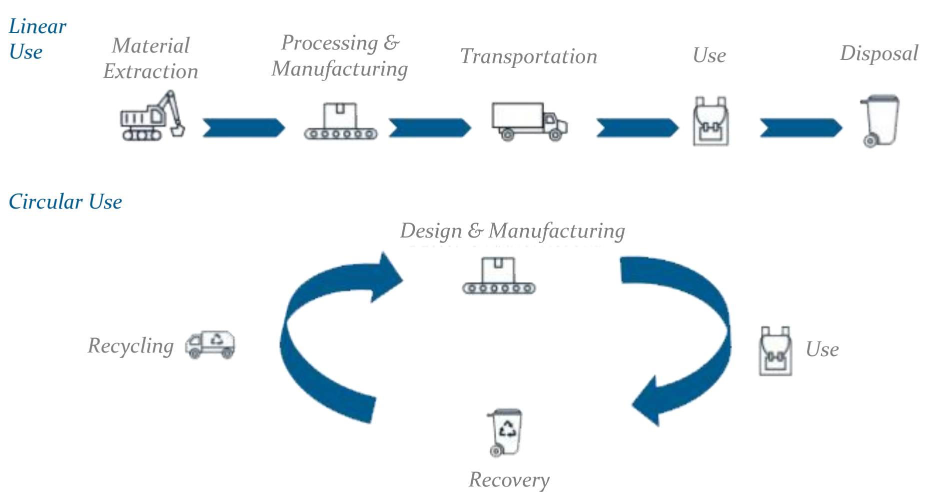


Figure 12 – Linear and circular material cycles.

Putting circular economy into perspective to sustainability and waste management. It handles economy as part of society, which is part of the environment, inside a closed ecosystem where the three influence each other. As you can see in the figure below.

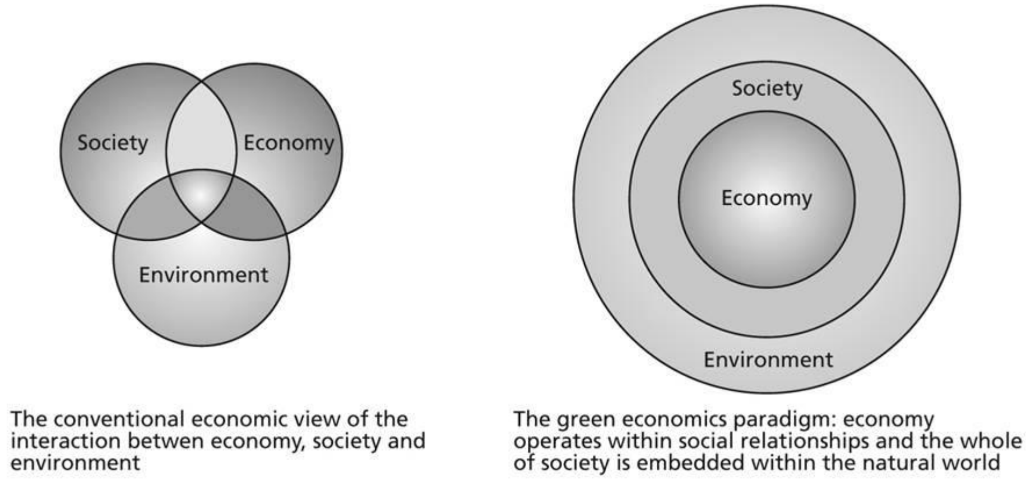


Figure 13 - green economy paradigm.

With respect to waste management, we can divide material treated inside the circular economy into two categories: technical and biological.

1. Technical materials are cycled like this (raw material is mined, product is manufactured and then it is used until the end of its life. And this is where the importance of waste management comes in as seen throughout the previous lessons in this course). For example, it is best to mine copper that is not used anymore (post-consumer copper) as opposed to mining new material from the ground, since copper is predicted to be mined out by 2040 and processing recycled copper takes 10-20 percent the energy it takes to process copper ore.

2. Biological materials (farmed or collected to be processed and transported before being consumed. This cycle is completed by introducing biogas or biochemical extraction and composting operations to the consumed biological resources. Thus, making our output a healthy food for something else)

In this regard Circular economy and therefor waste management economics utilize two characteristics which are substitution and dematerialization.

- Substitution: using different resources to achieve the same goal.

- Dematerialization: using less of a resource to serve the same economic function in a society.

Finally, our utilization of Circular Economy will be based on its advantage to promote sustainable benefits throughout our activities as represents an integral part of sustainability alongside sustainable agriculture, energy and waste management.

SUPPLY AND DEMAND

The law of supply and demand is a theory that explains the interaction between the sellers of a resource and the buyers for that resource. The theory defines the relationship between the price of a given good or product and the willingness of people to either buy or sell it. Generally, as price increases people are willing to supply more and demand less and vice versa when the price falls.

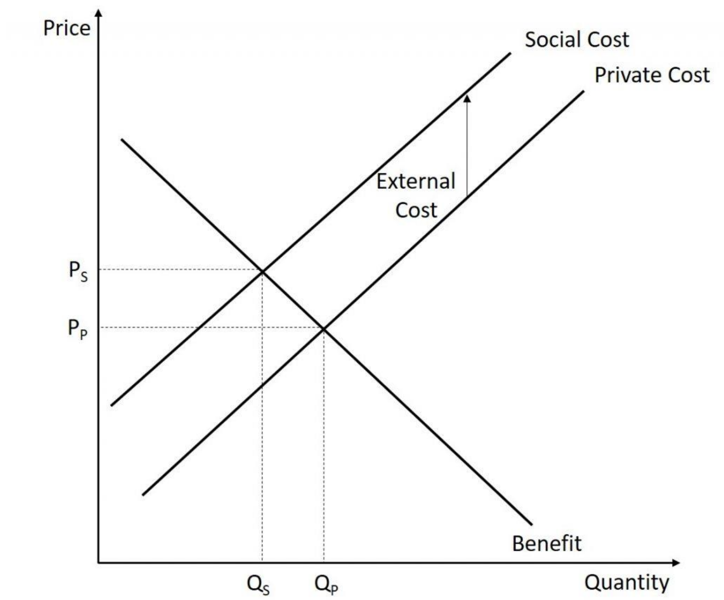


Figure 14 - Supply and demand curves adapted to externalities.

The environmental approach to supply and demand means that the price set for manufacturing a certain product is way too cheap as it does not take into account what we call externalities which push the supply curve in that direction, the difference between both curves represents the economic and environmental advantage acquired from adopting sustainable approaches.

In some countries, externalities represent a way of benefiting from waste management's reduction reuse and recycling approaches as this introduces new sources for different types of materials in addition to reduction in different taxes which relate to extended producer responsibility.

Another area of economic benefit comes in the form of using the outputs of different wastes as we shown you in the technical and biological waste examples. Examples are free, so Let give another example.

For municipalities or waste handling service providers, they can benefit from sorting technical wastes and selling raw materials and sorted wastes such as plastic, electronics and batteries. They can also benefit from composting biological waste and generating electricity from its methane output and sell it to the electric utility company.

As for facilities they can most noticeably benefit from modifying operations to reduce material consumption and modify purchase to ones which can be reused more. And if they generate adequate amounts of waste that can be recycled or traded.

Waste management economics has been growingly adopting the concepts of environmental economies and circular economy given that they provide a great approach towards what sustainable waste management target to achieve as well as the sustainable return it provides in operations ranging from industrial to residential.

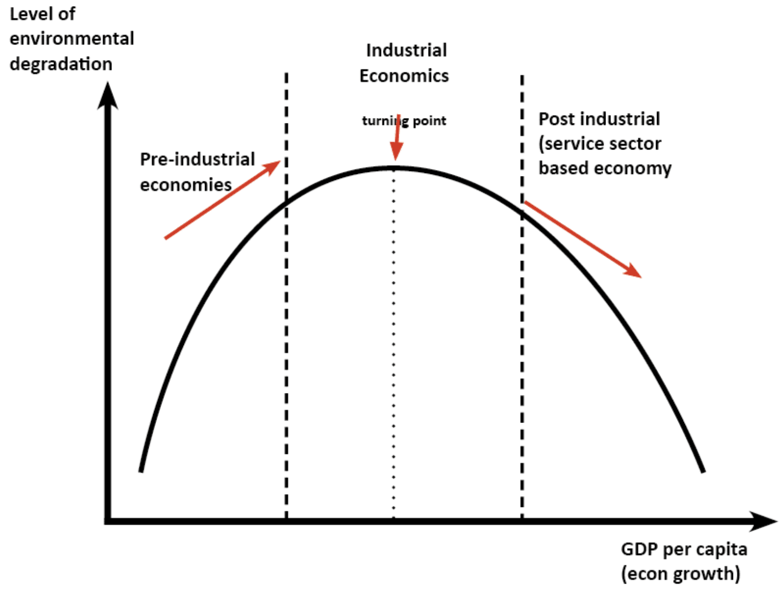


Figure 15 – Kuznets curve.

The figure above shows Kuznets curve, which describes the relation between environmental impact and the per capita income. This curve simplifies economical observations which show that as a country is developing. their environmental negative impact rises until they start noticing these effects and reach a capacity to introduce limitations and incentives to reduce the impacts. After that tipping point, they continue growing their economy, but while decreasing their environmental footprint.

Remarks

Waste management represents a constantly changing field that is shaped by constantly changing technologies and approaches which rely on the many increasing regulations, requirements and benefits that surround waste generation and management. These could range from reduction of pollutants, risks on wildlife, or human discomfort and could extend all the way to building a whole business models around the financial benefits of the different resources that different types of wastes hold.

Waste Management Systems which utilize sustainable designs represent the best method to realize the biggest impacts through daily operations both on the long term and short term, as shown throughout this text.

This text is meant to act as a gateway for future professionals from different disciplines which work might involve waste management (handling) activities. Additionally, it can be used for training and retraining staff on the different policies that could be adopted by an organization, as well as the design of a facility waste management plan from scratch.

Finally, we recommend that you constantly stay updated on the different approaches and technologies being pushed by different entities (private, public and social), as the field of waste management is in constant motion and is yet to reach its full potential.

Moving forward, you are highly recommended to pursue and follow other resources of waste management systems, in order to gain wider knowledge on the different technologies which you can adopt through you work. A great way for you to start, would be to begin with some of the references included in this text.

Eng. Ameer Mubaslat

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