مـــوان MWAN
المركز الوطني لإدارة النفايات
National Center for Waste Management

الضوابط والأدلة الفنية
للمعالجة الميكانيكية-البيولوجية للنفايات

Technical Guidelines
Mechanical - Biological Treatment of Waste

17 August 2023

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LIST OF ACRONYMS

AD	Anaerobic Digestion
BAT	Best Available Technique
CV	Calorific Value
HDPE	High-Density Polyethylene
HRT	Hydraulic Retention Time
IR	Implementing Regulations
KSA	Kingdom of Saudi Arabia
MBT	Mechanical-Biological Treatment
MEWA	Ministry of Environment, Water and Agriculture
MRF	Material Recycling Facility
MSW	Municipal Solid Waste
MWAN/ The Centre	National Centre for Waste Management
NCEC	National Centre of Environmental Compliance
PPE	Personal Protective Equipment
TG	Technical Guideline
RDF	Refuse Derived Fuels
SRF	Solid Recovered Fuel
WML	Waste Management Law
WtE	Waste-to-Energy

DEFINITIONS

Biogas	Mixture of gases produced by anaerobic digestion
Bio-stabilized material	Residual biodegradable municipal waste that has been treated to achieve an approved biodegradability stability standard prior to landfilling or alternative use agreed
Biological waste treatments	Treatment processes that utilise microorganisms to decompose waste, specifically organic waste, into either water, carbon dioxide and simple inorganics or into simpler organics such as aldehydes and acids

Circular Economy	An economic model that aims at sustaining products and consumable sources for the longest period possible by way of consuming products to each product's maximum limit as long as it is usable, and to turn it recyclable and regeneratable thereafter upon the end of its lifecycle.
Competent Authority	The government entity responsible for operationally managing waste in accordance with a special regulatory provision.
Digestate	Nutrient-rich material left following anaerobic digestion
Digester	The tank in which anaerobic digestion takes place
Drainage	Natural or artificial removal of surface and subsurface water from an area, including surface streams and groundwater pathways.
Emission	The direct or indirect release of substances, vibrations, heat, or noise from individual or diffuse sources in the installation into the air, water, or land.
Feedstock	The material that is put into the treatment facility.
Hazardous Waste	Waste classified as hazardous based upon the provisions of the Law and Regulations, which is resulting from industrial or non-industrial activities that contain toxic, flammable, or reactive materials, or corrosives, solvents, degreasers, oils, colorants, paste residuals, acids, and alkalis.
The Minister	Minister of Environment, Water and Agriculture, and Chairman of the Board of Directors of the Centre.
Leachate	Solution obtained by leaching. The solution consists of liquid that, in passing through matter, extracts solutes, suspended solids or any other component of the material through which it has passed.
Inspectors	Persons designated by a decision of the Minister to take charge of detecting, proving, and investigating violations of the provisions of the Law and Regulation, jointly or individually.
Licence	A written permission issued by the Centre for the purpose of carrying out any activity related to waste management in accordance with the controls determined by Law and Regulations.
Mechanical biological treatment	Treatment of mixed solid waste combining mechanical treatment with biological treatment such as aerobic or anaerobic treatment
Mechanical process	A series of technological process with the purpose of the separation of the non-organic and organic fractions as well as the recovery of recyclable materials
Odour Management Plan	An odour management plan is part of the environmental management system (EMS) of the installation (facility) and includes elements to prevent or reduce odorous nuisances.
Permit	A document granted by the Centre to waste recycling facilities attesting that they fulfil the Centre's controls and requirements before they obtain the licences issued by the competent entities in accordance with their regulations.
Recovered Derived Fuel (RDF)	Fuel is produced from combustible components that the industry calls Municipal Solid Waste
Regulation	The Implementing Regulation of the Law.

Residues Management Plan	The residue management plan is a set of measures to optimize the production of residues generated by the treatment of waste, to optimize the reuse, regeneration, recycling and/or recovery of the residues and to establish the proper disposal of internal residues or waste.
Sensitive Receptors	Receptors that may be notably affected by the activity or the project due to its location being nearby or due to its sensitive nature, and these include without limitation: environmental components, living organisms, historical and cultural and religious sites, or social groups, such as endangered species, hospitals, retirement homes, schools, and residential compounds.
Solid Recovered Fuel (SRF)	Fuel produced by shredding and dehydrating solid waste with waste converter technology
Sorting	It means separating waste components from each other manually or automatically, such as paper, glass, metals, and setting aside other components in transfer stations or sorting and treatment facilities; with the intent of recycling or processing them.
Storage	Storing the waste components or some of them temporarily for transfer or later use.
Treatment	It means the use of physical, biological or chemical means, or a combination of these means, or others to bring about a change in the specifications of waste in order to reduce its volume, or facilitate the processes of treating it when reusing or recycling, or extracting some products from it or to remove organic pollutants and others in order to reduce or utilize some of the waste components or eliminate the possibility of harm to humans or the environment.
Waste	All materials that are discarded or disposed of, and that directly or indirectly affect public health or the environment.
Waste Management	Organizing any activity or practice related to waste commencing from waste collection, transportation, sorting, storage, treatment, recycling, import, export, and safe disposal, including aftercare at waste disposal sites.
Waste Producer	Every person who produces classified waste according to the provisions of the Law.
Waste Service Provider	The person licensed or authorized to engage in one of the Waste Management activities.

1 PURPOSE AND SCOPE

1.1 Purpose

This Technical Guideline (TG) sets out the information that will be used by the National Centre for Waste Management (or the Centre) to regulate and licence Mechanical-Biological Treatment (MBT) plants in the Kingdom of Saudi Arabia (KSA).

Therefore, this document is intended to provide a guideline for those involved in design, construction and, operation of MBT Plants, to:

- Identify and determine all requirements for developing different MBT Plants according to the international best practices and latest available technologies;
- Provide practice guidance on how to treat mixed waste through different MBT technologies in an environmentally-sound manner;
- Identify the key technical and management parameters that influence the performance of MBT plants, minimise potential environmental impacts as well as health and safety risks for worker and the general public.

Nevertheless, it is crucial to emphasize that while this technical guideline provides essential information, it does not serve as a comprehensive design manual for MBT plants. It is imperative to exercise sound judgement and employ the appropriate technical expertise when constructing MBT plants. This ensures that the facilities adhere to the principles outlines in this guideline and meet all the conditions specified in the licence issued by the centre.

All the sections of the TG are based in the Best Available Technologies (BAT) in waste management to ensure an up-to-date guidance for any related component with the Mechanical-Biological waste treatment.

1.2 Scope

The provisions of this document apply to Mechanical-Biological Treatment Plants. The main purpose of an MBT is to separate mixed waste streams, typically from MSW, into a range of dry products (typically ferrous and non-ferrous metals and glass), high calorific value Refuse Derived Fuels (RDF) suitable for incineration, and wet biodegradable slurries suitable for either Composting or Anaerobic Digestion (AD). These treatments involve a mechanical separation of the waste, biological treatment (anaerobic and/or aerobic treatment) of the organic fraction, and a further mechanical separation if required.

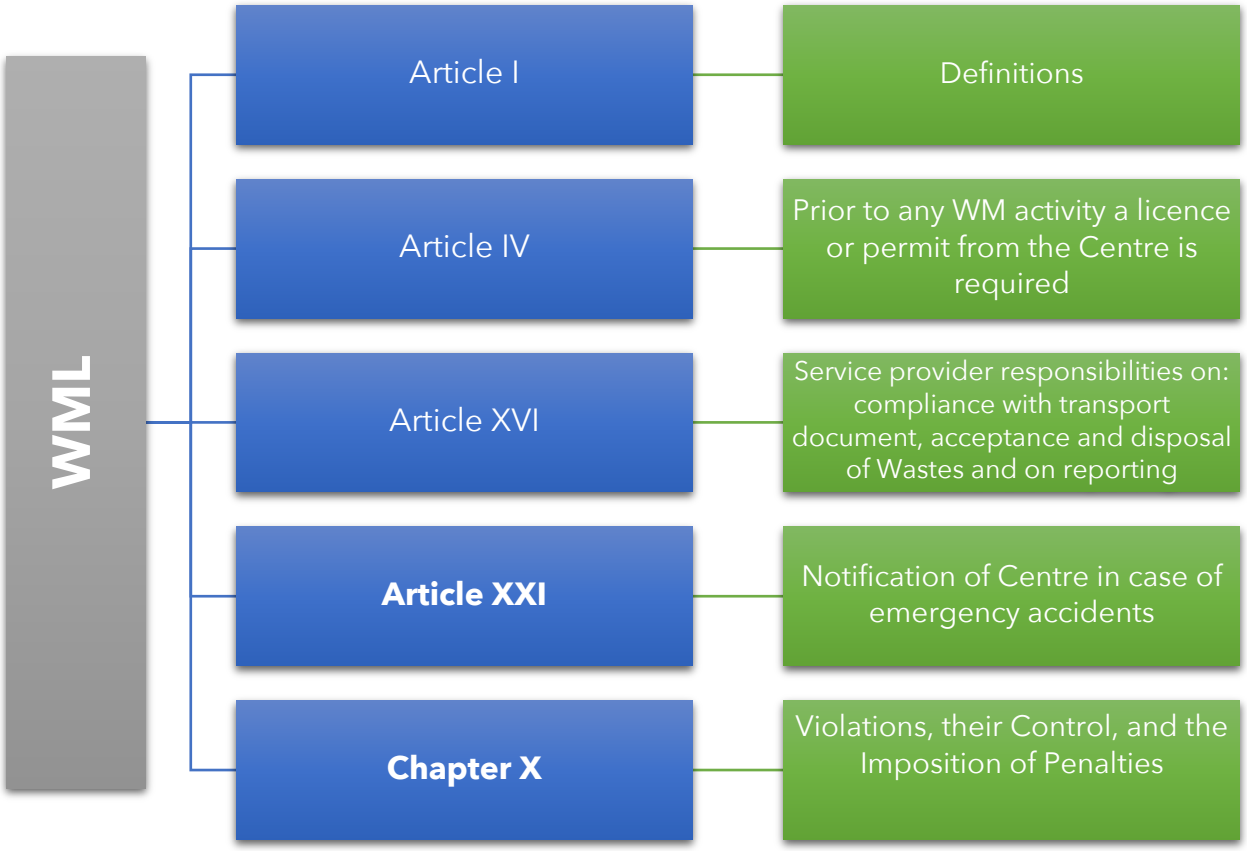
This Technical Guideline covers only specific techniques related to MBT. For specific information on biological waste treatment and mechanical waste treatment, in order to avoid duplication, cross references are made to the TG on Biological Waste Treatment and TG on Establishment and Operation of the Material Recovery Facilities.

The provisions of the present Technical Guideline address to all the Stakeholders for the design, construction, operation, monitoring and licencing of MBT waste facilities, namely:

- Ministry of Environment, Water and Agriculture (MEWA);
- The National Centre for Waste Management (MWAN/The Centre);
- Design and Construction companies involved in MBT projects; and
- MBT waste facilities facility operators (Service Providers).

2 LEGAL REQUIREMENTS

This TG for Mechanical-Biological Treatment of waste complements the information provided by the Waste Management Law (WML) and the corresponding Implementing Regulations (IR) so as to focus on the application of "best available techniques" and "best available practices" based on the local Saudi economic, environmental, and social context. Within this framework, users of this TG are advised to consult both the WML and the IR[1][2]. The main legal provisions on biological treatment of waste are highlighted in the following figures:



The terms used in this guidance document have the same meanings as in the Waste Management Law. Specifically, the term treatment, according to the WML, has the meaning of bringing about a change in the specifications of waste. These changes occur in order to:

- Reduce the volume of waste;
- Facilitate the processes of treating it when reusing or recycling, or extracting some products from it;
- Remove organic pollutants;
- Reduce or utilize some of the Waste components; or
- Eliminate the possibility of harm to humans or the environment.

[1] (Waste Management Law.Kingdom of Saudi Arabia, 2021)
[2] (The Implementing Regulations of the Waste Management Law, 2021)


IR
Chapter 2: Licensing and permits
Conditions, types and requirements
Issuance and renewal
Suspension of activity
Chapter 4 Waste Value Chain, Section Eight Waste Treatment
Site location Criteria
Selection of process and respective types of Wastes. Criteria for design, operation and maintenance
Health and safety of workers
Control and monitoring of emissions
Record-keeping and electronic registry of Wastes
Chapter 9
Waste Management Plans
Chapter 11
Inspection and Audit

3 ROLES AND RESPONSIBILITIES

The main organisations with responsibilities in Mechanical Biological Treatment of waste as defined in Section 1, include but not limited to: the Centre, the Ministry of Environment, Water and Agriculture, design and construction companies involved in MBT projects and Waste Service Providers (hereby only for treatment facilities). The key roles and responsibilities are detailed in the next paragraphs.

	Roles and Responsibilities
The Ministry of Environment, Water and Agriculture (MEWA)	▪ The sponsoring department in the government of KSA for MWAN, with overall responsibility for the environment and waste management; ▪ Policy maker for the sector; ▪ Set the overall direction for waste management.
The national Centre for Waste Management (MWAN) - The Centre	▪ Regulating the waste management sector: effectively to improve the quality of services across the entire value chain; ▪ Reducing waste disposal by stimulating the use of best practices of resource recovery techniques; ▪ Enhancing the capabilities, competencies, and knowledge of the workforce in the sector; ▪ Reviewing and determining permit/licence applications for waste treatment facilities including Mechanical Biological Treatment Plants; ▪ Issuing licences for Mechanical-Biological Treatment in accordance with the controls determined by law and Regulations; ▪ Monitoring the compliance of Service Providers with the provisions of the Law and the Regulations, the rules and instructions issued thereunder, as well as their licence terms and conditions via the inspectors, who are appointed by a decision of the Minister.
Design and Construction companies involved in MBT projects	▪ Compliance with the provisions of the Law and the Regulations, the rules and instructions issued thereunder, as well as the terms and conditions of the construction and environmental permits, as well as any other pertaining permits.
Service Providers / Operators	▪ Not to manage/treat waste without a valid licence, permit or exemption; ▪ Verify the authenticity of the waste transportation manifest details and ensure that they fall within the licence issued for the Mechanical-Biological Treatment Facility competency;

Roles and Responsibilities

- Submit periodic reports to the Centre, as per the controls stipulated by the Regulation;
- Maintain an adequate and up to date record of its operations and provide this on a monthly basis to the Centre;
- Provide adequate training to designated staff to ensure the highest level of skills and qualifications;
- Ensure proper and safe management of by-products and residues resulting from the Mechanical-Biological treatment processes of waste, according to the applicable regulations and instructions by the Center;
- Carry out a self-monitoring system of the plant technological and quality of environmental factors self-monitoring and bear its costs;
- Be responsible for the maintenance, supervision, monitoring according to the relevant License and/or other Licenses or Permits required by the Law, the Regulations, and the relevant technical controls the Centre issues;
- Report to the Centre notifications within a maximum of 24 hours from the finding of any negative ecological effects revealed by the self-monitoring;
- Provide financial guarantees to guarantee the fulfilment of their obligations.

4 OVERVIEW OF MECHANICAL-BIOLOGICAL TREATMENT

4.1 Purpose

The purpose of the MBT plants is to reduce the weight, and to render inert any biologically active organic materials (typically called 'stabilised residue'), extract recyclable materials and produce a refuse-derived fuel (RDF) and/or a solid recovered fuel (SRF) for industrial thermal applications.

MBT was initially conceived to reduce the organic matter content of waste which is sent to final disposal with the aim of reducing the production of biogas and leachate and ultimately to reduce the amount of waste directed to the landfill.

The main difference with a Dirty Material Recovery Facility (Dirty MRF) is that the MBT also covers the biological side of the organic fraction treatment while the MRF could be considered as a pre-treatment that requires a complementary solution to handle the organic fraction.

4.2 Waste streams suitable for Mechanical-Biological Treatment

Typically, the MBT plants are designed to process mixed Municipal Solid Waste including commercial waste and, to a lesser extent, non-hazardous industrial waste.

In principle, many types of waste materials can be accepted at a MBT plant. The materials broken down and digested in the biological stage include paper and board, green/kitchen organics, and the organic content contained within nappies, packaging, textiles, some types of sewage sludge, etc. Generally, only mixed, unsorted Municipal Solid Waste[3] enters the plant.

Otherwise, some waste streams catalogued as Hazardous Waste[3] or animal by-products and derived products not intended for human consumption are restricted to be treated in a MBT Plant. These waste streams are not appropriate for a biological treatment causing inhibition of biological activity.

The moisture content of waste intake is extremely variable, but household wastes would be expected to have a moisture content of at least 40–50 %.

4.3 Treatment Technology Overview

The Mechanical-Biological treatment (MBT) of waste refers to a two-step process for the use of:

- Mechanical equipment to sort and recover some recyclable materials from the mixed waste (generally plastics, ferrous and non-ferrous metals) on a **first stage** to then;

- Use living microorganisms to decompose the organic fraction of the mixed waste flow into either carbon dioxide and simple inorganics, or into simpler organics such as aldehydes and acids on a **second stage.**

While the mechanical side of the process (first stage) is a common procedure that will be later explained in the document, the biological treatment of the organic waste flow could be treated under different treatment technologies, including:

[3] As per definition and terminology of the *Chapter 1: Definitions and Terminology* of the IR

- Aerobic Biodrying;
- Aerobic stabilization; and
- Anaerobic digestion.

Note: This TG will cover the MBT facilities as whole process as any detail on mechanical or biological treatment as standalone process are discussed in another Technical Guidelines[4] and therefore are not covered in this document

The figure below presents a summary of a flow diagram for a typical MBT process:

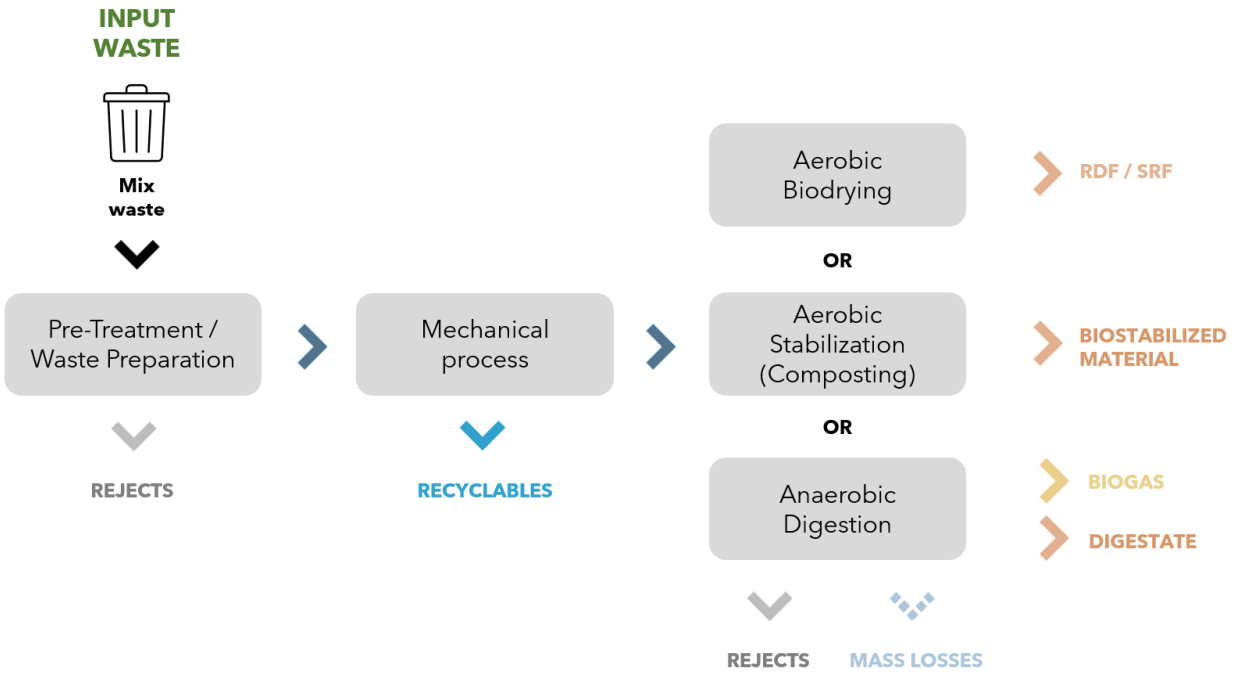


Figure 4-1. Flow diagram MBT process

The following figures include a brief description and technology overview of the process for each of the MBT options detailed within this TG:

[4] Technical Guideline on Establishment and Operation of Material Recovery Facilities and Technical Guideline on Biological Waste Treatment

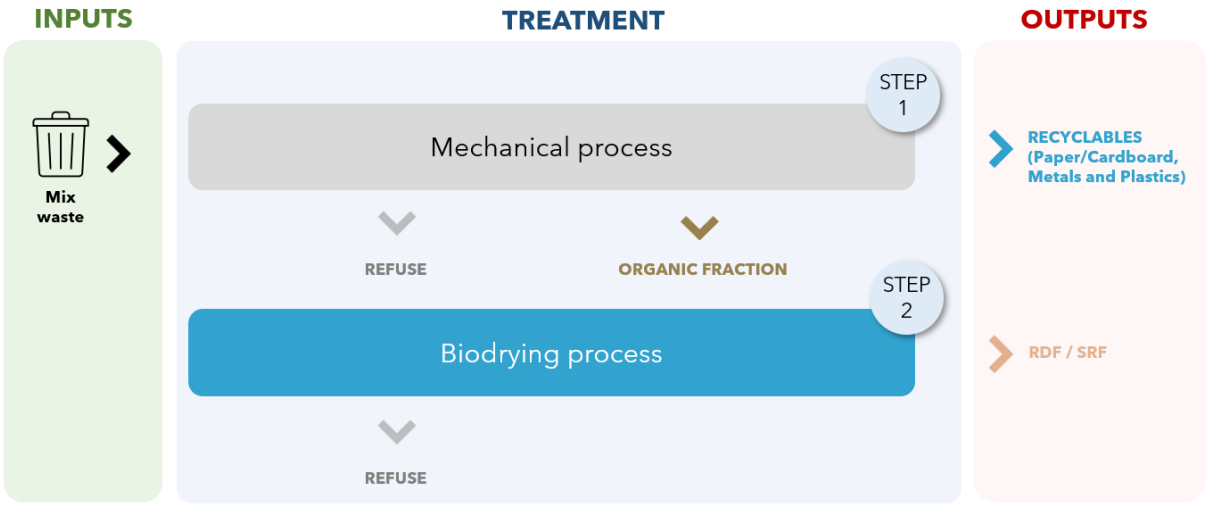
MBT – AEROBIC BIODRYING

Overall process: The Mechanical-Biological process of mixed waste through **Biodrying** combines technological methods to recover recyclable materials from the mix waste stream and produce a Refuse Derived Fuel (RDF) and/or Solid Recovered Fuel (SRF) with the non-recovered waste stream to be used with energy recovery purposes.

Outputs:

- *Mechanical Process:* Recyclable materials such as ferrous and non-ferrous metals, plastics and to a lesser extend paper/cardboard;
- *Biodrying Process:* combustible material (RDF and/or SRF) for industrial thermal applications;
- *Rejects/refuse* directed to final disposal (landfilling or WtE).

Flowchart Diagram:



Notes: As detailed later in Section 6.1 the Biodrying process can be included before or after the Mechanical process. A refining stage after the Biodrying process can enable the final product to achieve SRF parameters depending on the characteristics of the input Mix waste and the specifications classifying such combustible materials.

Illustrative overview:

Figure 4-2. MBT - Biodrying - Technology overview

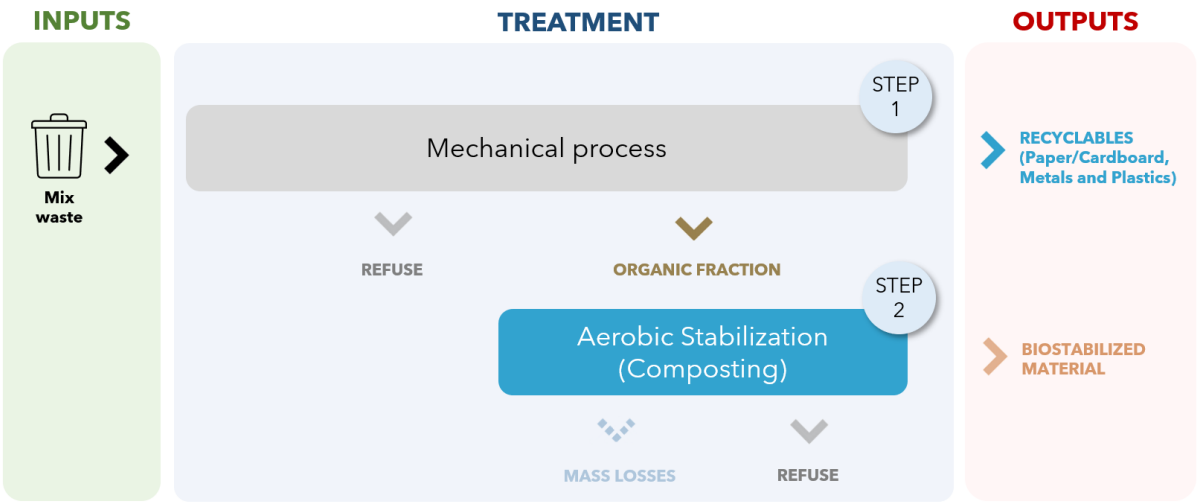
MBT – AEROBIC STABILIZATION

Overall process: The Mechanical-Biological process of mixed waste through **stabilization** combines technological methods to recover recyclable materials from the mix waste stream and produce a bio-stabilised material to be used a low-quality soil amendment or alternative uses as slope backfilling.

Outputs:

- *Mechanical Process:* recyclable materials such as ferrous and non-ferrous metals, plastics and to a lesser extend paper/cardboard and RDF (contaminated paper/cardboard, textile, wood, and non-recyclable plastic);
- *Stabilization process:* slope backfill or cover material. If there is no market available, the biological stabilised material is typically direct to the final disposal;
- *Rejects/refuse* directed to final disposal (landfilling or WtE).

Flowchart Diagram:



Illustrative overview:

Figure 4-3. MBT – Aerobic Stabilization - Technology overview

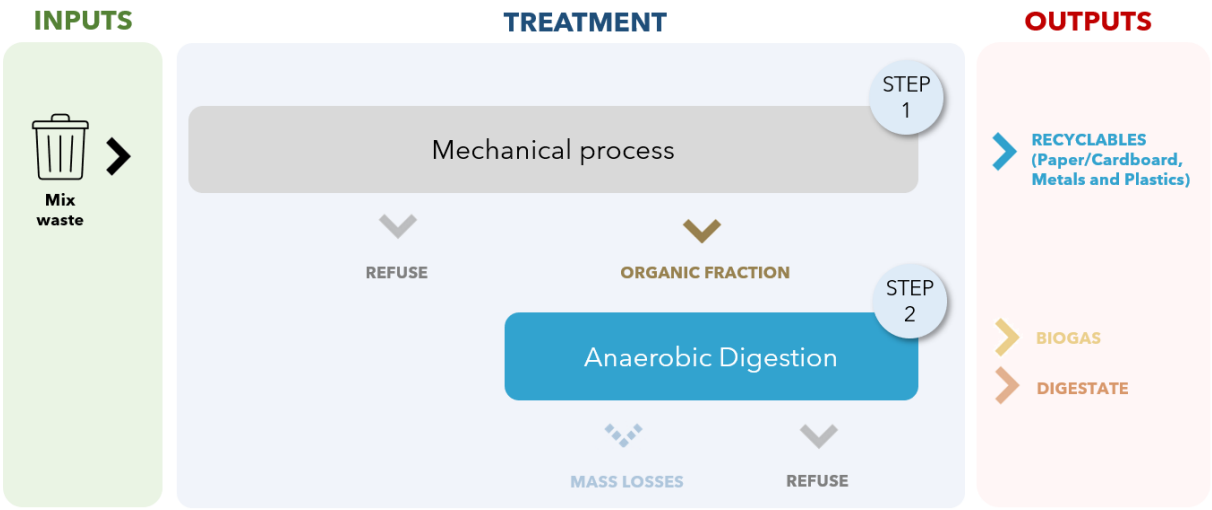
MBT – ANAEROBIC DIGESTION

Overall process: The Mechanical-Biological process of mixed waste through **Anaerobic Digestion** combines technological methods to recover recyclable materials from the mix waste stream and produce biogas to be potentially used with energy recovery purposes and partially bio-stabilised digestate material to be used a low-quality soil amendment after a stabilization process.

Outputs:

- *Mechanical Process:* Recyclable materials such as ferrous and non-ferrous metals, plastics and to a lesser extend paper/cardboard and RDF (contaminated paper/cardboard, textile, wood, and non-recyclable plastic);
- *Stabilization process:* Biogas and digestate (to be potentially composted);
- *Rejects/refuse* directed to final disposal (landfilling or WtE).

Flowchart Diagram:



Illustrative overview:

Figure 4-4. Anaerobic Digestion - Technology overview

5 SITE SPECIFICATIONS AND INFRASTRUCTURE REQUIREMENTS

Article 95 of Section 8 (Chapter 4) of the IR provides general guidelines for site selection of waste facilities including the Mechanical-Biological waste treatment facilities. Those include:

- The distance between the suggested site and the production, collection, and storage of Waste locations;
- Availability of infrastructure and paths for facilitating the arrival to the location in all seasons, and the impact of the facility on the traffic at that area;
- Keeping away from historical sites and reserves;
- That the area has suitable capacity for all generated wastes throughout the facility's lifecycle;
- Avoidance of sites on very steep locations, as level grounds are preferrable;
- That the site is distant from valleys, reefs, flood streams, beaches, bodies of water and water sources, such that it does not pollute any water source;
- That the site is not in areas where the groundwater percentage is high, or in sabkhas;
- The dominant direction and speed of the winds, such that the facility must be located in the opposite direction from the wind direction in that area;
- That the site is distant from currently used lands or the lands that are planned for development purposes, such as urbanized, commercial, agricultural, or industrial areas;
- In case of choosing a location for a landfill, the suitable and fulfilling soil must be existent to cover the waste, taking into consideration that the soil has low permeability and coherence;
- That the site is as far as possible from any masts, electric lines, railways, airports, facilities' pipelines, and highways; and
- Any other controls or requirements the Centre issues.

The Centre may exempt from any of these conditions in accordance with the nature of the project.

As per article 97 of the IR, it is forbidden to build a Mechanical-Biological treatment plant on the following sites and areas:

- Sites adjacent to planned land for development purposes such as urban, commercial, and agricultural expansion areas;
- Sites located in valleys, reefs, and flood streams, where the treatment and disposal of Waste may expose the water to contamination, as a result of leakage of fluids to the ground;
- Sites with high groundwater attributed, especially in areas where this water is used for agriculture or drinking;
- Sites on very steep locations;
- Sites on historical archaeological or natural areas or environmental reserves;
- Areas adjacent to airports and subject to the classification of the General Authority of Civil Aviation; and
- Any other area deemed by the competent authorities as invalid for the establishment of a facility for the treatment and disposal of Waste.

5.1 Site Infrastructure Guidelines for Mechanical-Biological Waste Treatment Facilities

The Site Infrastructure Guidelines as far as Mechanical-Biological waste treatment facilities are concerned, are set out as follows:

5.1.1 Siting – General Considerations

Mechanical-Biological waste treatment facilities should be configured and organized in accordance with the expected uses of the land within them; this form of spatial organization and planning is known as "zoning ".[5]

Zoning helps by encouraging on-site economies of scale in utilities infrastructure concentration and utilization, for instance, as regards waste collection and treatment, internal transport networks and other amenities. It also smooths vehicular and pedestrian circulation by enabling clear movement patterns.

Mechanical-Biological waste treatment plants zoning maps are prepared based on such key site parameters as boundary (perimeter) shape, physical site features, area availability, environmental considerations, micro climatic conditions, compatibility issues, surrounding areas, accessibility, transportation issues and visibility.

Existing and adjacent land use are also critical considerations in deciding on nearby and future onsite land uses and zoning.

Zoning within the Mechanical-Biological waste treatment plant can be designed furthermore in such a way as to encourage industrial symbiosis for the utilization of materials, industrial water, and energy by-products.

Energy efficiency optimisation can be attained by stimulating and facilitating 'energy symbioses' and cooperation amongst residents. Surplus energy (e.g., heat, steam, hot water, etc.) from a plant can be transferred to other companies, either within the biological waste treatment or in nearby communities.

Segregating polluting and non-polluting activity is another sound zoning practice.

In any case, the Mechanical-Biological waste treatment plan must be within the approved plans as industrial zones, and proportional in size to the volume of work and the quantity of production, according to the areas approved in the industrial plans.

5.1.2 Surface Water Drainage

Surface water caused by run off of entrained water from the Waste mass and storm water drainage are collected and managed separately. Contaminated water is transferred to a treatment unit while storm water runoff is disposed on to a natural recipient.

The design of the drainage system must be taken into account pre-development. The drainage systems must be inspected at annual intervals throughout the operational life of the facility to ensure their integrity.

5.1.3 Utilities and Facilities

In order to ensure the health and safety of on-site personnel, and to enable control of operations on site the following utilities and facilities in combination with the appropriate equipment must be provided at all Mechanical-Biological waste treatment plants[6]:

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[5] (United Nations Industrial Development Organization, INTERNATIONAL GUIDELINES FOR INDUSTRIAL PARKS, 2019)

[6] (United Nations Industrial Development Organization, INTERNATIONAL GUIDELINES FOR INDUSTRIAL PARKS, 2019)

- Water supply:
  - Sufficient drinking and non-potable water, with separate distribution networks;
  - Water pumping station.

- Power supply:
  - Distribution substations at strategic locations, with network of underground cables or overhead lines.

- Street lighting:
  - Conventional or solar street lighting;
  - Smart energy-efficient lighting.

- Sewerage:
  - Sewage and effluent collection and storage systems;
  - Systems for removal of contaminants from wastewater, and storm run-off through primary treatment of effluents;
  - Treated and recycled water distribution system.

- IT connectivity, telecommunication, and ICT-enabled resident services:
  - High-speed Wi-Fi and internet services;
  - Robust data infrastructure system;
  - Communication system within the Mechanical-Biological waste treatment plant.

- Safety and security:
  - Health care centre, medical facilities;
  - Emergency response centre/s (including for accidents and first aid, fire, and chemical hazards, security incidents, natural disasters, and crises, etc.);
  - Public safety infrastructure, including lighting and CCTV surveillance systems.

5.1.4 Fencing and Security

A fence must be constructed around the perimeter of the Mechanical-Biological waste treatment plant to reduce onsite trespass, provide a screen for the facility, delineate the property lines, and provide a control for litter blow. Fences must be a minimum of 2 metres tall around the entire perimeter of the site. Appropriate signage to discourage trespassers must be erected at the site entrance.

5.1.5 Waste Rejects Area

An area of the site must be made available to allow for the temporary segregation of suspect, burning or unacceptable waste loads which enter the site. This area should be located away from the main areas frequented by personnel. Firefighting equipment must be available in case of burning waste loads.

This area must be clearly marked with reference to its required purpose to ensure that there is no inadvertent mixing of waste materials.

5.1.6 Licensing

Facility licensing will be covered under the Authorisation and Licensing of Activities and Facilities Technical Guideline.

6 DESIGN REQUIREMENTS AND BEST SUITABLE TECHNIQUES APPLICABLE FOR MECHANICAL-BIOLOGICAL TREATMENT PLANTS

6.1 MBT Plants with Aerobic Biodrying

6.1.1 Treatment process

The Mechanical-Biological Treatment of mixed waste through Biodrying combines technological methods to recover recyclable materials from the mix waste stream and produce a Refuse Derived Fuel (RDF) and/or Solid Recovered Fuel (SRF) with the non-recovered waste stream to be used with energy recovery purposes.

6.1.1.1 Feedstock

Mixed collected Municipal Solid Waste including Commercial waste is the primary feedstock for MBT Biodrying waste facilities. However, assimilable household waste from Industrial waste is also suitable to act as input.

6.1.1.2 Process Description

The MBT Biodrying facilities process involves four main steps:

Step 1) Reception/pre-treatment storage;

Step 2) Mechanical process;

Step 3) Biological process - Biodrying;

Step 4) Refining and after-treatment storage.

Reception

The process begins with the delivery of the mix waste to the reception area, where the characteristics (type of mix waste, level of organic waste, etc) of the waste through visual inspection and weight of the waste by use of a scale will be recorded.

The reception area must have a total capacity that allows a certain flexibility in the treatment of the material received. Given the organic component of the mixed solid waste, leachate is generally produced during the pre-storage of waste before treatment. Therefore, the reception area must be equipped with a drainage and leachate collection system. Priority will be given to recirculating these leachates to process as far as possible. Also, to avoid the emission of odours to the outside it is advisable to keep the building in depression.

Mechanical process

The mechanical process involves a series of technological process with the purpose of the separation of the non-organic and organic fractions as well as the recovery of recyclable materials.

Mechanical treatment can vary from a simple shredding and trammelling process to a complicated system that incorporates shredding, trammelling, magnetic extraction, eddy current separation, near infra-red separation, optical separation, or ballistic separation. The processes that may be involved are as follows:

- Opening of waste bags (where applicable) (e.g., shredders);
- Extraction of bully waste/undesirable components that might obstruct the subsequent processing;

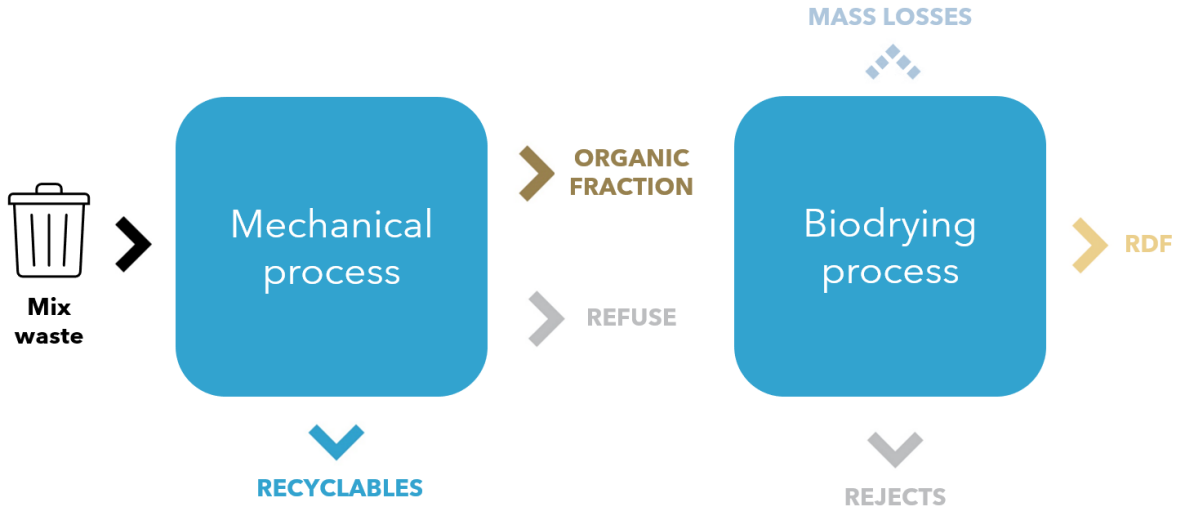
- Optimisation of the particle size for subsequent processing and segregation of biodegradable materials in the underflows of primary screening, so that they can be sent to the biological treatment process (e.g., by sieves);
- Segregation of materials with a high calorific value, such as textiles, paper, and plastics, in the overflows of primary screening, so that they can be sent for use in the production of fuel; also, segregation of those materials suitable for further material recovery (e.g., by air separation);
- Homogenisation of materials destined for biological treatment.

Biodrying

In this stage the refuse from the previous mechanical process together with the organic fraction and other refuses (i.e., combustible bulky waste) will undergo a process of decomposition, under aerobic conditions, of the most biodegradable fraction of waste (carbohydrates, proteins, and fat from organic waste), using the energy released in the form of heat to evaporate the humidity and therefore dry the waste. Commonly, as a pre-treatment prior to the Biodrying process, the material is crushed trough shredding systems in order to homogenise it and increase the contact surface of the waste with the heat flow. Conveyor belts and/or overhead cranes will be the transport method between processes.

In some cases, depending on the composition and nature of the feedstock, the Biodrying stage could be placed at the beginning of the entire Mechanical-Biological process. The earlier Biodrying of the mix waste in this instance could increase the subsequent mechanical sorting performances based on the decoupled of some comingled materials within the mix waste owing to the heat flow that will facilitate sorting and recovery. The following figure presents a diagram scheme of both options:

Figure 6-1: MBT Biodrying flow process diagram – Option 1



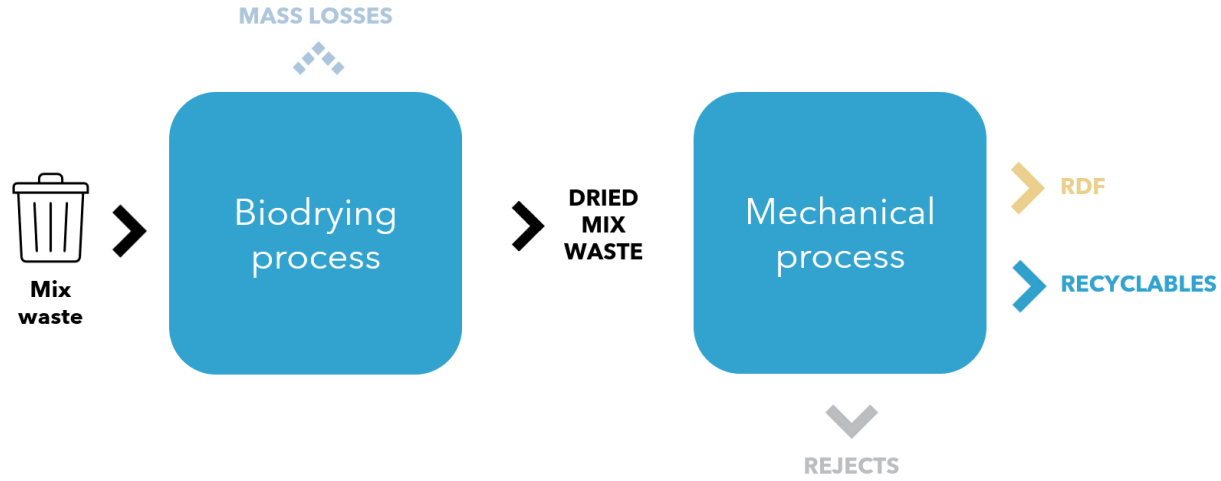


Figure 6-2: MBT Biodrying flow process diagram – Option 2

Refining

The final step of the Mechanical-Biological process is the finalisation of the product, the RDF and or SRF materials. The main difference between them is the level of refining that derives into the composition and properties of the fuel. RDF is a relatively crude material with low-medium calorific value, higher percentages levels of moisture and particle size than SRF. On the other hand, SRF is a more refined resource, commonly produced to a defined quality specification with restrictions in components such as Chlorines or Sulphurs with higher price and better acceptance by the off-takers.

This refining stage includes the extraction of improper materials (glass, stones, sands) and ferrous and non-ferrous metals through a magnetic separation system and an eddy current system, respectively.

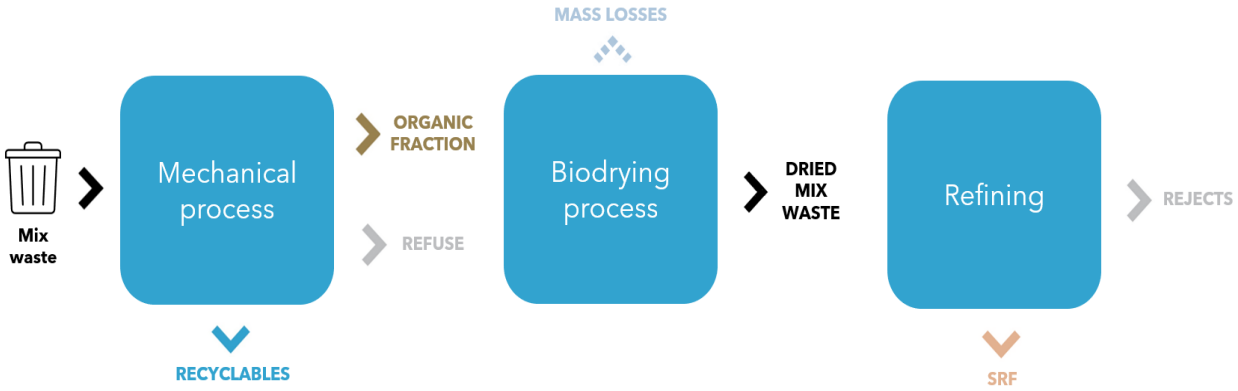


Figure 6-3. MBT Refining flow process diagram - Option 1

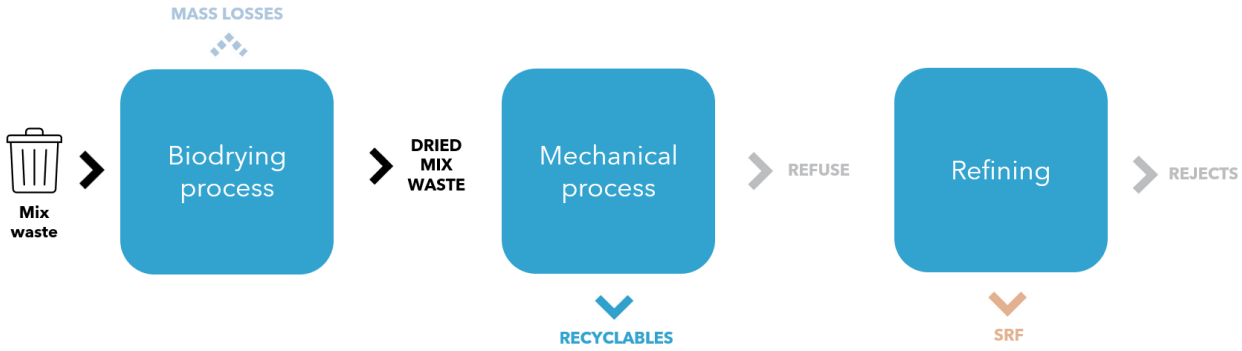


Figure 6-4. MBT Refining flow process diagram - Option 2

Storage

The RDF, SRF and recyclable materials recovered through the process will be stored within the facilities before its transport to the final off-taker or further treatment.

6.1.2 Outputs (standards, market, etc.)

The primary output of the of the MBT Biodrying process is the combustible material (RDF and/or SRF). This can be used for the purpose of energy recovery purposes in many industries, such cement plants, or waste-to-energy facilities.

Another output is the recyclable materials flow potentially recovered in the mechanical process of the MBT for material such as ferrous and non-ferrous metals and plastics. The amount and quality of this stream will fully depend on the waste composition of the mix waste. On a general basis, lower recovery performance can be expected as the percentage of recyclables in total composition decreases.

Finally, a stream of inorganic fines and inerts will be obtained as rejects.

Table 6-1: MBT Biodrying treatment technologies

Treatment technology	Outputs
MBT with Aerobic Biodrying	RDF or SRF;
	Recyclable materials (vary depending on configuration but generally ferrous and non-ferrous metals and plastics);
	Inorganic fines and inerts (rejects stream).

6.2 MBT with Aerobic Stabilization

6.2.1 Treatment process

The Mechanical-Biological process of mixed waste through stabilization combines technological methods to recover recyclable materials from the mix waste stream and produce a bio-stabilised material to be used a low-quality soil amendment or alternative uses as slope backfilling.

6.2.1.1 Feedstock

Mixed waste from Municipal and Commercial waste is the primary feedstock for MBT aerobic stabilisation waste facilities. However, assimilable household waste from Industrial waste is also suitable to act as input.

6.2.1.2 Process Description

The MBT Biodrying facilities process involves four main steps:

Step 1) Reception/Pre-treatment storage;

Step 2) Mechanical process;

Step 3) Aerobic Stabilisation;

Step 4) Refining and after-treatment storage.

Reception

The process begins with the delivery of the mix waste to the reception area, where the characteristics (type of mix waste, level of organic waste, etc) of the waste through visual inspection and weight of the waste by use of a scale will be recorded.

The reception area must have a total capacity that allows a certain flexibility in the treatment of the material received. Leachate is produced during the storage of waste. For extraction, the reception must be equipped with a drainage and leachate collection system. Priority will be given to recirculating these leachates to process as far as possible. Also, to avoid the emission of odours to the outside it is advisable to keep the building in depression.

Mechanical process

The mechanical process involves a series of technological process with the purpose of the separation of the non-organic and organic fractions as well as the recovery of recyclable materials. Firstly, the mixed waste is sorted to separate the organic fraction from the main waste stream using trommels. The remaining waste stream is then mechanically sorted using a number of methods to separate any recyclable material. These methods may include gravity sorting of light material, magnetic and eddy current separators, sieving of broken glass and optical separators. Any residual material that is non-organic or recyclable is classified as refuse.

Aerobic stabilisation

In this stage the organic fraction of the mix waste that has sunk from the trommels in the mechanical process stage will undergo a process of decomposition, under aerobic conditions, of the most biodegradable fraction of waste (carbohydrates, proteins, and fat from organic waste), using the energy released in the form of heat to evaporate the humidity and therefore dry the waste. This stabilisation process is governed by the same principles as of composting but with a more contaminated organic fraction which commonly cannot produce

quality compost to be used as fertiliser. Any technological processes followed to carry out the stabilisation of the material shall ensure correct aeration and mixed to properly stabilise the mix waste.

Commonly, as a pre-treatment prior to the stabilisation process, the material is crushed trough shredding systems in order to homogenise it. Conveyor belts and/or overhead cranes will be the transport method between processes. The following figure presents a diagram scheme of the process above described:

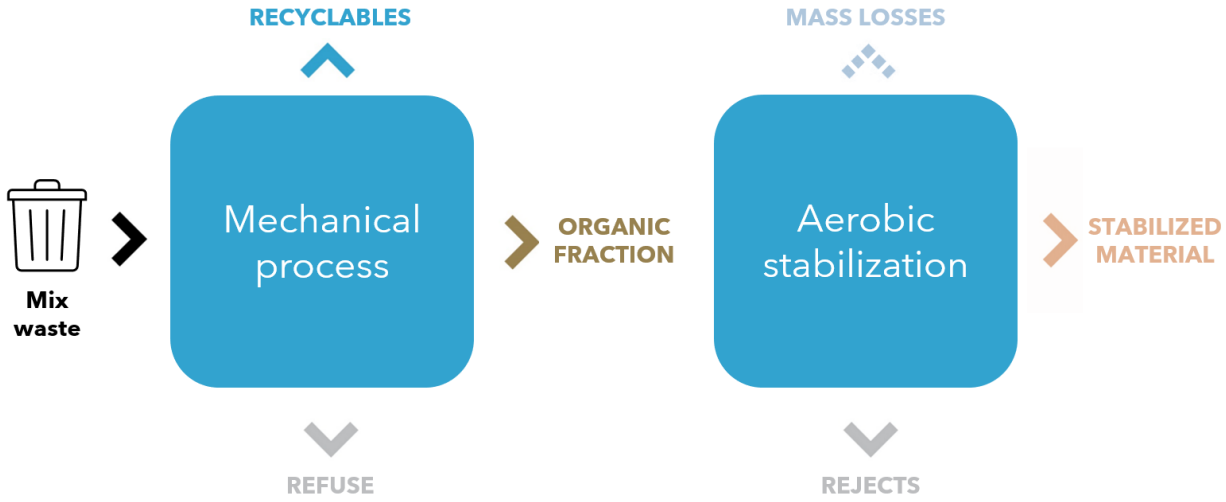


Figure 6-5. MBT with Aerobic Stabilization flow process diagram

Note: This TG will cover the MBT facilities as whole process as any detail on biological treatment as standalone process are discussed in another Technical Guidelines[7] and therefore are not covered in this document

Refining

The final step of the Mechanical-Biological with aerobic stabilization process is the finalisation of the product, the bio-stabilised material. The refining stage includes the extraction of improper materials (glass, stones, sands) and ferrous and non-ferrous metals through a magnetic separation system and an eddy current system, respectively. This refining stage will depend on the requirements and parameters expected for the potential use of the output.

6.2.2 Outputs (standards, market, etc.)

The primary output of the of the MBT Stabilisation process is the bio-stabilised material. This can be used for slope backfill or cover material purposes as well as a low-quality fertiliser depending on the content level, nature, and characteristics of the organic fraction in the incoming mix waste. The potential applications of this output are dependent upon their legislative and market conditions.

Plastics and other inorganic residues not suitable for bio-stabilisation and production of separated and treated organic fraction will also be obtained.

Another output is the recyclable materials flow potentially recovered in the mechanical process of the MBT for material such as ferrous and non-ferrous metals or plastics and to a lesser extend paper/cardboard. The amount and quality of this stream will fully depend on the waste composition of the mix waste. On a general basis, lower recovery performance can be expected as the percentage of recyclables in total composition decreases.

[7] Technical Guideline on Biological Waste Treatment

Finally, a stream of inorganic fines and inerts will be obtained as rejects.

Table 6-2. Treatment technologies for MBT with Aerobic Stabilization

Treatment technology	Outputs
MBT with Aerobic Stabilization	Separated and treated organic fraction or bio-stabilised waste;
	Plastics and other inorganic residues not suitable for bio-stabilisation and production of separated and treated organic fraction;
	Recyclable materials (vary depending on configuration but ferrous and non-ferrous metals and plastics);
	Inorganic fines and inerts (rejects stream).

6.3 MBT with Anaerobic Digestion

6.3.1 Treatment process

The Mechanical-Biological process of mixed waste through Anaerobic Digestion combines technological methods to recover recyclable materials from the mix waste stream and produce biogas to be potentially used with energy recovery purposes and partially bio-stabilised digestate material to be used a low-quality soil amendment after a stabilization process.

6.3.1.1 Feedstock

Mixed waste from Municipal and Commercial waste is the primary feedstock for MBT Anaerobic Digestion waste facilities. However, assimilable household waste from Industrial waste is also suitable to act as input. It is important to note that in an MBT-Anaerobic Digestion configuration, the non-organic fraction must be very efficiently separated prior to the digester. Unlike the Aerobic biodegradation, the Anaerobic Digestion cannot accept a significant contamination of the organic fraction.

6.3.1.2 Process Description

The MBT Biodrying facilities process involves four main steps:

Step 1) Reception;

Step 2) Mechanical process;

Stage 3) Preparation;

Step 4) Digestion;

Step 5) Stabilisation and refining.

Reception

The process begins with the delivery of the mix waste to the reception area, where the characteristics (type of mix waste, level of organic waste, etc) of the waste through visual inspection and weight of the waste by use of a scale will be recorded. The reception area must have a total capacity that allows a certain flexibility in the treatment of the material received. Leachate is produced during the storage of waste. For extraction, the reception area must be equipped with a drainage and leachate collection system. Priority will be given to recirculating these leachates to process as far as possible. Also, to avoid the emission of odours to the outside it is advisable to keep the building in depression.

Mechanical process

The mechanical process involves a series of technological process with the purpose of the separation of the non-organic and organic fractions as well as the recovery of recyclable materials. Firstly, the mixed waste is sorted to separate the organic fraction from the main waste stream using trommels. The remaining waste stream is then mechanically sorted using a number of methods to separate any recyclable material. These methods may include gravity sorting of light material, magnetic and eddy current separators, sieving of broken glass and optical separators. Any residual material that is non-organic or recyclable is classified as refuse.

Preparation

The organic fraction of the mix waste is then prepared for treatment through material separation and pre-treatment; this is done to improve the digestion process. Materials such as plastics (including biodegradable plastic bags), metals and oversized components are manually extracted from the waste. Size reduction to create a more homogenous material, facilitating the anaerobic digestion process, is then undertaken through screw-cutting, milling, drumming, pulping or shredding machines. As part of the pre-treatment process, preliminary aerobic decomposition can be performed over a period of two to four days to improve material breakdown and warm the substrate. This can be undertaken in box fermenters or in separate preliminary digestion unites (such as composting tunnels with forced aeration tunnels). Heating the substrate reduces the consumption of energy required to heat the digester. This decreases the amount of organic matter for anaerobic treatment; however, it increases the biogas yield. Furthermore, since anaerobic digestion is limited in its ability to degrade cellulose, hemicellulose and lignin, pre-treatment methods (whether physical, chemical, or biological) are preferred.

Digestion

In this stage the organic fraction of the mix waste that has sunk from the trommels in the mechanical process stage will undergo a process of decomposition, under anaerobic conditions, of the most biodegradable fraction of waste (carbohydrates, proteins, and fat from organic waste). This Anaerobic Digestion process is based in five successive stages (Hydrolysis, Acidogenesis, Acetogenesis, Methanogenesis) and taken into consideration several operation parameters that shall be controlled and monitored (Temperature, pH, loading rate, Hydraulic retention time (HRT), C:N and particle size).

Commonly, as a pre-treatment prior to the stabilisation process, the material is crushed trough shredding systems in order to homogenise it. Conveyor belts and/or overhead cranes will be the transport method between processes. The following figure presents a diagram scheme of the process above described:

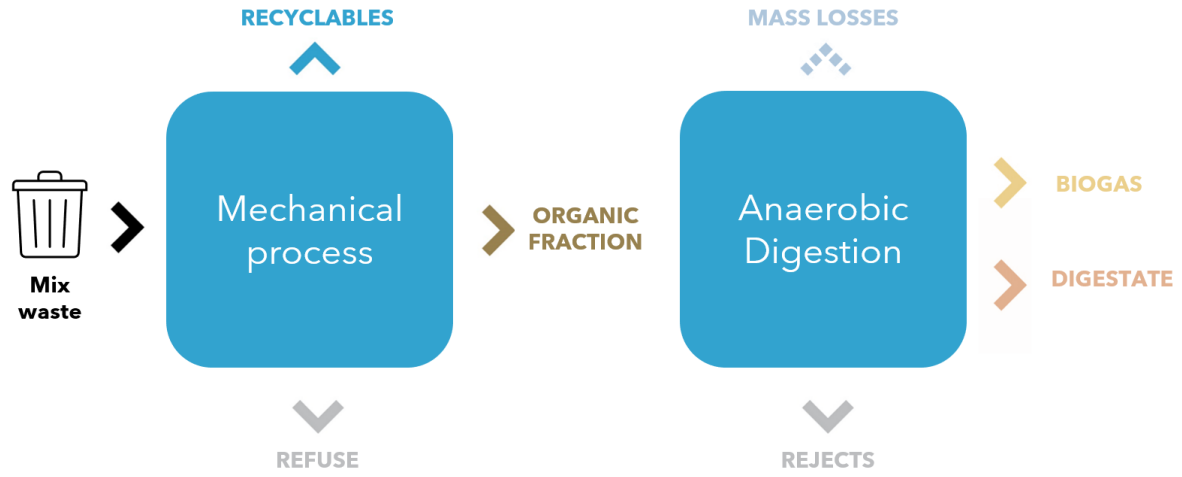


Figure 6-6. MBT with Anaerobic Digestion flow process diagram

- Note: This TG will cover the MBT facilities as whole process as any detail on biological treatment as standalone process are discussed in another Technical Guidelines and therefore are not covered in this document

Stabilisation and Refining

The final step of the Mechanical-Biological with Anaerobic digestion process is the finalisation of the product. This includes sanitation, maturation, and biogas treatment. If thermophilic digestion is performed, the sanitation can be considered complete; else, a separate sanitation stage may be required. Maturation (or post-composting) may be needed as it reduces the water content and prevents methane formation in solid digestate products. It can be performed in boxes or tunnels with forced aeration systems, and generally lasts between two to six weeks, depending on the desired degree of maturation. Lastly, biogas treatment is done to dehumidify and clean the biogas and ensure the removal of hydrogen sulphide.

Figure 6-7. MBT with Aerobic Stabilization flow process diagram

6.3.2 Outputs (standards, market, etc.)

The primary outputs of the MBT anaerobic digestion process are biogas and digestate. It should be noted that the characteristics of the feedstock have very important effects on the anaerobic digestion process and therefore directly impact the biogas yield and digestate quality.

Biogas

Biogas is composed primarily of methane (50 – 70%), carbon dioxide (30 – 50%), with small quantities of other gases such as hydrogen sulphide (50 – 4000 ppm). It is saturated with water and use of the biogas requires the removal of this water as well as the hydrogen sulphide to prevent corrosion. Biogas can be used as any combustible gas and burned to provide heat and generate electricity, among other uses. Furthermore, by removing carbon dioxide from the biogas, the biogas can be upgraded to biomethane. Biomethane can be injected into the natural gas distribution network or used as a transport fuel in a similar way as compressed natural gas or liquified natural gas.

Digestate

The solid digestate can be used as an organic fertiliser and soil improver in a similar manner to compost from composting. However, if the digestate is contaminated with heavy metals, which may be the case with sewage sludge as feedstock, the digestate may require further treatment and its uses may be limited (low calorific value (CV) RDF additive or landfill restoration addictive).

Plastics and other inorganic residues not suitable for Anaerobic Digestion will also be obtained.

Another output is the recyclable materials flow potentially recovered in the mechanical process of the MBT for material such as paper/cardboard, metals, or plastics. The amount and quality of this stream will fully depend on the waste composition of the mix waste. On a general basis, lower recovery performance can be expected as the percentage of recyclables in total composition decreases.

Finally, a stream of inorganic fines and inerts will be obtained as rejects.

Table 6-3. Treatment technologies for MBT with Anaerobic Digestion

Treatment technology	Outputs
MBT with Anaerobic Digestion	Biogas;
	Digestate to be potentially composted or with possible use as a low calorific value (CV) RDF additive or landfill restoration additive;
	Plastics and other inorganic residues not suitable for Anaerobic Digestion;
	Recyclable materials (vary depending on configuration but generally glass, ferrous and non-ferrous metals, and plastics);
	Inorganic fines and inerts (rejects stream).

6.4 Techniques for the control and prevention of emissions

During the operation of MBT Plants, emissions and consumption arise, whose existence or magnitude is influenced by the facilities design and operation. As most emissions from Mechanical-Biological Treatment operations result from biological treatment of biodegradable waste, the emissions are similar to composting or AD. However, the end product is usually contaminated to a level which hinders its further use. Nevertheless, the implementation of best available techniques has the advantage of purifying the combustible fraction for incineration with energy recovery.

As per BAT document, the potential emissions from mechanical-biological treatment of waste are summarised in the figure below.

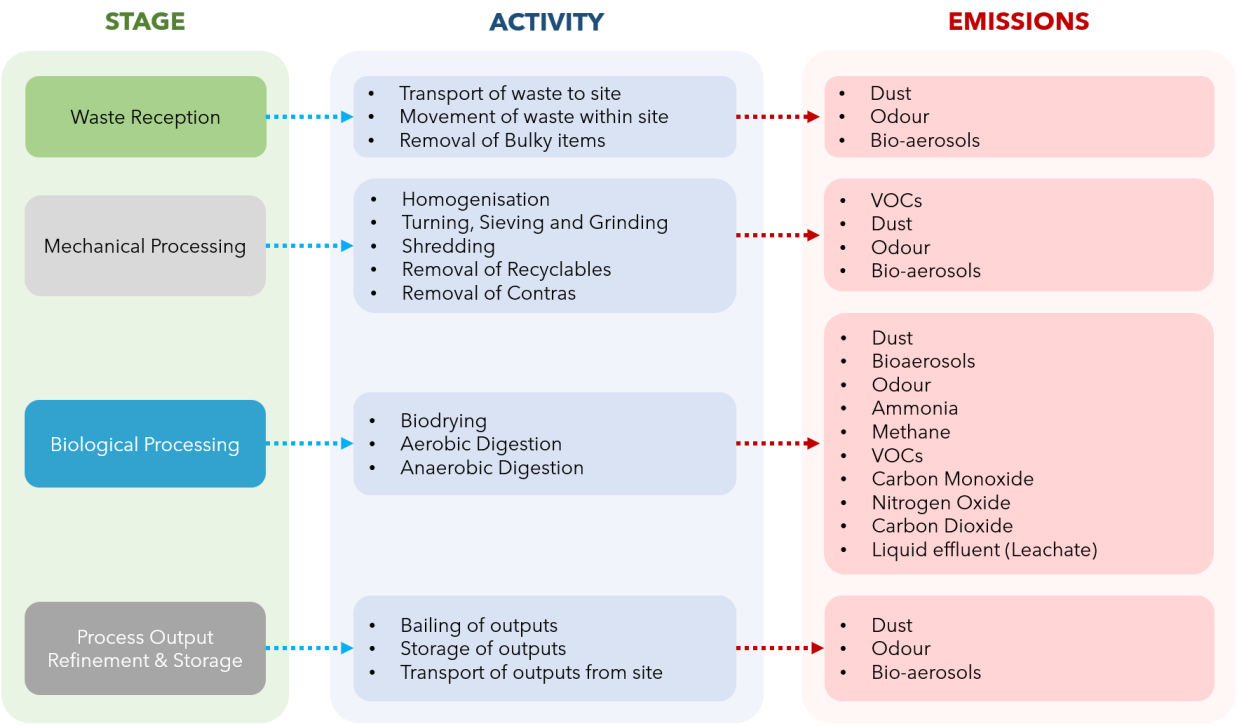


Figure 6-8: Potential emission sources from MBT processes

Therefore, in the next paragraphs are presented the best available techniques, as per BAT documents[8], in order to control, reduce and prevent emissions:

- Techniques to reduce odour emissions and to improve the overall environmental performance of the biological treatment;
- Techniques to reduce channelled emissions to air;
- Techniques to reduce wastewater and water usage.

[8] Commission Implementing Decision (EU) 2018/1147 of 10 August 2018 establishing best available techniques (BAT) conclusions for waste treatment, under Directive 2010/75/EU and Best Available Techniques Reference Document for Waste treatment, Joint Research Centre (JRC), EC, 2018

6.4.1.1 Techniques to reduce odour emissions and to improve the overall environmental performance

As per BAT document, the best available techniques to reduce odour emissions and to improve the overall environmental performance consists of carrying out the pre-acceptance, acceptance, and sorting of the waste.

Table 6-4: Techniques to Reduce Odour Emissions and to Improve the Environmental Performance

Technique		Description
a	Pre-acceptance/ acceptance and sorting of waste input criteria	- Pre-acceptance procedures may include an operator carrying out up-stream audits on their feedstock suppliers to ensure waste is consistently presented in a manner which is suitable for their waste treatment operation. They may include a limit on the age of the waste by the time it reaches the facility to prevent the acceptance of highly odorous material; - Selection of the waste input to ensure its suitability for the waste treatment; - Maximising the quality of the feedstock in line with the treatment.
b	Storage management	- The storage area of mixed waste feedstock (residual waste) shall be designed with an impermeable surface with a sealed drainage system, to prevent any spillage entering the storage systems or escaping off site. The design prevents the contamination of clean surface water; - The storage area shall be also designed to allow complete emptying and cleaning including drainage to allow appropriate leachate and washing water collection, transfer, and discharge. Other techniques related to the operational stage, such as the residence time, are presented in Section 7.
c	Monitor and/or control process parameters	- Monitoring and/or control of key waste and process parameters.

6.4.1.2 Techniques to reduce emissions to air

The emissions to air of pollutants and odorous substances of MBT plants are:

- Waste-specific (type, composition, age);
- Treatment-specific (aerobic degradation, anaerobic digestion);
- Process-specific (type of aeration);
- Dependent on operational management;
- Influenced meteorologically (weather conditions) in the case of open reactors.

In addition to the release of odorous substances at delivery and during mechanical treatment, the emissions of the plant mainly originate from the following sources:

- Aerobic degradation;

- Anaerobic digestion;
- Exhaust air/exhaust gas treatment

Given that MBT is a combination of mechanical and biological treatments, techniques described in TG on design and establishment of the Material Recovery Facilities and the Technical Guideline on Biological Treatment of Waste are also partially or fully relevant for MBT, depending on the subprocesses involved (for instance, aerobic or anaerobic). Therefore, this section, focuses on emissions and associated prevention techniques, specific to the MBT plants only.

In order to reduce channelled emissions to air of dust, organic compounds, and odorous compounds, including H2S and NH3, BAT is to use both of the techniques given below.

Technique		Description
a	Segregation of the Waste gas streams	Splitting of the total waste gas stream into waste gas streams with a high pollutant content and waste gas streams with a low pollutant content.
b	Recirculation of waste gas	Recirculation of waste gas with a low pollutant content in the biological process followed by waste gas treatment adapted to the concentration of pollutants. The use of waste gas in the biological process may be limited by the waste gas temperature and/or the pollutant content. It may be necessary to condense the water vapour contained in the waste gas before reuse. In this case, cooling is necessary, and the condensed water is recirculated when possible or treated before discharge.

6.4.1.3 Techniques to Reduce Water and Water Usage

Generally, there are three main sources of wastewater resulting from the operation of the composting treatment plants:

- Leachate;
- Washing water that is used to clean plant/equipment and surfaces; and
- Surface run-off water that has fallen on storage and/or treatment areas and might be contaminated. Run-off water from roofs or from areas that are not used for storing and treating waste are considered ‘clean’ water and may be discharged directly to the environment or can be used to keep the waste moist, for vehicle cleaning and hygiene.

The best available technologies for preventing and reducing emissions to air from the mechanical treatment are detailed in the TG on design and establishment of the Material Recovery Facilities and the emissions from the biological component of an MBT are presented in the Technical Guideline on Biological Treatment of Waste.

7 OPERATION AND MAINTENANCE

The following sections includes a series of techniques applicable to all MBT treatment plants in order to improve the overall performance based on Best Available Techniques (BAT), including:

- Waste pre-acceptance procedures;
- Waste acceptance;
- Waste storage and handling procedures;
- Facility and Equipment Maintenance;
- Output Management.

7.1 Waste pre-acceptance procedures

Pre-acceptance procedures shall be put in place in order to assess and confirm that the waste is technically and legally suitable for the MBT treatment plants. These pre-acceptance procedures must follow a risk-based approach, considering:

- The source and nature of the waste;
- Potential risks to process safety, occupational safety, and the environment (for example from odour and other emissions); and
- Knowledge about the previous waste holder(s).

Enough information from the waste producer/generator shall be shared to identify and track the waste that arrives in the MBT treatment plant. As a minimum, the following information shall be shared following the corresponding and stablished channels:

- Details of the waste producer including their organisation name, address and contact details;
- A description of the waste;
- The waste's List of Wastes Regulations code;
- The source of the waste;
- The waste's composition (based on representative samples if necessary); and
- An estimate of the quantity you expect to receive in each load and in a year.

Pre-acceptance procedures may also include waste sampling and waste characterisation in order to understand the composition of the waste.

After a waste has been properly assessed and classified, the waste's suitability for storage or treatment at the MBT treatment plant shall be technically assessed to make sure the permit conditions are met.

7.2 Waste acceptance

Controlling the waste input at a MBT treatment plant is one of the most important steps that will affect the entirety of the operations at a facility, directly impacting the pollution and nuisance potential, health and safety issues, material output quality, and the overall feasibility. It's essential that any input control measure

introduced is aligned with the waste acceptance requirements, both regarding the facility design and the corresponding license. At a minimum, upon reception the following procedures should be conducted:

- The waste should be weighed;
- The waste description should be matched with the actual content through a visual assessment at the inspection or tipping area. This visual assessment can be performed both before and after the waste is unloaded;
- Should a visual inspection not enable the facility operator to make a conclusive verification regarding the contamination of the load, further testing can be required;
- A record should be made for every batch including waste type, quantity, source, and transporter.

Acceptable materials, along with contaminants and prohibitive items should be clearly stated with any contracting party in order to ensure good input feed.

Prohibitive items, on the other hand, are those that do not meet the acceptance criteria, and can not only lead to issues for the treatment process and material output, but also cause major problems for the system and endanger the workers. For these items, any percentage detected within the load will lead to immediate rejection. The following is a non-exhaustive list of some common prohibitive items:

- Construction and demolition waste;
- Medical and biological waste;
- Explosives/flammables/combustibles;
- Bulky waste;
- Batteries; and
- Materials coated in liquids such as paint, petroleum, or chemical substances.

7.3 Waste storage and handling procedures

Waste shall be stored and handled in a way that ensures prevention and minimisation pollution risks by using appropriate measures. Storage will be located in areas where handling procedures are minimised. Waste handling must be carried out by qualified and authorised staff using appropriate equipment.

Storage areas shall be located within a security protected area to prevent unauthorised access and covered from potential meteorological agents like rain, wind, or sandstorms.

Maximum storage capacity of the MBT treatment plant and the designated storage areas shall be clearly documented in the management system. Stored waste against allowed maximum capacities must be regularly monitored to not exceed them.

First-in-first-out approach shall be followed unless a higher risk of pollution requires to prioritise more recently received waste.

In the event that combustible derived from waste will be produced (RDF and/or SRF) would be produced by the MBT treatment plant, the bales must be securely wrapped with high-density polyethylene (HDPE) membrane or equivalent. This is to prevent the ingress of water, access by pests and odour release. You should inspect bales regularly and rewrap any that are damaged. If wrapped securely, they can be stored outside

(unless your permit forbids this). If you store bales outside, your fire prevention plan must manage risks from solar heating during hot weather.

RDF and SRF storage duration shall be minimised. An auditable bale identification system shall be put in place in order to remove bales in date order. An export contract for the end use of your RDF or SRF before you export it shall be put in place. A certain limit of stockpile shall be established aligned with a contingency plan and measures for a potential diversion strategy to a Landfill disposal.

Any extra requirement for reception/storage for a specific MBT facilities process are included in the specific treatment subsections in Section 6.

7.4 Facility and Equipment Maintenance

Facility and equipment maintenance are a critical component of the daily operations at any MBT treatment plan as it will allow to maintain performance levels and product quality.

Some considerations regarding the choice of equipment can help prevent wear and reduce maintenance requirements. For instance, choosing equipment with newer technologies or equipment better fit to handle the waste expected, can lead to streamlined performance.

In terms of the mechanical process, equipment such as trommel screens can easily become plugged with plastic and other materials, reducing its ability to process waste, and resulting in lower quality screening. A correct cleaning of the screens together with a timely lubrication of all parts of the equipment is essential for a correct performance. Optical sorters for example can have performance issues due to the accumulation of dirt in the optics. If not maintained properly, every equipment, in addition to the lower performance, can end up requiring downtime, which would mean at the very least loss of revenue and increased expenses, and also lead to environmental constraints such as leaks, spillages, among others.

The following are some considerations to follow related to facility and equipment maintenance generally at a MBT treatment plant:

- Perform frequent preventative maintenance of processing and control equipment (i.e., cleaning, greasing, etc);
- Conduct periodic testing of storage equipment to search for signs of decaying structural integrity;
- Regularly inspect the facility looking for cracks, worn equipment, leaks, etc;
- Floors and walls should be cleaned frequently; and
- Drain holes should be cleared of debris.

Best practice dictates that equipment maintenance should be performed outside of working hours to prevent equipment downtime, and also to prevent maintenance being conducted on working equipment which could represent serious health risks.

7.5 Output Management

After materials are sorted, decisions must be made on whether they should be mechanically processed in order to have their size reduced through, for example, a shredder or a baler.

Shredders are more commonly applied to organic waste, since it increases the surface area and therefore air exposure, accelerates decomposition, reduces odours, and promotes dryness. This equipment is commonly

included in the initial steps of the different technologies of and MBT treatment plant (Aerobic Biodrying, Aerobic Stabilization and Anaerobic Digestion)

Balers, on the other hand, are a very common piece of equipment that will compact the sorted waste, allowing it to be stored and transported with the highest cost efficiency through the maximization of storage space and volume in each load. Bale selection is part of MBT treatment plant establishment as the recovered recyclable materials within the mechanical process and/or the RDF/SRF produced must meet market requirements in terms of size, density, and weight. Additionally, careful consideration must be given to the selection of materials to be baled, as depending on the input material and process efficiencies, baling materials with significant levels of contamination, typically of recyclable recovered materials from mix waste in a MBT treatment plant, can lead to large batches of sorted items being lost or having their market value dramatically reduced.

8 GENERAL HEALTH AND SAFETY CONSIDERATIONS AT LICENCES MECHANICAL BIOLOGICAL TREATMENT FACILITIES

8.1 Occupational health

Health and Safety requirements can be defined as the regulations and procedures intended to prevent injury and ill health to employees and those affected by their work. Normal activities on a MRF expose the workers, neighbouring communities, and environmental receptors to significant risks, potentially affecting not only those directly involved but a significantly larger population.

The organisation or facility management must:

- Provide changing rooms and toilets for personal hygiene and somewhere safe to eat and drink;
- Provide personal protective equipment; such as overalls, safety boots, safety gloves, masks, goggles or safety glasses, and head covers, if required; and
- Implement an occupational health and safety program for those handling waste, including:
    - Maintain a special file for each employee including the dates of examinations and vaccinations they received and any findings or reactions (this file shall be kept in the workplace); and
    - Report work injuries and, unless otherwise specified by the KSA government, record these against each employee, each job function, location worked and overall, for the facility.

All structures must be located in a suitable area of the site to allow control of day activities whilst also taking account of health and safety aspects.

Additional recommended operational measures include:

- Compost turners should be equipped with dust covers and moisture injection equipment in order to reduce the release of dust;
- Immediate processing of input organic waste should be carried out in order to prevent attracting rodents, birds, and insects;
- Regular cleaning and decontamination of the areas of the facility that are exposed to fresh feedstocks should be carried out in order to reduce unwanted microbial growth;
- The cleaning and servicing of equipment used in the composting area should be undertaken in non-contaminated areas;
- Doors and windows should be kept closed during operation; the cleanliness of the control cabin should be maintained;
- With cleansing and servicing work, which generate considerable amounts of microbial aerosols (e.g., bio-filter exchange), respiratory protection should always be worn;
- The driveways and working areas should be moistened, kept dust-free and cleaned regularly preferably with a sweeper or industrial vacuum cleaner;
- Avoid untreated process water from coming into contact with sanitized composting materials to prevent contamination.

For anaerobic digestion facilities in particular, there is the added hazard of potential asphyxiation and explosion as a result of the accumulation of pockets of bigas. Therefore, the plant must be well ventilated, particularly in areas handling post-digested sludge. Furthermore, the use of wall-mounted and or personal detectors/ alarms

in plant areas is common to warn operators of potential atmospheric hazards. Special attention must be given to maintenance work requiring work in confined spaces and to the removal of all ignition sources.

8.2 Safety equipment

All licensed waste facilities should be equipped with the following:

- Suitable personal protective equipment (PPE) appropriate for the type(s)waste being handled, including hazardous wastes, for all staff involved. Such PPE should include, as a minimum:
  - Eye protection, such as safety glasses, goggles, or a visor;
  - Gloves of suitable material to prevent penetration by sharp objects or by chemicals according to what is handled;
  - Safety boots;
  - Safety helmets if working under beams with high objects;
  - Suitable skin protection/covering;
  - Face masks to prevent inhalation of particulates in dusty atmospheres; and where working with plant or where vehicles are present;
  - High-visibility vests or similar.

- An internal communications or alarm system capable of providing immediate emergency instruction or warning to all personnel;
- A device, such as a telephone (immediately available at the scene of operations) or a hand-held, two-way radio, capable of summoning emergency assistance from local fire departments, ambulance, or emergency response teams;
- Where combustible and/or flammable wastes are stored, storage areas should be equipped with automatic smoke detection and, where necessary, fire suppression systems such as automatic sprinklers or other fire suppression systems;
- Portable fire extinguishers, fire control devices (including special extinguishing equipment, such as that using foam, inert gas, or dry chemicals), spill control materials and decontamination supplies; and
- Water at adequate volume and pressure to supply hoses, foam-producing equipment if appropriate.

All PPE and emergency equipment must be tested regularly and maintained to ensure proper operation.

Where combustible wastes or flammable hazardous wastes are stored or processes, it is good practice to develop a fire prevention and management plan, agreed with the relevant emergency services and approved by the Centre, which covers the management of combustible and/or flammable wastes, fire detection, suppression and fighting equipment and emergency procedures.

8.3 Professional Training and Certification

Facilities will only be operated by qualified and trained personnel. Therefore, the MBT treatment plants' Service Provider will regularly offer adequate training and education to its staff to ensure they are well-equipped to

manage the waste streams safely. Furthermore, the Service Provider will ensure to provide certificate, inhouse or via a 3rd parties, proving the fitness and health of workers on an annual basis.[9]

In detail, candidates who wish to be certified must have knowledge and be trained in all of the following areas:

- Mechanical-Biological treatment plants (MBT) theory, site infrastructure and basic design concepts including how features protect groundwater, surface water and air quality;
- MBT site operations such as:
  - Handling of waste including the movement, sorting, and storage of waste;
  - Receiving and transporting waste for onward transfer;
  - Site security.
- Regular maintenance of surface water control systems;
- Monitoring and reporting requirements specific to the relevant MRF including spills and storage requirements;
- Employee health and safety to include hazardous substances, PPE, and clean up requirements;
- Use of first aid kits and medical emergency equipment.

Employee training to include developing, implementing, and documenting training programmes for all personnel at the MBT. Prior to commencing work involving handling chemical substances or hazardous wastes, all personnel must be familiar with the relevant hazardous properties and instructed on what to do in case of emergency. Such instruction or training must include, as a minimum, the following:

- How to report a fire, injury, chemical spill, or other emergency;
- The location of emergency equipment, such as safety showers and eyewashes;
- The location of fire extinguishers and spill control equipment;
- The locations of all available exits for evacuation; and
- Names and phone numbers of the designated emergency coordinator and an alternate.

Training-related documents and records must be kept at the facility. These must include a job title for each person and the name of the employee filling that position. Also, a written job description is needed for each position and records documenting that the employee holding that position has completed the training or job experience satisfactorily. Finally, the files must contain the training records on current personnel and past employees for three years.

8.4 Accident Management Plan

An Accident Management Plan must be in place (reviewed at least once every three years or as requested by the competent authority, or in an event of an accident) which identifies:

- The likelihood and consequence of accidents; and
- Actions to prevent accidents and mitigate any consequences.

[9] (The Implementing Regulations of the Waste Management Law, 2021)

A structured accident management plan includes the following:

- Identifying the hazards to human health and environment posed by the treatment facilities:
  - Particular areas to consider may include waste types, overfilling of vessels, failure of equipment (e.g. over-pressure of vessels and pipework, blocked drains), failure of containment (e.g. bund and/or overfilling of drainage sumps), failure to contain firefighting water, making the wrong connections in drains or other systems, preventing incompatible substances coming into contact, unwanted reactions and/or runaway reactions, emission of an effluent before adequate checking of its composition has taken place, vandalism/arson, extreme weather conditions, e.g. flooding, very high winds.
- Assessing all risks (hazard multiplied by probability) of accidents and their possible consequences. Having identified the hazards, the process of assessing the risks can be viewed as addressing six basic questions:
  - What is the estimated probability of their occurrence? (Source, frequency);
  - What may be emitted and how much? (Risk evaluation of the event);
  - Where does it go? (Predictions for the emission – what are the pathways and receptors?);
  - What are the consequences? (Consequence assessment – the effects on the receptors);
  - What is the overall risk? (Determination of the overall risk and its significance for the environment);
  - What can be done to prevent or reduce the risk? (Risk management – measures to prevent accidents and/or reduce their environmental consequences).

  In particular, identifying fire risks that may be posed for example by:
  - Arson or vandalism;
  - Self-combustion (e.g., Due to chemical oxidation);
  - Plant or equipment failure & other electrical faults;
  - Naked lights & discarded smoking materials;
  - Hot works (e.g., Welding or cutting), industrial heaters and hot exhausts;
  - Reactions between incompatible materials;
  - Neighbouring site activities;
  - Sparks from loading buckets;
  - Hot loads deposited at the site.

  The depth and type of assessment will depend on the characteristics of the plant and its location. The main factors taken into account are:
  - The scale and nature of the accident hazard presented by the plant and the activities;
  - The risks to areas of population and the environment (receptors);
  - The nature of the plant and complexity of the activities and the relative difficulty;
  - In deciding on and justifying the adequacy of the risk control techniques.

- Identifying the roles and responsibilities of personnel involved in accident management. Together with this, clear guidance is available on how each accident scenario needs to be managed; for example, containment or dispersion, to extinguish fires or to let them burn;
- Establishing communication routes with relevant authorities and emergency services both before and in the event of an accident. Post-accident procedures include an assessment of the harm that may have been caused and remediation actions to be taken;
- Including the procedures and requirements to report to the relevant authorities (i.e., MWAN) all the necessary information in the event of an accident;
- Putting in place emergency procedures, including safe shutdown procedures and evacuation procedures;
- Appointing one facility employee as an emergency coordinator to take leadership responsibility for implementing the plan. It is important that the facility offers training to its employees to perform their duties effectively and safely so that staff know how to respond to an emergency.

9 DATA RECORDING, MONITORING AND REPORTING

9.1 Data recording

It is the responsibility of the operator of a Mechanical Biological Treatment Plant to implement, use and maintain a computerised waste tracking system to hold up-to-date information about the available capacity of different parts of the Mechanical Biological Treatment Facility, to make sure that the facility has enough waste storage and process capacity for the incoming acceptable waste.

The Service provider (plant operator) shall record, monitor, and report data on waste according to the license requirements as issued by the Centre. The minimum information to be kept up to date are as follows:

- The details of all waste received at the site, including date and time, the source and nature of waste, including the original producer's details and any waste code(s), weight, details of the transporter, the vehicle, and the driver;
- Details of any non-conformances and rejections, including consignment notes for waste rejected because is hazardous;
- The details of the outputs obtained after the waste treatment in the plant including the weight and the final destination. In the case of residues/rejects redirected to another waste facilities the information recorded will include also details of the transporter, the vehicle, and the driver;
- The details on the duration of the outputs stored within the site awaiting recovery/recycling (the stick);
- Any incidents that did result, or could have resulted, in an uncontrolled or unpermitted release from the site, such as a spillage of waste into the surface water drainage system; and
- Any accidents involving waste or waste transporting vehicles or waste processed in the plant that result in injury to staff or the public or serious damage to property.

The waste recording system shall be able to generate information for the waste streams accepted for treatment in the waste facility, the following as a minimum:

- The total amount of waste present on site at any one time;
- A breakdown of the waste quantities stored pending on-site treatment or awaiting onward transfer;
- Where a batch of waste is located based on a site plan;
- The quantity of waste on site compared with the limits set out in the license/permit;
- The length of time the waste has been on site compared with the limits in the license/permit.

Note: in addition to the above the service providers shall record, monitor, and report all environmental related parameters (water quality, air quality, noise, dust etc) according to the requirements of the Environmental Permit issued by the competent authority (NCEC) for the plant.

9.2 Periodic inspections and internal audits

Each facility should be monitored, either at random or at regular intervals to ensure that the site is being operated in accordance with:

- The working plan agreed with the Centre and incorporated into the licence; and
- Any conditions in the licence issued by the Centre.

This monitoring should be conducted by the designated responsible person, who should, *inter alia*:

- Periodically but irregularly undertake inspections to check the integrity of the equipment in the facility to prevent/reduce the risk of major accidents and to ensure that all primary and secondary containment is fit for purpose;
- The responsible person should ask questions of those responsible for handling the waste as to whether they have encountered any problems and what suggestions, if any, they may have for improvements; and
- The data on waste inputs and outputs should be interrogated and the amount and types of different wastes in store compared with the amount of waste visible in the temporary storage area and any differences noted and acted upon.

9.3 Waste Data Reporting

The designated person should use the data recorded above to monitor the production and/or the management of waste at the Mechanical Biological Treatment Plant on an ongoing basis. The designated person must prepare reports regarding all aspects related to waste such as production, processing, after treatment storage, waste redirected to 3rd parties for recycling/recovery or final elimination and provide a copy of these to the Centre competent authorities periodically as determined by these authorities.

Data can be reported on monthly or yearly basis as per requirements established in the Licence issued by the Centre and the data to be reported can include the following as an example:

A. General data:
   - The facility name, address, and permit number;
   - Site location (e.g., address of the site where works are carried out);
   - Name and contact detailed of the person in charge with data recording and reporting.

B. Data on the waste processed in the Facility:
   - Amount of waste accepted in the facility by waste stream and fraction including any waste code;
   - The total quantity in tons of output (recycling materials, SRF/RDF, compost/digestate, biogas) produced at the facility during the period covered by the report;
   - The total quantity in tons of output (recycling materials, SRF/RDF, compost/digestate, biogas) removed for use or disposal from the facility during the period covered by the report;
   - The results of analytical testing of the marketable outputs (SRF/RDF, compost/digestate, biogas), as well as all effluent to be disposed of or to undergo further treatment; and
   - Amount of waste/products awaiting transfer.

C. Data on Service Providers

APPENDIX 1 displays a table that can be used as template for recording and reporting waste data.

Failure to maintain records or provide documentation when solicited is a violation of the Law and will lead to legal consequences.

In addition, the Centre should analyse the data from each facility to compare the amounts of different categories of waste reported and seek reasons or explanations for any significant differences.

APPENDIX 1 Date Reporting – template

A. General information

- Name of the Waste Facility;
- Site Location;
- Period covered by the report and Completion date;
- Name and contact details of the person who filled in the data and approved the figures.

B. Information on resources and waste

B.1 Waste processed

Crt	Waste received in the Plant				
	Waste generator	Waste Transporter	Waste Stream/Fraction	Waste code	Amount Tones
1					
2					

B.2 After treatment products

Crt	Waste/products	Total Amount, tone	Amount directed to 3rd parties, tone	Amount in stock, tone
1	Recycling materials			
	- Paper/cardboard			
	- Glass			
	- Plastic			
	- others			
2	RDF/SRF			
3	Digestate/compost			
4	Rejects			
5	Others (biogas etc)			

C. Information on 3rd parties

- Information on waste transporters;
- Details of the entities who has purchased the products including name and address, amount of waste/materials purchased (by stream and total).

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National Center for Waste Management