

# **Solid waste management**

## **Introduction to solid waste management**

Solid waste is the unwanted or useless solid materials generated from combined residential, industrial and commercial activities in a given area. It may be categorised according to its origin (domestic, industrial, commercial, construction or institutional); according to its contents (organic material, glass, metal, plastic paper etc); or according to hazard potential (toxic, non-toxin, flammable, radioactive, infectious etc).

Management of solid waste reduces or eliminates adverse impacts on the environment and human health and supports economic development and improved quality of life. A number of processes are involved in effectively managing waste for a municipality. These include monitoring, collection, transport, processing, recycling and disposal.

## **Reduce, Reuse, Recycle**

Methods of waste reduction, waste reuse and recycling are the preferred options when managing waste. There are many environmental benefits that can be derived from the use of these methods. They reduce or prevent green house gas emissions, reduce the release of pollutants, conserve resources, save energy and reduce the demand for waste treatment technology and landfill space. Therefore it is advisable that these methods be adopted and incorporated as part of the waste management plan.

### *Waste reduction and reuse*

Waste reduction and reuse of products are both methods of waste prevention. They eliminate the production of waste at the source of usual generation and reduce the demands for large scale treatment and disposal facilities. Methods of waste reduction include manufacturing products with less packaging, encouraging customers to bring their own reusable bags for packaging, encouraging the public to choose reusable products such as cloth napkins and reusable plastic and glass containers, backyard composting and sharing and donating any unwanted items rather than discarding them. All of the methods of waste prevention mentioned require public participation. In order to get the public onboard, training and educational programmes need to be undertaken to educate the public about their role in the process. Also the government may need to regulate the types and amount of packaging used by manufacturers and make the reuse of shopping bags mandatory.

## Recycling

Recycling refers to the removal of items from the waste stream to be used as raw materials in the manufacture of new products. Thus from this definition recycling occurs in three phases: first the waste is sorted and recyclables collected, the recyclables are used to create raw materials. These raw materials are then used in the production of new products.

The sorting of recyclables may be done at the source (i.e. within the household or office) for selective collection by the municipality or to be dropped off by the waste producer at a recycling centres. The pre-sorting at the source requires public participation which may not be forthcoming if there are no benefits to be derived. Also a system of selective collection by the government can be costly. It would require more frequent circulation of trucks within a neighbourhood or the importation of more vehicles to facilitate the collection.

Another option is to mix the recyclables with the general waste stream for collection and then sorting and recovery of the recyclable materials can be performed by the municipality at a suitable site. The sorting by the municipality has the advantage of eliminating the dependence on the public and ensuring that the recycling does occur. The disadvantage however, is that the value of the recyclable materials is reduced since being mixed in and compacted with other garbage can have adverse effects on the quality of the recyclable material.

## Waste Collection

Waste from our homes is generally collected by our local authorities through regular waste collection, or by special collections for recycling. Within hot climates such as that of the Caribbean the waste should be collected at least twice a week to control fly breeding, and the harbouring of other pests in the community. Other factors to consider when deciding on frequency of collection are the odours caused by decomposition and the accumulated quantities. Descriptions of the main types of collection systems are given in the table below.



**Figure 1. Colour coded recycling bins for waste separation at the source of production** (source [www.unpluggedliving.com](http://www.unpluggedliving.com))

**Table 1 Descriptions of the main collection systems.** (Sourced from <http://web.mit.edu/urbanupgrading/upgrading/issues-tools/issues/waste-collection.html#Anchor-Collection-45656>)

System	Description	Advantages	Disadvantages
<b>SHARED: Residents can bring out waste at any time</b>			
Dumping at designated location	Residents and other generators are required to dump their waste at a specified location or in a masonry enclosure.	Low capital costs	Loading the waste into trucks is slow and unhygienic. Waste is scattered around the collection point. Adjacent residents and shopkeepers protest about the smell and appearance.
Shared container	Residents and other generators put their waste inside a container which is emptied or removed.	Low operating costs	If containers are not maintained they quickly corrode or are damaged. Adjacent residents complain about the smell and appearance.
<b>INDIVIDUAL: The generators need a suitable container and must store the waste on their property until it is collected.</b>			
Block collection	Collector sounds horn or rings bell and waits at specified locations for residents to bring waste to the collection vehicle.	Economical. Less waste on streets. No permanent container or storage to cause complaints.	If all family members are out when collector comes, waste must be left outside for collection. It may be scattered by wind, animals and waste pickers.
Curbside collection	Waste is left outside property in a container and picked up by passing vehicle, or swept up and collected by sweeper.	Convenient. No permanent public storage.	Waste that is left out may be scattered by wind, animals, children or waste pickers. If collection service is delayed, waste may not be collected or some time, causing considerable nuisance.
Door to door collection	Waste collector knocks on each door or rings doorbell and waits for waste to be brought out by resident.	Convenient for resident. Little waste on street.	Residents must be available to hand waste over. Not suitable for apartment buildings because of the amount of walking required.
Yard collection	Collection laborer enters property to remove waste.	Very convenient for residents. No waste in street.	The most expensive system, because of the walking involved. Cultural beliefs, security considerations or architectural styles may prevent laborers from entering properties.

## Treatment & Disposal

Waste treatment techniques seek to transform the waste into a form that is more manageable, reduce the volume or reduce the toxicity of the waste thus making the waste easier to dispose of. Treatment methods are selected based on the composition, quantity, and form of the waste material. Some waste treatment methods being used today include subjecting the waste to extremely high temperatures, dumping on land or land filling and use of biological processes to treat the waste. It should be noted that treatment and disposal options are chosen as a last resort to the previously mentioned management strategies reducing, reusing and recycling of waste (figure 1).

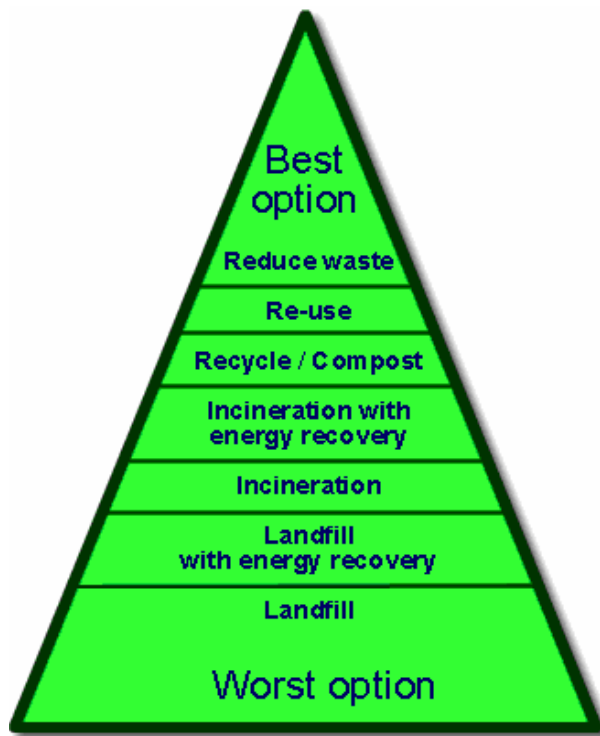


Figure 2 Solid waste management hierarchy (source <http://www.sustainability-ed.org/pages/example2-2.htm>)

## **Thermal treatment**

This refers to processes that involve the use of heat to treat waste. Listed below are descriptions of some commonly utilized thermal treatment processes.

### *Incineration*

Incineration is the most common thermal treatment process. This is the combustion of waste in the presence of oxygen. After incineration, the wastes are converted to carbon dioxide, water vapour and ash. This method may be used as a means of recovering energy to be used in heating or the supply of electricity. In addition to supplying energy incineration technologies have the advantage of reducing the volume of the waste, rendering it harmless, reducing transportation costs and reducing the production of the green house gas methane

### *Pyrolysis and Gasification*

Pyrolysis and gasification are similar processes they both decompose organic waste by exposing it to high temperatures and low amounts of oxygen. Gasification uses a low oxygen environment while pyrolysis allows no oxygen. These techniques use heat and an oxygen starved environment to convert biomass into other forms. A mixture of combustible and non-combustible gases as well as pyrolytic liquid is produced by these processes. All of these products have a high heat value and can be utilised. Gasification is advantageous since it allows for the incineration of waste with energy recovery and without the air pollution that is characteristic of other incineration methods.

### *Open burning*

Open burning is the burning of unwanted materials in a manner that causes smoke and other emissions to be released directly into the air without passing through a chimney or stack. This includes the burning of outdoor piles, burning in a burn barrel and the use of incinerators which have no pollution control devices and as such release the gaseous by products directly into the atmosphere (Department of environmental quality 2006). Open-burning has been practiced by a number of urban centres because it reduces the volume of refuse received at the dump and therefore extends the life of their dumpsite. Garbage may be burnt because of the ease and convenience of the method or because of the cheapness of the method. In countries where house holders are required to pay for garbage disposal, burning of waste in the backyard allows the householder to avoid paying the costs associated with collecting, hauling and dumping the waste.

Open burning has many negative effects on both human health and the environment. This uncontrolled burning of garbage releases many pollutants into the atmosphere. These include dioxins, particulate matter, polycyclic aromatic compounds, volatile organic compounds, carbon monoxide, hexachlorobenzene and ash. All of these chemicals pose serious risks to human health. The Dioxins are capable of producing a multitude of health

problems; they can have adverse effects on reproduction, development, disrupt the hormonal systems or even cause cancer. The polycyclic aromatic compounds and the hexachlorobenzene are considered to be carcinogenic. The particulate matter can be harmful to persons with respiratory problems such as asthma or bronchitis and carbon monoxide can cause neurological symptoms.

The harmful effects of open burning are also felt by the environment. This process releases acidic gases such as the halo-hydrides; it also may release the oxides of nitrogen and carbon. Nitrogen oxides contribute to acid rain, ozone depletion, smog and global warming. In addition to being a green house gas carbon monoxide reacts with sunlight to produce ozone which can be harmful. The particulate matter creates smoke and haze which contribute to air pollution.

## **Dumps and Landfills**

### *Sanitary landfills*

Sanitary Landfills are designed to greatly reduce or eliminate the risks that waste disposal may pose to the public health and environmental quality. They are usually placed in areas where land features act as natural buffers between the landfill and the environment. For example the area may be comprised of clay soil which is fairly impermeable due to its tightly packed particles, or the area may be characterised by a low water table and an absence of surface water bodies thus preventing the threat of water contamination.

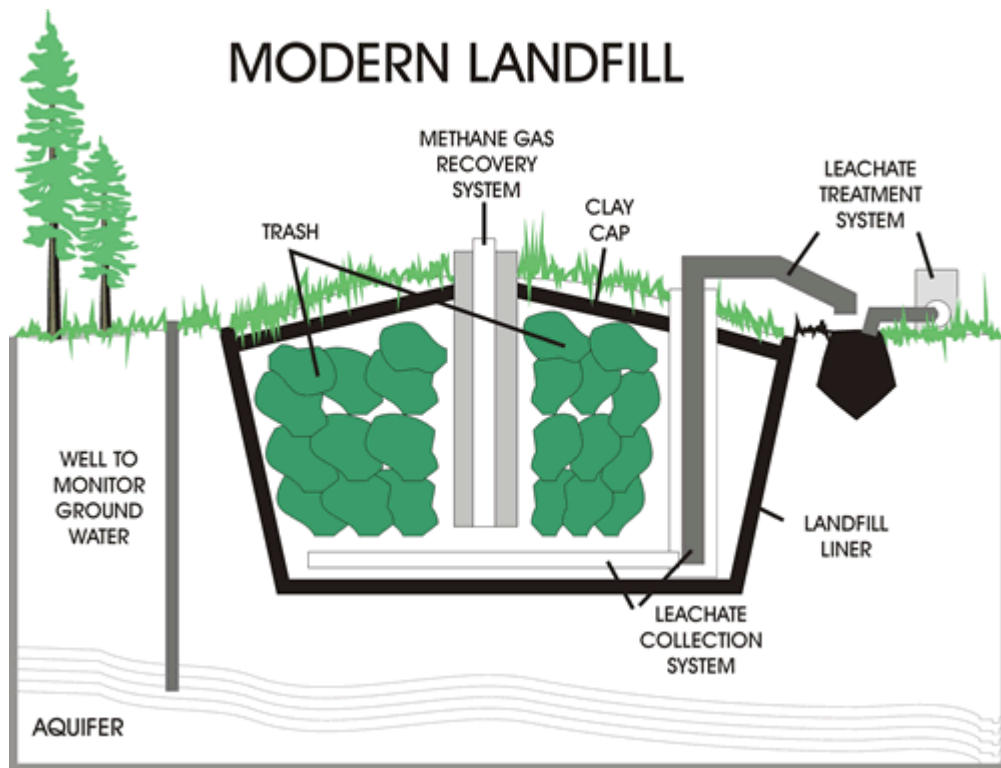
In addition to the strategic placement of the landfill other protective measures are incorporated into its design. The bottom and sides of landfills are lined with layers of clay or plastic to keep the liquid waste, known as leachate, from escaping into the soil. The leachate is collected and pumped to the surface for treatment. Boreholes or monitoring wells are dug in the vicinity of the landfill to monitor groundwater quality.

A landfill is divided into a series of individual cells and only a few cells of the site are filled with trash at any one time. This minimizes exposure to wind and rain. The daily waste is spread and compacted to reduce the volume, a cover is then applied to reduce odours and keep out pests. When the landfill has reached its capacity it is capped with an impermeable seal which is typically composed of clay soil.

Some sanitary landfills are used to recover energy. The natural anaerobic decomposition of the waste in the landfill produces landfill gases which include Carbon Dioxide, methane and traces of other gases. Methane can be used as an energy source to produce heat or electricity. Thus some landfills are fitted with landfill gas collection (LFG) systems to capitalise on the methane being produced. The process of generating gas is very slow, for the energy recovery system to be successful there needs to be large volumes of wastes.

These landfills present the least environmental and health risk and the records kept can be a good source of information for future use in waste management, however, the cost of

establishing these sanitary landfills are high when compared to the other land disposal methods.



**Figure 3 Main features of a modern landfill (source <http://www.eia.doe.gov/kids/energyfacts/saving/recycling/solidwaste/landfiller.html>)**

### *Controlled dumps*

Controlled dumps are disposal sites which comply with most of the requirements for a sanitary landfill but usually have one deficiency. They may have a planned capacity but no cell planning, there may be partial leachate management, partial or no gas management, regular cover, compaction in some cases, basic record keeping and they are fenced or enclosed. These dumps have a reduced risk of environmental contamination, the initial costs are low and the operational costs are moderate. While there is controlled access and use, they are still accessible by scavengers and so there is some recovery of materials through this practice.

### *Bioreactor Landfills*

Recent technological advances have led to the introduction of the Bioreactor Landfill. The Bioreactor landfills use enhanced microbiological processes to accelerate the decomposition of waste. The main controlling factor is the constant addition of liquid to maintain optimum moisture for microbial digestion. This liquid is usually added by re-

circulating the landfill leachate. In cases where leachate is not enough, water or other liquid waste such as sewage sludge can be used. The landfill may use either anaerobic or aerobic microbial digestion or it may be designed to combine the two. These enhanced microbial processes have the advantage of rapidly reducing the volume of the waste creating more space for additional waste, they also maximise the production and capture of methane for energy recovery systems and they reduce the costs associated with leachate management. For Bioreactor landfills to be successful the waste should be comprised predominantly of organic matter and should be produced in large volumes.

## **Biological waste treatment**

### *Composting*

Composting is the controlled aerobic decomposition of organic matter by the action of micro organisms and small invertebrates. There are a number of composting techniques being used today. These include: in vessel composting, windrow composting, vermicomposting and static pile composting. The process is controlled by making the environmental conditions optimum for the waste decomposers to thrive. The rate of compost formation is controlled by the composition and constituents of the materials i.e. their Carbon/Nitrogen (C/N) ratio, the temperature, the moisture content and the amount of air.

The C/N ratio is very important for the process to be efficient. The micro organisms require carbon as an energy source and nitrogen for the synthesis of some proteins. If the correct C/N ratio is not achieved, then application of the compost with either a high or low C/N ratio can have adverse effects on both the soil and the plants. A high C/N ratio can be corrected by dehydrated mud and a low ratio corrected by adding cellulose.

Moisture content greatly influences the composting process. The microbes need the moisture to perform their metabolic functions. If the waste becomes too dry the composting is not favoured. If however there is too much moisture then it is possible that it may displace the air in the compost heap depriving the organisms of oxygen and drowning them.

A high temperature is desirable for the elimination of pathogenic organisms. However, if temperatures are too high, above 75°C then the organisms necessary to complete the composting process are destroyed. Optimum temperatures for the process are in the range of 50-60°C with the ideal being 60°C.

Aeration is a very important and the quantity of air needs to be properly controlled when composting. If there is insufficient oxygen the aerobes will begin to die and will be replaced by anaerobes. The anaerobes are undesirable since they will slow the process, produce odours and also produce the highly flammable methane gas. Air can be incorporated by churning the compost.



## Anaerobic Digestion

Anaerobic digestion like composting uses biological processes to decompose organic waste. However, where composting can use a variety of microbes and must have air, anaerobic digestion uses bacteria and an oxygen free environment to decompose the waste. Aerobic respiration, typical of composting, results in the formation of Carbon dioxide and water. While the anaerobic respiration results in the formation of Carbon Dioxide and methane. In addition to generating the humus which is used as a soil enhancer, Anaerobic Digestion is also used as a method of producing biogas which can be used to generate electricity.

Optimal conditions for the process require nutrients such as nitrogen, phosphorous and potassium, it requires that the pH be maintained around 7 and the alkalinity be appropriate to buffer pH changes, temperature should also be controlled.

## Integrated Solid Waste Management

Integrated Solid Waste Management (ISWM) takes an overall approach to creating sustainable systems that are economically affordable, socially acceptable and environmentally effective. An integrated solid waste management system involves the use of a range of different treatment methods, and key to the functioning of such a system is the collection and sorting of the waste. It is important to note that no one single treatment method can manage all the waste materials in an environmentally effective way. Thus all of the available treatment and disposal options must be evaluated equally and the best combination of the available options suited to the particular community chosen. Effective management schemes therefore need to operate in ways which best meet current social, economic, and environmental conditions of the municipality.

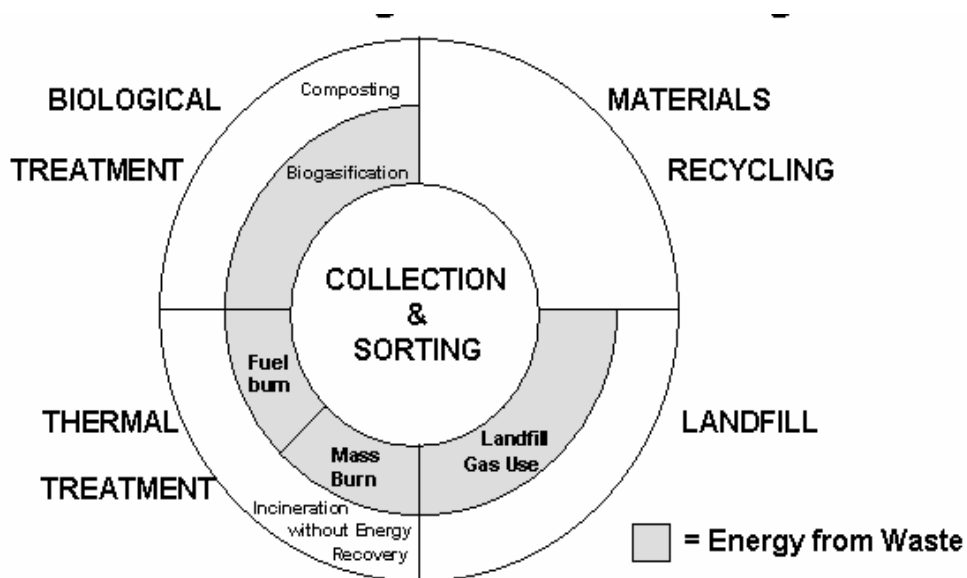


Figure 4 Elements of Integrated Solid Waste Management (source <http://viso.ei.jrc.it/iwmlca/>)

## Useful Websites

- United Nations Environment Programme *International Source Book on Environmentally Sound Technologies (ESTs) for Municipal Solid Waste Management (MSWM)* <<http://www.unep.or.jp/ietc/ESTdir/Pub/MSW/index.asp>>
- Sewerage and Solid Waste Project Unit. 2000. *The solid waste management programme*. Sewerage and Solid Waste Project Unit, Barbados.  
<<http://www.solid.gov.bb/Resources/Brochures/Programme/program02.asp>>
- <http://www.wasteonline.org.uk/resources/InformationSheets/WasteDisposal.htm>
- <http://www.eia.doe.gov/kids/energyfacts/saving/recycling/solidwaste/landfiller.html>
- <http://web.mit.edu/urbanupgrading/upgrading/issues-tools/issues/waste-collection.html#Anchor-Collection-45656>
- <http://www.sustainability-ed.org/pages/example2-2.htm>
- <http://www.massbalance.org/downloads/projectfiles/1826-00237.pdf>
- <http://msw.cecs.ucf.edu/Lesson8-Incineration.html>
- <http://www.csiro.au/org/ps16w.html>
- <http://viso.ei.jrc.it/iwmlca/>