Technological solutions for urban solid waste management

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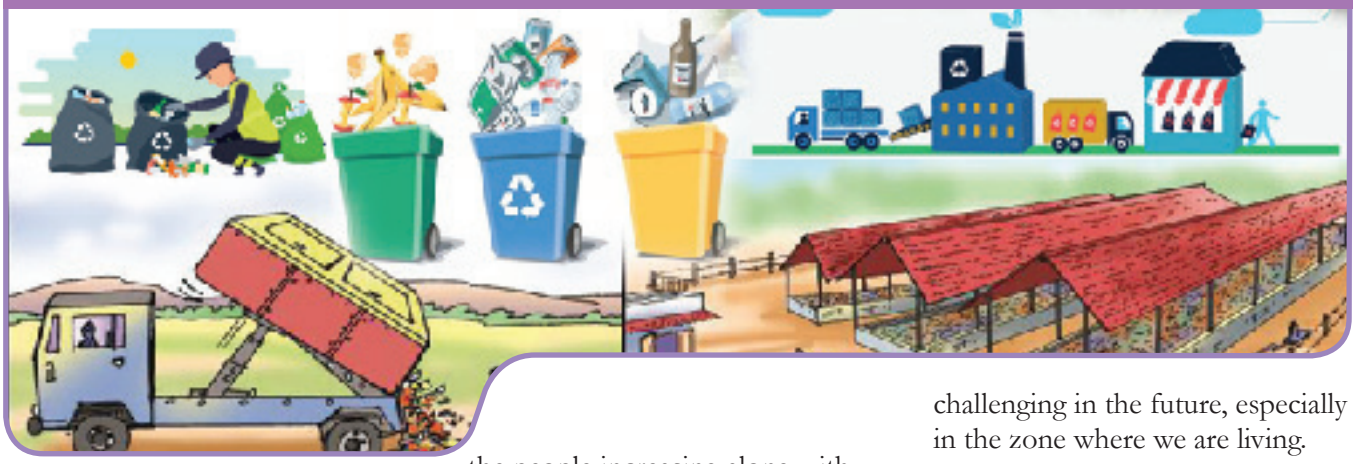


Solid waste is the waste that is physically identifiable as solid or semi solid matter and generated by our activities on a daily basis. Solid waste may be mainly categorized into three groups according to how such waste should be handled or managed. These categories are

1. Municipal Solid Waste
2. Industrial Solid Waste
3. Biomedical Solid Waste

Each of the above groups possess specific qualities and municipal solid waste is considered as the normal solid waste. Industrial waste and Biomedical waste are referred to as hazardous waste and infection waste respectively. This article will discuss mainly the technological methods relevant to the management of normal solid waste or the solid waste that is collected by the provincial institutions.

Waste generation is determined mainly by two factors. They are the extent of the population and their economic status. What is meant by this is that with the increase in population in a country or a region, and the change in the economic status of its people, and the consumer capacity of the people increasing along with their economic capacity, waste generation increases simultaneously. Today the municipal solid waste generated annually in the entire globe is about 1.3 billion tonnes. It is predicted that this could increase upto 2.2 billion tonnes by 2025.

The main reason for the two fold increase in waste generation globally during the next decade is the increase in the economic capacity and the concomitant increase in the pattern of material consumerism among the population of Asia and Asia Pacific regions. Therefore it is likely that the waste problem will be immensely challenging in the future, especially in the zone where we are living.

The global municipal waste generation during the next few decades

It is calculated that at present in Sri Lanka about 7000 metric tonnes of municipal solid waste is generated per day. Of this 60% is generated in the western province. According to the information available at present, the solid waste generation in Sri Lanka increases by 2% annualy. This would increase further along with the special development projects taking place in the country. Therefore, it is important for the institutions dealing with this subject and also for the citizens in general

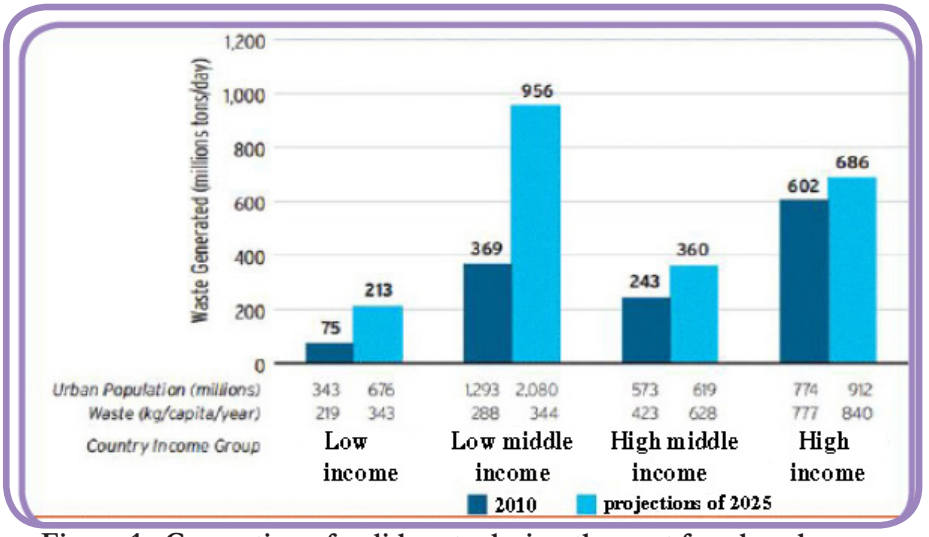


Figure 1 : Generation of solidwaste during the next few decades

to be equipped with relevant knowledge, and a training in waste management and the technological methods that can be used for waste management.

Waste management is not merely the final disposal of waste but it is tied up with a series of background processes. Accordingly in waste management it is necessary to consider the chain of processes such as reduction of waste generation, sorting, collection, reuse, recycling, treatment and the final disposal. Of these the treatment of waste is very crucial. It would be possible to manipulate the waste management technology by gaining knowledge of the scientific background relevant to waste management. Therefore, in the following sections it is proposed to discuss the technological processes of waste treatment.

The various technological processes employed in waste management should be determined by the nature of the waste to be treated. Thus it is important to be aware of the nature of waste. (characterization) Through this it will be possible to employ the most suitable technology and manipulate it for successful management. In order to identify the nature of waste three simple characteristics of the waste are considered. They are:

- Physical Properties
- Chemical Properties
- Biological Properties

The composition, density (specific density) moisture content, particle size and its distribution, the water holding capacity (field capacity) and the permeability to water are identified as the main physical properties of waste material. For example by knowing the composition of the waste material one can gain an idea of its content and based on this it is possible to decide on the type of treatment. If the waste has a very high percentage of decaying matter and moisture it can be used for making compost or production of biogas. Chemical properties of waste includes proximate analysis, fusing point of ash, ultimate analysis and energy value. These properties receive much consideration when waste is used for the generation of electricity. For example in order to employ the technology for electricity generation from waste it is essential that the energy content of waste should have a minimum value of 1500-2000 Kcal/Kg. Thus, this information can be obtained by studying the chemical properties of waste.

The biological properties of waste include its biodegradability and the production of bad smelling gases. Even though it is necessary to obtain more information regarding the afore mentioned properties it is not intended to discuss them at length in this article.
However it is possible to identify the real scientific nature of waste based on the above properties and thereby determine the suitable method for treatment of waste. There are various treatment methods for waste management and they can be summarized as shown in the diagram given below.
Waste treatment methods

As shown in the diagram waste treatment can be categorized into three main methods as

1. Physical treatment
2. Thermochemical treatment
3. Biochemical treatment

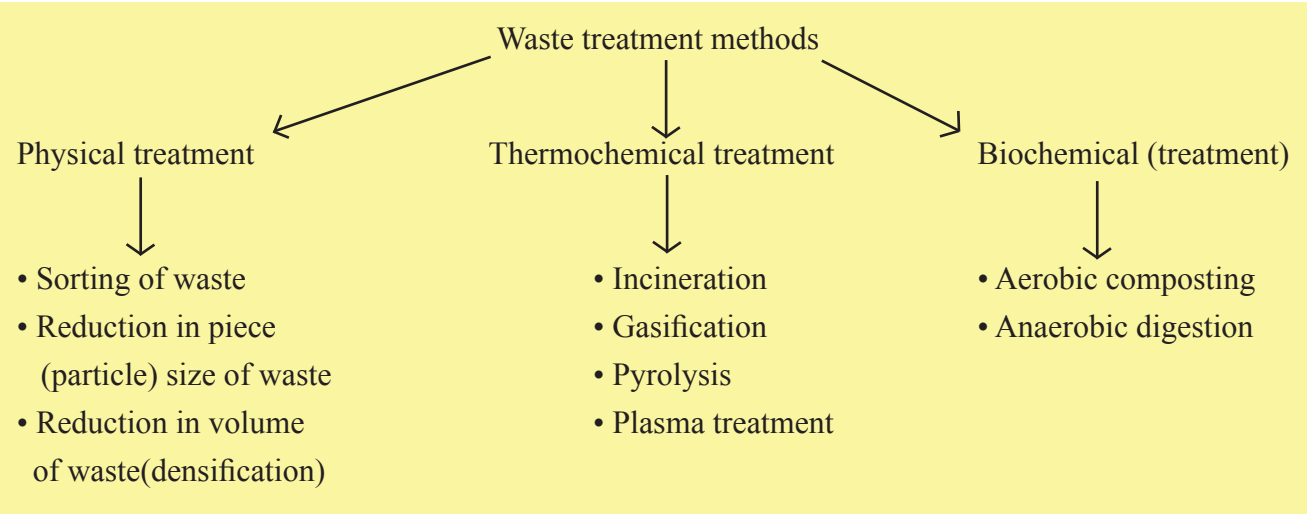


Figure 2 : Classification of waste treatment methods

A. Physical treatment methods

All physical treatment methods are considered as pretreatment methods. Physical treatment methods do not bring about a change in the chemical nature of the waste material. It only causes a change in the physical nature of the waste there by making the waste management process easier. There are several physical treatment methods. The details of these are described below.

Figure 3 : Usage of colour codes to seperate waste

Sorting of the waste

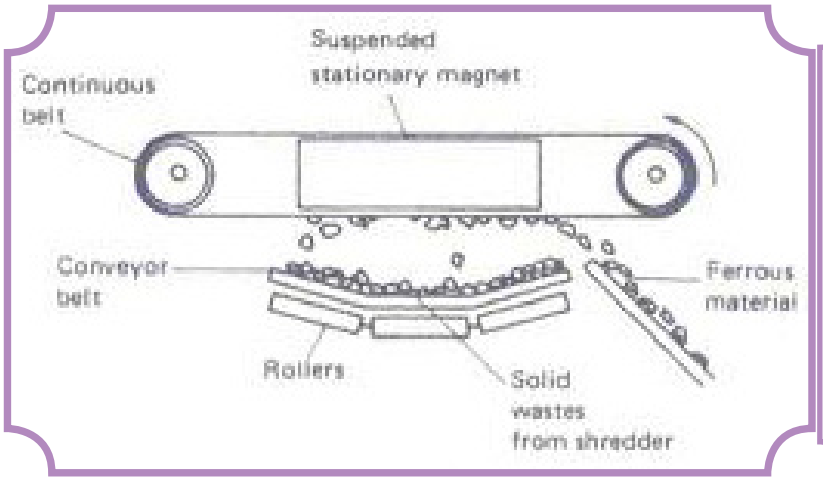
This is a simple process. Sorting may be carried out either manually or using machines. The mixture of solid waste is separated into more uniform fractions by sorting. The separated fractions are then further treated according to their nature. The most difficult task in waste management is the manual sorting. Various methods are employed to make this simpler. Of these the main one is the colour scheme method. The waste cooked food is placed in green bins, waste polythene and plastic is placed in orange bins, paper waste in blue bins and metal waste in brown bins, according to the national policy in Sri Lanka.

Use of the colour schme method for sorting waste

Machinery may be used for sorting waste and is used in the waste management projects at the commercial level. Screening, density separation, Electronic sorting and Magnetic sorting are the separation methods when machines are used. In these mechanized methods of separation technological principles are employed. As an example in the Density separation method the machine is used to separate the fractions based on the density of the particles / pieces of the solid.

Reduction in particle/piece size of waste (shredding/ pulverization)

This is also a physical treatment process during which the solid material is broken down into smaller pieces making it easier for further treatment. As an example, for composting, machines are used to reduce the size of the pieces of waste material. This increases the surface area which brings about better microbial activity. Such machines are used in most



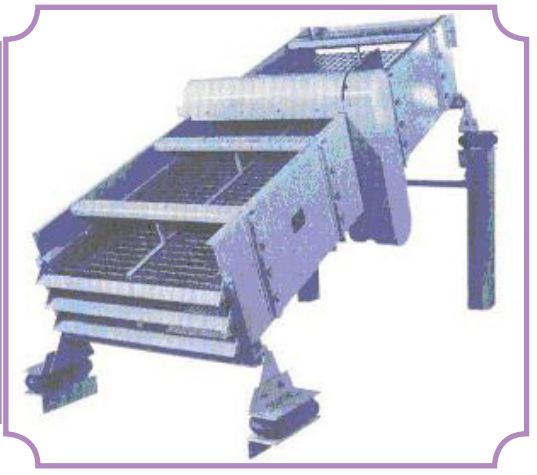


Figure 4 : Equipments for mechanical waste seperation

Table 1 : Thermochemical treatment methods and the resulting products

By products	Pyrolysis	Gasification	Combustion	Plasma treatment
Gaseous by products	H_2,CO,H_2O,N_2 Hydrocarbons	H_2,CO,CO_2, CH_4,H_2O,N_2	CO_2,H_2O, O_2,N_2	H_2,CO,N_2, CO_2,CH_4,H_2O
Solid by products	Ash, coke/charcoal	Ash,Slag	Ash	Slag
Liquid by products	Pyrolysis oil, Water			Pyrolysis oil,Water

waste management projects at a commercial scale.

Increasing the density of waste material - Densification

The main problem in waste management during handling and transport is the volume of the waste material. The physical treatment methods offer a solution to this problem. By subjecting the waste material to high pressure it is possible to increase the density and there by greatly reduce the volume. Then it is easier to store and transport the waste material. Baling and Pelleting are two of the main methods of subjecting the waste to high pressure.

Figure 5 : A machine used to reduce the size of waste particles/pieces (Shredder)

Waste made into Pellets and Bales

B. Thermochemical treatment methods

Thermochemical treatment is one of the methods employed at the commercial level for treatment of waste. During this process the chemical nature of the waste is made to undergo a change. The more suitable waste for this treatment is that which has more moisture and a relatively high calorific value.
This treatment is based on heat. The chemical nature of the waste is changed by heat. This is called thermal decomposition. There are many thermal processes that are employed for this chemical treatment. Incineration, Gasification, Pyrolysis and Plasma treatment are some of these technologies. The treatment methods in each of these processes are different and the products also vary accordingly.

When waste treatment is carried out by thermochemical methods heat is generated. During some thermochemical treatments combustible gases (syn gas : carbon monoxide, hydrogen, methane) and oils with high energy values are generated as byproducts. These by products may be directly used in the production of energy. When considering all these factors it would be possible to produce 14.4 kwh of electricity from 1 metric tonne of normal urban solid waste through this treatment.
The thermochemical treatment method is a fine solution for two of the problems that the world is facing today, namely, the crisis of urban solid waste and the energy crisis.

There are advantages and disadvantages of the Thermochemical treatment method. During this process gases which are harmful are released. Also waste ash (bottom

Figure 6 : Waste made into Pellets and Bales

ash and fly ash) is produced as a residue. Most countries employ various methods of treating these problem causing byproducts generated during thermochemical treatment before releasing them to the environment. Also in many countries limits and regulations have been laid down for the release of the gases from the incinerators to the environment. Accordingly it is very important to control the environmental problems caused by the thermochemical treatment of waste material. Subsequent post investigations are also necessary to be carried out. In Sri Lanka there are no environmentally friendly, thermochemical treatment mehods carried out on a commercial scale. This type of method carried out especially in the Western Province for waste management in the coming years, can be turned into a blessing. In order to popularize this type of a treatment method the government has already taken the policy decision of agreeing to purchase the electricity generated by such a method, taking into consideration the dangerous problems caused by waste.

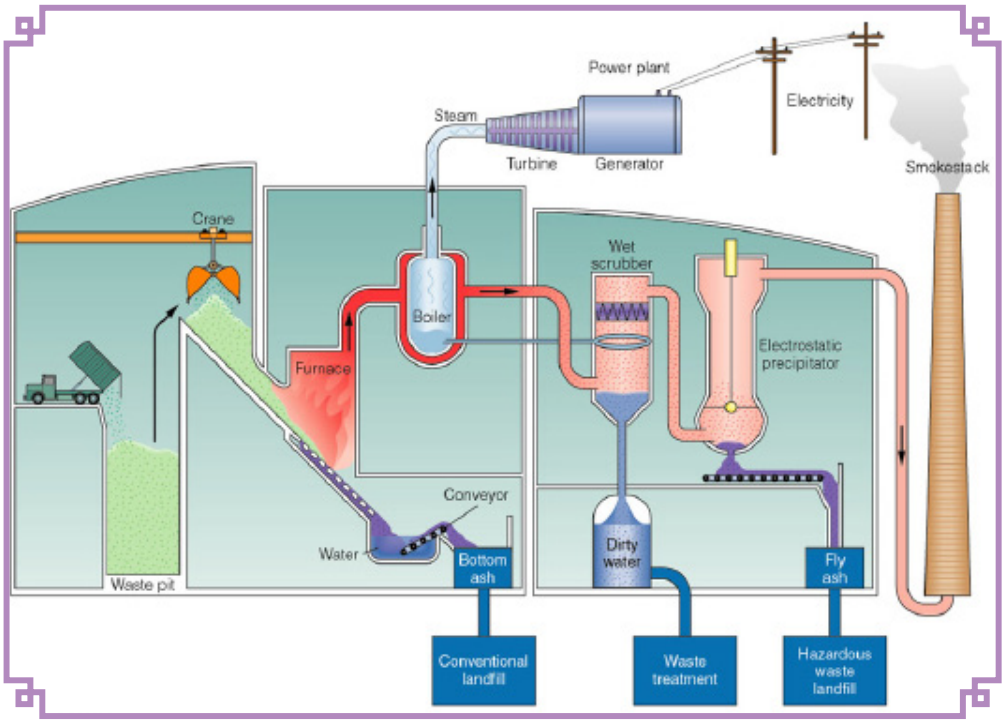


Figure 7 : Diagram of a incinerator used in the combustion of waste

C. Biochemical treatment methods

- The third main waste treatment method is the biochemical method. It is the waste with a high moisture content and having a relatively high percentage of biodegradable waste material that can be used for this type of treatment. This method can be considered as a naturally occurring process. During this treatment the nature of the waste material is subjected to physical as well as chemical changes. The microorganisms living naturally in nature are used for the process. Biochemical treatment may be discussed as two methods:
  - aerobic composting
  - anaerobic digestion

A. Aerobic composting

In a simple way composting can be described as the complete or partial decomposition of biodegradable or decomposable waste material by microorganisms. The direct product obtained is humus or compost. This is a more environmentally friendly method that can be used for waste management. The potential to use the resulting compost in agriculture and land- scaping activities is high. It is possible to use such compost to improve the soils with a lower percentage of carbon (less than 1%) which is present specially in the tropical countries (Tropical ferruginous soil).

Even though composting takes place as a natural process, it is controlled based on scientific principles. There are many factors affecting the decomposition of waste material. By gaining a thorough knowledge of such factors it is possible to make decomposition take place in an environmentally friendly manner and to obtain the maximum beneficial results. The C:N ratio, pH value, air, water content, temperature and the nature of the particle/piece size of the material are among the very important factors affecting the composting process. It is possible to carry out the composting process to obtain better results by maintaining the above factors at optimum levels. It is possible to carryout compostng in an environmentally

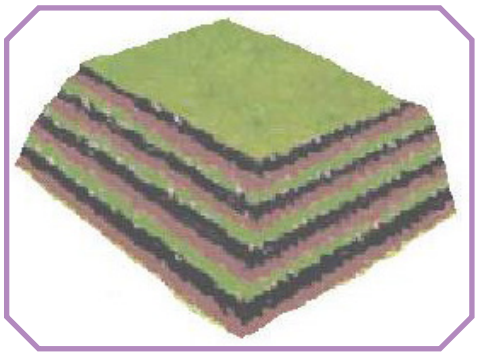




Figure 8 : Pit method, Pile method & Biological enclosure method

friendsly manner at various levels such as from the household level to the commercial levels. Various machinery, apparatus and methods can be used for the purpose. Traditional methods such as the pit method, land (or pile) method and biological enclosure method are employed. These traditional methods are less costly and can be carried out by any individual in their home or garden environment. Modern composting methods have already been introduced, considering the acute necessity of composting. Passive piles, windrowing, aerated stock piles, reactor vessels, rotating drums and invasive composting are such techniques.

Each of these methods create the environment to provide the various factors which affect composting at optimum levels. Through such methods it is also possible to obtain compost of high quality.
When producing compost on a commercial scale it is essential to examine the quality of the compost. Accordingly the physical, the chemical and the biological properties of the compost has to be examined. It is also necessary to determine whether heavy metals are presnt. Then it is possible to certify the quality of the compost.

B. Anaerobic Digestion

This is the anaerobic digestion or biogas production method. This is a digestion process carried out using microorganisms. Methane which is a combustible gas is produced as a direct product of this process. With a composition of 65% of CH_4 and 35% of CO_2, biogas technology has a long history, and it is believed that the Chinese introduced this method to the world. It is possible to employ this technological method of waste treatment from the house hold level right up to commercial scale. It is a complex technological process which has to be manipulated with great care and attention. Similar to composting, there are many factors affecting this process and by providing these factors at optimum levels it would be possible to use biogas generators profitably for waste management.
Various technical methods are used world over to generate biogas. They are categorized as follows.
1. Chinese method (continuous fixed dometype)
2. Indian method (continuous floating gas holder type)
3. Sri Lankan method (Sri Lankan batch type reactor)

These biogas generators possess various efficiencies. They have to be manipulated according to specific procedures. In Sri Lanka the present number of biogas generators exceed 2000 and it is possible to use these as a solution to the energy crisis. During the anaerobic digestion process, in addition to the main product of biogas it is possible to obtain liquid fertilizer and compost. The biogas can be purified by removing the CO_2 and then used to generate electricity with a generator. Therefore this method is not only a waste management process but also an important method that can be used to produce energy. The energy contained in one cubic inter of biogas is equivalent to that in 0.6 liters of diesel or 0.67 liters of petrol or 1.25 kwh of electricity.

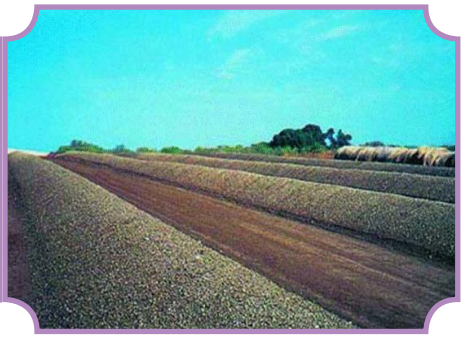



Figure 9 : Static pile & Windrow

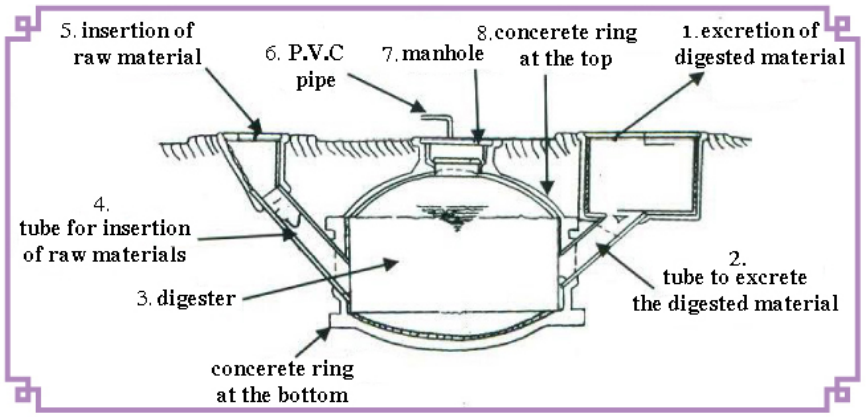


Figure 10 : Chinese method (continous fixed dome type)

The Chinese method is characterized by a continuous fixed dome type and the following features.

- Exit of decomposed matter
- Outlet pipe for decomposed matter
- Digester
- Inlet for raw materials
- Feeding in raw materials
- PVC pipe
- Manhole
- Top concrete ring

Sanitary land filling

In addition to the waste treatment methods given above, it is also important to be informed of the final disposal of the residual matter resulting from waste management. So it is necessary to be aware of the land fill technology. Land filling has received minimum attention by the national policy on waste management. Sanitary land filling was introduced to the world in 1900 as a final waste disposal method. This method by following certain procedures, aims to minimize the harm caused to the environment by irregular deposition of waste material. Scientifically the method is called sanitary land filling. During sanitary land filling, the management of the treatment of the waste water generated, foul smells, and the environmental problems that may be created by the waste material are the main factors to be considered.

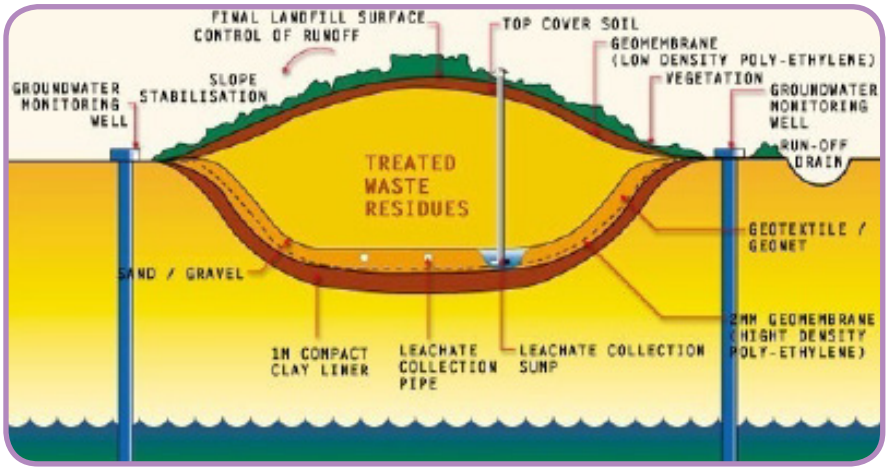


Figure 11 : Plan of a Sanitary land filling

Plan of a sanitary land filling

The objective of waste management in the 21st century is to use waste material as a resource as far as possible. Therefore many countries use sanitary land filling only for the residual waste material - the ash and other matter which cannot be used as a resource any more.

All methods mentioned above (except for the sanitary land filling method) aim to use waste material as a resource. However, it is very difficult to get the general public to use these methods. It is necessary to direct the attention of the public towards this objective. It has to be made clear that it is a social responsibility of the public. Also the public has to be duly informed of the technologies of waste management. It is possible to have a fruitful solution to the waste material problem.

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