Synthetic Microbial Research- Challenges and Prospects

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The 3Rs of managing solid waste: reduce, reuse and recycle

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Abstract

Proper waste management is an essential part of society's public and environmental health. A technological approach to solid-waste management began to develop in the latter part of the 19th century. The common methods used are Incineration and landfilling. Due to growth in population & urbanization the generation of solid waste has increased significantly, which leads to Health, environmental issues. Modern solid-waste management plants in most developed countries now emphasize the practice of recycling and waste reduction at the source. Proper collection, storage, processing, transport & disposal of waste should be followed to minimize the issues related to waste generation for a green living.

Key words: solid waste management, Reduce, Reuse, Recycle

Introduction

As defined under the Environment Protection Act 1993, Waste means – any discarded, rejected, abandoned, unwanted or surplus matter, whether or not intended for sale or for recycling, reprocessing, recovery or purification by a separate operation from that which produced the matter; or anything declared by regulation (after consultation under section 5A) or by an environment protection policy to be waste, whether of value or not. Waste is an unavoidable by-product of most human activity (Abdel-Shafy HI et.al 2018). The disposal of waste has been done in a haphazard manner since ages, be it in villages, towns or cities. But today waste generation and disposal has become a matter of concern owing to the enormous increase in population, the changes in our lifestyles . in this context the chapter discuss the different dimensions of waste management,which include the types of solid waste generated,treatment and sustainable management.

What is waste

The definition for waste; a material, substance, or by-product) eliminated or discarded as no longer useful or required after the completion of a process. It is often also called trash, garbage, rubbish, or junk. It can be solid, liquid, or gas, or it can be waste heat. Waste can be classified based on source, hazard properties , management or a mix of these concepts.The type and quantity of waste may vary depending on the geographical region,population,socio-cultural practices and life style.

Classification of waste

waste generated can be mainly classified into two categories

❖ **Non-hazardous/solid waste** is all waste which has not been classified as hazardous: paper, plastics, glass, metal and beverage cans, organic waste etc. It does not pose a direct threat to human health or the environment, but it still cannot be dumped into a trash receptacle or a sewer line because of the risks it could pose. (Ankit Agarwal et.al 2005) Even though not hazardous, solid waste can have serious environmental and health impact if left uncollected and untreated ,While a significant proportion of solid waste could theoretically be reused or recycled.(Ghiani, G et al,2014).

Some common non-hazardous waste examples:

- **Agricultural waste:** Some types of agricultural waste are non-hazardous waste. Organic waste matter such as animal manure, urine and bedding material is non-hazardous waste, though chemical waste may be classified as hazardous waste.

- **Construction debris:** Construction and demolition debris also falls into the category of non-hazardous waste. Many of the materials used in construction, such as wood, glass, concrete, asphalt, bricks, gypsum from drywall, plastics, solvents and metal parts, must be properly disposed of rather than tossed into the nearest dumpster. The same goes for salvaged building components such as doors, windows and plumbing fixtures, as well as downed

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trees, limbs, rocks and dirt from clearing and excavation sites. Most non-hazardous construction debris goes to specially designated landfills for disposal.

- **Industrial waste:** Though some industrial waste is hazardous, most industries also produce substantial amounts of non-hazardous waste. Substances like sugars, lactic acid, bromides and carbonates would not necessarily harm the environment but still must be managed properly to avoid pollution.

- **Muncipal Solid waste(MSW) :** Solid waste is the unwanted or useless solid materials generated from human activities in residential, industrial or commercial areas. It may be categorised in three ways. According to its:origin (domestic, industrial, commercial, construction or institutional)contents (organic material, glass, metal, plastic paper etc),hazard potential (toxic, non-toxin, flammable, radioactive, infectious etc).

❖ **Hazardous waste** is waste that poses a severe threat to human health or the environment if improperly disposed of. According to the EPA, a substance is a hazardous waste if it appears on specific lists of hazardous waste or exhibits the established characteristics of hazardous waste. Hazardous waste is regulated under the Resource Conservation and Recovery Act (RCRA).

Hazardous waste needs special, separate treatment and handling Chemical and physical characteristics determine the exact collection and recycling process. Flammability, corrosiveness, toxicity, ecotoxicity and explosiveness are the main characteristics of hazardous waste. Liquid, gaseous and powder waste need special treatment by default to avoid the dispersal of the waste. Generally, separate collection and handling are established to avoid contact with non-hazardous waste. (Bhoj Raj Khanal et.al,2005) Chemical treatment, incineration or high-temperature treatment, safe storage, recovery and recycling are possible modes of treatment for hazardous waste. Most hazardous waste originates from industrial production. Special kinds of hazardous waste include:

- **E-waste** is waste from electric and electronic equipment such as end-of-life computers, phones and home appliances. E-waste is generally classified as hazardous because it contains toxic components (e.g. PCB and various metals).
- **Medical waste** originates from the human and animal healthcare systems and usually consists of medicines, chemicals, pharmaceuticals, bandages, used medical equipment, bodily fluids and body

parts. Medical waste can be infectious, toxic or radioactive or contain bacteria and harmful microorganisms (including those that are drug-resistant).

- **Radioactive waste** contains radioactive materials. The management of radioactive waste differs significantly from that of other waste. It is broadly classified into low-level waste (LLW), such as paper, rags, tools, clothing, which contain small amounts of mostly short-lived radioactivity, intermediate-level waste (ILW), which contains higher amounts of radioactivity and requires some shielding, and high-level waste (HLW), which is highly radioactive and hot due to decay heat, so requires cooling and shielding. uranium tailings, Spent fuel rods, Transuranic (TRU) nuclear waste are few examples.

Waste management

Waste management (or waste disposal) includes the processes and actions required to manage waste from its inception to its final disposal. This includes the collection, transport, treatment and disposal of waste, together with monitoring and regulation of the waste management process and waste-related laws, technologies, economic mechanisms. A large portion of waste management practices deal with municipal solid waste (MSW) which is the bulk of the waste that is created by household, industrial, and commercial activity.(Chang Jiang Yang et.al,2012) Waste Management Planning helps to

- Saves valuable time and resources during an incident
- Allows more efficient and effective waste management decision-making during an incident
- Encourages stakeholders (e.g., state, local, tribal and territorial governments; owners of private storage, treatment and disposal facilities; residents) to work together before an incident occurs
- Boosts the community’s resiliency, resulting in a quicker and less costly recovery to its pre-incident state
- Enhances communities’ adaptation to the waste-related impacts of climate change
- Minimally detracts from, or otherwise impacts, the broader response and recovery efforts due to the efficient implementation of waste management activities.
- Protection of environmental health.
- Promotion of environmental quality.

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- Supporting the efficiency and productivity of the economy.
- Generation of employment and income.

Waste management hierarchy

The **waste management hierarchy** indicates an order of preference for action to reduce and manage waste, and is usually presented diagrammatically in the form of a pyramid. The hierarchy captures the progression of a material or product through successive stages of waste management, and represents the latter part of the life-cycle for each product. The hierarchy of waste management is reducing the use of materials and reusing them to be the most environmental friendly. Source reduction begins with reducing the amount of waste generated and reusing materials to prevent them from entering the waste stream. Thus, waste is not generated until the end of "reuse" phase. Once the waste is generated, it needs to be collected. Material recovery from waste in the form of recycling and composting is recognized to be the most effective way of handling wastes. Due to technical and economic limitations of recycling; product design; inadequate source separation and lack of sufficient markets that can use all sorted materials, most of the MSW generated in India ends up in landfills. Local authorities should start working with their partners to promote source separation. While this is being achieved and recycling is increased, provisions should be made to handle the non-recyclable wastes that are and will be generated in the future.(Dijkema, G. P. J et al 2000).

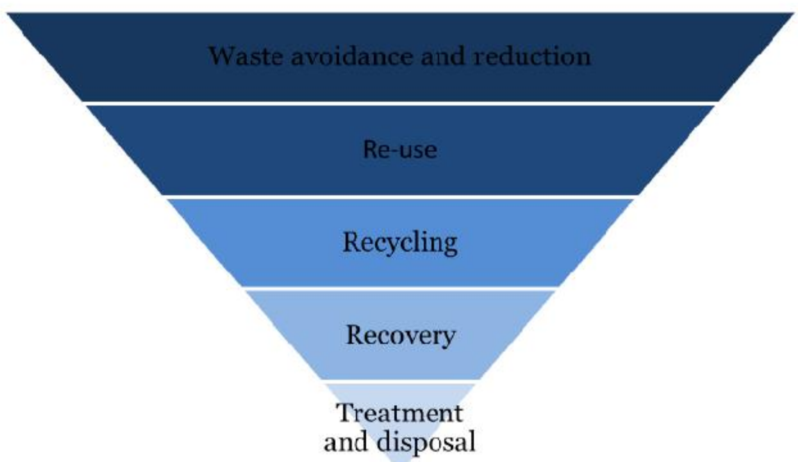

Fig 1 : waste management hierarchy

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There are a number of benefits accompanied with the waste management hierarchy, including

- Re-use, recycling and waste minimization reduce all environmental and social costs (externalities) associated with landfills (such as odours, health hazards, pollution of water resources and soil, visual impact, reduced value and availability of land, greenhouse gas emissions, etc.);
- Waste re-use and reduction can reduce the environmental and social costs of waste collection and disposal;
- Energy recovery and recycling contribute to job creation and economic growth as a whole, and can also promote improvement and create new business opportunities;
- Energy recovery and recycling motivate the recycling of energy or valuable materials and recycle it back into the economy. These materials can contribute in the manufacture of new products.
- The proper application of the waste hierarchy can have several benefits. It can help prevent emissions of greenhouse gases, reduces pollutants, save energy, conserves resources, create jobs and stimulate the development of green technologies.

Solid waste management (SWM)

Due to growth in population & urbanization the generation of solid waste has increased significantly.Solid waste has many bad influences over development of city or village.Diseases, odour pollution are the major threats arise due to solid waste. Major countries in India are producing more than tonnes per day of solid waste· Major part of this waste is treated by land filling which has its own influences over land & environment.Proper SWM provides facility of collection, segregation, transportation, & treatment of waste.This reduces odour pollution & risk of diseases, also good management improves the aesthetics of the city.Though SWM is complex to execute but with modern eco-friendly techniques & disciplinary work. (Demirbas, A 2011) It is possible to achieve needful.The two main methods involved in SWM are

Centralised Method: This method involves the collection of municipal waste from all over the local area and by by means of landfilling, dump out of the city /nagar/panchayath limits.This process looks at door to door collection of solid waste by waste pickers who hand over to the collection team who then discard the collected waste in the landfill.The waste pickers are the employees of Panchayath/Corporation and the collection team is generally contracted out by a tendering process.

Decentralised Method: This is a model seen in few places like Suryapet in AndraPradesh and Bengaluru in Karnataka.The waste is collected ward wise and is segregated at source into bio-degradable and non biodegradable..The biodegradable waste is composted at a nearby facility by different methods of aerobic and anaerobic composting.The non-biodegradable waste is further categorized into paper,plastic,metal and other waste and then further collected by recyclers for upcycling or downcycling of products.

Objectives Of Waste Managemet: The primary goal of solid waste management is reducing and eliminating adverse impacts of waste materials on human health and the environment.It also aims to support economic development and superior quality of life It is to be done in the most efficient cost effective maaner.and should also prevent further waste build up.

Functional elements of solid waste management

A SWM system refers to a combination of various functional elements associated with the management of solid wastes. The system, when put in place, facilitates the collection and disposal of solid wastes in the community at minimal costs, while preserving public health and ensuring little or minimal adverse impact on the environment. The functional elements that constitute the system are:

Waste generation: Wastes are generated at the start of any process, and thereafter, at every stage as raw materials are converted into goods for consumption. The source of waste generation, determines quantity, composition and waste characteristics. For example, wastes are generated from households, commercial areas, industries, institutions, street cleaning and other municipal services. The most important aspect of this part of the SWM system is the identification of waste. (European Environment Agency, 2013).

Waste storage: Storage is a key functional element because collection of wastes never takes place at the source or at the time of their generation. The heterogeneous wastes generated in residential areas must be removed within 8 days due to shortage of storage space and presence of biodegradable material. Onsite storage is of primary importance due to aesthetic consideration, public health and economics involved. Some of the options for storage are plastic containers, conventional dustbins (of households), used oil drums, large storage bins (for institutions and commercial areas or servicing depots), etc. Obviously, these vary greatly in size, form and material.

Waste collection: This includes gathering of wastes and hauling them to the location, where the collection vehicle is emptied, which may be a transfer station (i.e., intermediate station where wastes from smaller vehicles are transferred to larger ones and also segregated), a processing plant or a disposal site. Collection depends on the number of containers, frequency of collection, types of collection services and routes. Typically, collection is provided under various management arrangements, ranging from municipal services to franchised services, and under various forms of contracts.

Fig 2 : Waste collection colour codes

Transfer and transport: This functional element involves,the transfer of wastes from smaller collection vehicles, where necessary to overcome the problem of narrow access lanes, to larger ones at transfer stations; the subsequent transport of the wastes, usually over long distances, to disposal sites. The factors that contribute to the designing of a transfer station include the type of transfer operation, capacity, equipment, accessories and environmental requirements.

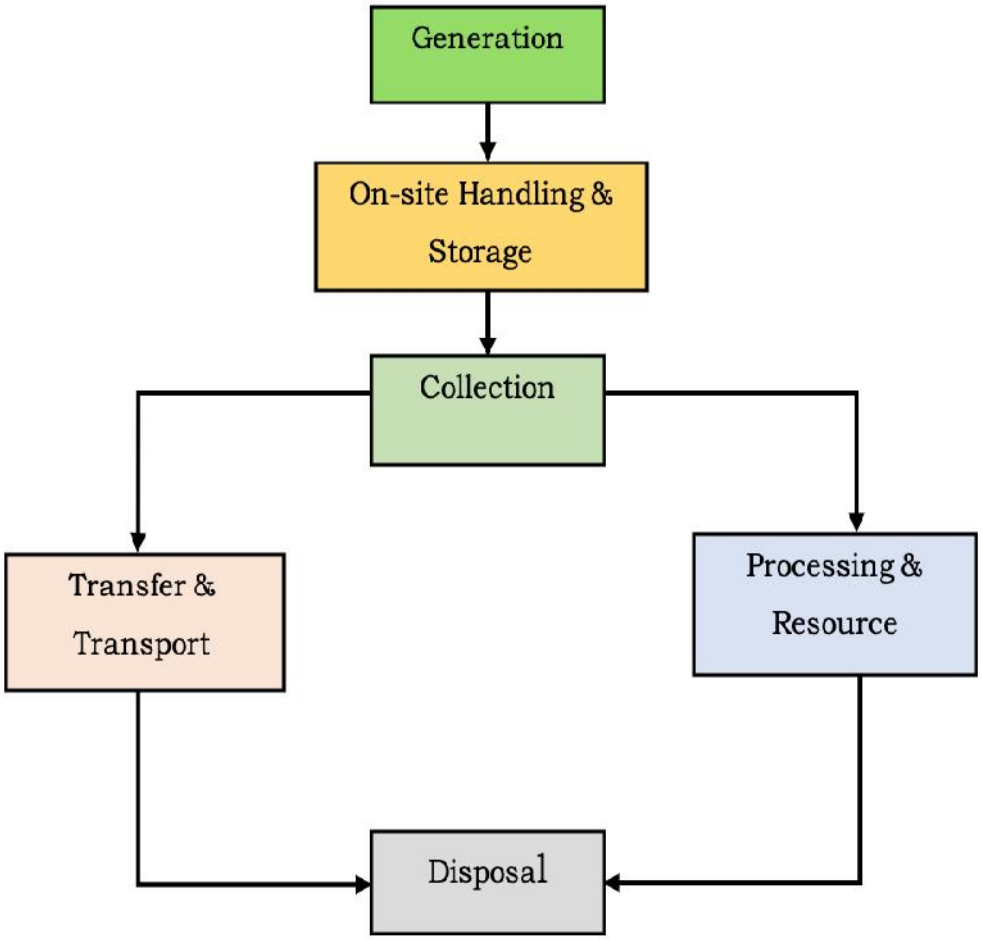

Fig 3 : Functional elements of solid waste management

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Processing: Processing is required to alter the physical and chemical characteristics of wastes for energy and resource recovery and recycling. The important processing techniques include compaction, thermal volume reduction, manual separation of waste components, incineration and composting.(Ngoc, U. N et al, 2009).

Recovery and recycling: This includes various techniques, equipment and facilities used to improve both the efficiency of disposal system and recovery of usable material and energy. Recovery involves the separation of valuable resources from the mixed solid wastes, delivered at transfer stations or processing plants. It also involves size reduction and density separation by air classifier, magnetic device for iron and screens for glass.The selection of any recovery process is a function of economics, i.e., costs of separation versus the recovered-material products. Certain recovered materials like glass, plastics, paper, etc., can be recycled as they have economic value.

Waste disposal: Disposal is the ultimate fate of all solid wastes, be they residential wastes, semi-solid wastes from municipal and industrial treatment plants, incinerator residues, composts or other substances that have no further use to the society. Thus, land use planning becomes a primary determinant in the selection, design and operation of landfill operations. A modern sanitary landfill is a method of disposing solid waste without creating a nuisance and hazard to public health. Generally, engineering principles are followed to confine the wastes to the smallest possible area, reduce them to the lowest particle volume by compaction at the site and cover them after each day's operation to reduce exposure to vermin. One of the most important functional elements of SWM, therefore, relates to the final use of the reclaimed land.(Jasem M. Alhumoud 2005).

Methods of solid waste management

The final stage of solid waste management is safe disposal where associated risks are minimised. There are four main methods for the disposal of solid waste:

- Dumps and landfills
- Thermal disposal
- Biological disposal
- Resource recovery

The most common of these is undoubtedly land application, although all four are commonly applied in emergency situations.

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On-site disposal options

Common pits and bins are used on this type of waste disposal,The number of bins and size of pits may vary depending on the type and qyuantity of waste generated .In some places the generated waste is directly disposed on the ground and it is transported to other sites for further treatment.(Mohan Yellishetty et.al 2011).

Eg: family bin, Communal pits etc

Off-site disposal options

Sanitary landfills: 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. 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.

(a)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.

(b) Bioreactor Landfills: Recent technological advances have lead 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 in 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.(Ebikapade Amasuomol et.al, 2016).

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.

(a) 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

(b) 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. 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.

(c) Open burning: Openburning 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.(Kaseva, M. E et .al 1996).

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Biological waste treatment

(a) 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.

(b) 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.(Tarmudi Z .et al, 2012).

The 3R Principle (reduce, reuse and recycle)

The most importantly is that 3R principle helps us toward sustainable living. Making people think about the impact of their consumption and production of waste can help to encourage us to make lifestyle decisions to reduce the waste we create and reduce the impact on the environment.The principle of reducing waste, reusing and recycling resources and products is often called the "3Rs."

• Reducing means choosing to use items with care to reduce the amount of waste generated.

• Reusing involves the repeated use of items or parts of items which still have usable aspects. • Recycling means the use of waste itself as resources.

Waste minimization can be achieved in an efficient way by focusing primarily on the first of the 3Rs, "reduce," followed by "reuse" and then "recycle." The waste hierarchy refers to the "3Rs" i.e., reduce, reuse and recycle, which classify waste management strategies according to their desirability. The 3Rs are meant to be a hierarchy, in order of importance. The waste hierarchy has taken many forms over the past decade, but the basic concept has remained the cornerstone of most waste minimization strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste. The concept of minimizing waste impacts in terms of quantity or ill-effects, by reducing quantity of wastes, reusing the waste products with simple treatments and recycling the wastes by using it as resources to produce same or modified products is usually referred to as "3R". Purchasing and using resources with care can reduce the pace of consumption of resources and further connected energy and resources, ultimately reducing wastes multifold for waste streams. When long lasting goods are reused time and again, it offsets harvesting of new similar or same products. This saves fresh resources exploitation and waste generation quantity. Some waste products can be consumed as resources for production of different goods or the same product, meaning recycling the same resource. This too saves fresh resources and offsets waste generation. All in all, the 3Rs individually or collectively saves fresh resources exploitation, add value to the already exploited resources and very importantly minimizes the waste quantity and its ill effects. Waste minimization efficiency is stated to be better achieved applying 3Rs in a hierarchical order- Reduce, Reuse and Recycle.

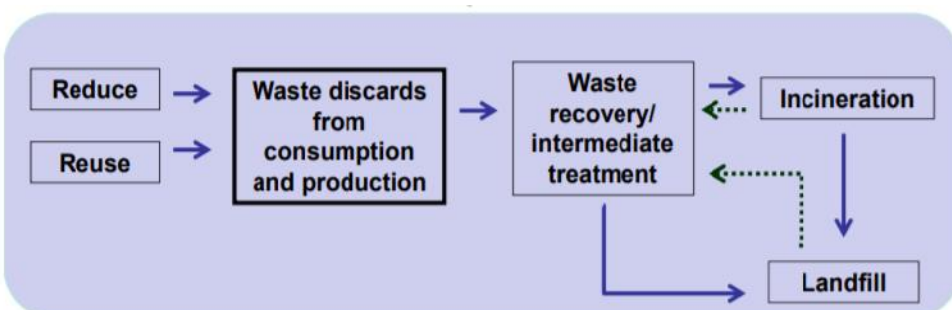

Fig 4 : Waste flow under a 3 R concept

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Reduce: The first step in waste management is to try and prevent the generation of waste by reducing at source the waste produced. This is the prevention principal "avoidance of waste".[(14)]some means to reduce waste include Avoid packaging when possible, Avoid single-use cleaning products,Buy items in bulk, in concentrate, or in refillable packages.To reduce toxicity Whenever possible use nonhazardous or less hazardous materials at home and work. Instead of pesticides, for example, use Integrated Pest Management (IPM) techniques to control insects and other pests.

Reuse: Reuse is the action or practice of using an item, whether for its original purpose (conventional reuse) or to fulfil a different function.It can be practised when reducing of waste is not possible.

Fig 5 : 3Rs of waste management

Recycle: Recycling of waste is defined as any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. The basic phases in recycling are the collection of waste materials, their processing or manufacture into new products, and the purchase of those products, which may then themselves be recycled. Typical materials that are recycled include iron and steel scrap, aluminum cans, glass bottles, paper, wood, and plastics. Recycling can help reduce the quantities of solid waste deposited in landfills, which have become increasingly expensive. Recycling also reduces the pollution of air, water, and land resulting from waste disposal.There are two broad types of recycling operations: internal and external. Internal recycling is the reuse in a manufacturing process of materials that are a waste product of that process.(YadavIshwar Chandra .et al) External recycling is the reclaiming of materials from a product that has been worn out. Recycling becomes economically attractive when the cost of reprocessing waste or recycled material is less than the cost of treating and disposing of the materials or of processing new raw materials.

3Rs offer an environmentally friendly alternatives to deal with growing generation of wastes and its related impact on human health, economy and natural ecosystem. Seven elements to improve Eco-efficiency:

1.) Reduce material intensity

2.) Reduce energy intensity

3.) Reduce dispersion of toxic substances

4.) Enhance the ability to recycle

5.) Maximize use of renewable resources

6.) Extend product durability

7.) Increase service intensity

Conclusion

The most important aspect of waste management is the protection of environment and human health.The Integrated soild waste management strategic approach of sustainable management of solid waste can be practised,It covers all areas of waste management with an emphasis on maximum resource recovery,thus resulting in economic growth.The earth is what we all have in common,Conserve it for future.

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