Waste Management

(A Guide for Future Studies)

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Introduction

Waste (also referred to as rubbish, trash, refuse, garbage, or junk) is unwanted or unusable materials (Techobanologous G, Kreith I, p.I.I). The UNEP has defined waste as "materials that are not prime products (that is products produced for the market) for which the generator has no further use in terms of his/her own purpose of production, transformation or consumption, and of which they intended to dispose. Wastes may be generated during the extraction of raw materials into intermediate and final products, the consumption of final products, and other human activities. Residuals recycled or reused at the place of generation are excluded.

In living organism, waste is the unwanted substances or toxins that are expelled from them. More commonly, waste refers to the materials that are disposed of in a system of waste management. Waste is directly linked to human development, both technologically and socially. The composition of different wastes has varied over time and location. With industrial development and innovation being directly linked to waste materials. Examples of this include plastics and nuclear technology. Some components of waste have economical value and can be recycled once correctly recovered (Rhymer CR, 1995). Waste is sometimes a subjective concept, because items that some people discard may have value to others. It is widely recognized that waste materials are valuable

resources, whilst there is debate as to how this value is best realized. *(Waste, http://www.seccommonalanguage.eu/index.php).*

There are many types of waste defined by modern systems of waste management, notably including:

- Municipal Solid Waste (MSW)

  MSW also called urban solid waste is a waste type that includes predominantly household waste (domestic waste) with sometimes the addition of commercial wastes collected by a municipality within a given area. They are in either solid or semisolid form and generally exclude industrial hazardous wastes. The term residual waste relates to waste left from household sources containing materials that have not been separated out or sent for reprocessing **(Robinson WD, 1986)**

- Construction waste and demolition waste (C&D)

  Construction waste consists of unwanted materials produced directly or incidentally by the construction or industries. This includes building materials such as insulation, nails, electrical wiring, and rebar, as well as waste originating from site preparation such as dredging materials, tree stumps, and rubble. Construction waste may contain lead, asbestos, or other hazardous substances. **(El-Hagger S, 2007, p-261)**

- Institutional waste, Commercial waste, and Industrial waste (IC&I)

  Industrial waste is a type of waste produced by industrial activities, such as that of factories, mills and mines. It has existed since the outset of the industrial revolution. Much industrial waste is neither hazardous nor toxic, such as waste fiber produced by agriculture and logging. **(Woodard & Curran, 2006, p-18)**

- Medical waste (also known as clinical waste)

  Medical waste, also known as clinical waste, normally refers to waste products that cannot be considered general waste, produced from healthcare premises, such as hospitals, clinics, doctor' offices, labs and nursing homes. **(Landrum VJ, 1991)**

- Hazardous waste and radioactive waste

  A hazardous waste is waste that possesses substantial or potential threats to public health or the environment. Ignitability, reactivity, corrosively and toxicity determine whether or not a substance is hazardous. Radioactive waste is a waste product containing radioactive materials. It is usually the product of a nuclear power industry may also produce radioactive waste. **(Dawson GW, Mercer BW, 1986)**

- Biodegradable waste

  Biodegradable waste can be commonly found in municipal solid waste as green wastes, food waste, paper waste, and biodegradable plastics. Other biodegradable waste include human waste, manure, sewage, slaughterhouse waste. ***(http://en.wikipedia.org/wiki/Biodegradable_waste)***

- Electronica Waste (E-Waste)

  Discarded electronic devices like television personal computers, floppies, audio-video compact disks, batteries, electric switches, telephones, air conditioners, mobile phones, electronic toys, refrigerators, washing machines, dryers, kitchen utensils and even aircraft contribute to the growing pile of e-waste in the city. These products contain components that contain toxic substance like lead, cadmium, mercury, hexavalent chromium, plastic, Poly Vinyl Chloride (PVC), Brominated Flame Retardants (BFR), barium, beryllium, and carcinogens like carbon black and heavy metals. The deadly mix can cause severe health problems for those handling the waste. **(Luther L, 2009)**

On the other hand, the waste management can be defined as "the processes involved in dealing with the waste of human and organisms, including minimization, handling, processing, storage, recycling, transport, and final disposal". ***(Lexicon Dictionary, 2003)***

"Waste" also includes any matter prescribed to be waste and any matter, whether liquid, solid, gaseous, or radioactive, which is discharged, emitted, or deposited in the environment. In such volume consistency or manner as to cause an alteration to the environment. "Litter" means unwanted waste material, whether a by-product which has

arisen during a manufacturing process or a product which has passed its useful working life and has been discarded. ***(Zon & Siriwardena, 2000)***

Theoretical aspects of waste management

The following theories/concepts have been developed/introduced by researchers in time to time. Those are considered as important techniques to establish a good waste management system in a country as the waste generated cannot be reduced easily. The amount of waste generated in countries increases every year due to an improved living standard and growing population.

3R and 4R Concept and Waste Minimization

The popular and well-known concept of "3R" refers to reduce, reuse and recycle, particularly in the context of production and consumption. It calls for an increase in the ratio of recyclable materials, further reusing of raw materials and manufacturing wastes, and overall reduction in resources and energy used. These ideas are applied to the entire lifecycles of products and services from design and extraction of raw materials to transport, manufacture, use, dismantling/reuse and disposal. 3R technology is the first integrated process technology worldwide, which is able to combine input materials from landfills and high value raw materials from the first user market. The 3R; system separates metals, organic materials, glass, paper/cardboard and plastics. It is a real recycling process technology and not a down-cycling system. ***(Hari Srinivas, http://www.gdrc.org/uem/waste/3r-minimization.html)***

However, this ideology has now expanded to '4R' i.e. reduce, reuse, recycle and recover waste. It is based on the idea that most of the household waste, which accounts for more than 70% of total waste, can be efficiently converted into valuable compost. ***(Footsteps, http://tilz.tearfund.org/webdocs/Tilz/Footsteps/English/FSS9_E.pdf, June 2004).*** This reduces disposal costs and prolongs the lifetime of landfill sites. It also reduces the harmful environmental impact of landfill sites, because organic waste is responsible for groundwater contamination and methane gas emissions. By turning the organic waste into compost, it has been proven that the soil in urban areas can be improved.

The waste hierarchy has taken many forms over the past decades, 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. Therefore, in Europe the waste hierarchy has 5 steps: reduce, reuse, recycle, recovery and disposal**.** ***(Amazins, http://amazines.c0m/reduce_reuse_recycle_related.html)***

Source reduction

Source reduction involves efforts to reduce hazardous waste and other materials by modifying industrial production. Source reduction methods involve changes in manufacturing technology, raw material inputs, and product formulation. At times, the term "pollution prevention" may refer to source reduction.

Source reduction is to increase incentives for recycling. Many communities in the United States are implementing variable rate pricing for waste disposal (also known as Pay As You Throw - PAYT) which has been effective in reducing the size of the municipal waste stream. ***(http://www.ec0zine.c0.uk/Waste.htm)***. Source reduction is typically measured by efficiencies and cutbacks in waste. Toxics use reduction is a more controversial approach to source reduction that targets and measures reductions in the upstream use of toxic materials. Toxics use reduction emphasizes the more preventive aspects of source reduction but, due to its emphasis on toxic chemical inputs, has been opposed by chemical manufacturers.

A far more potent greenhouse gas than carbon dioxide. Some of it can be tapped for use as a fuel.

Some oppose to the use of landfills arguing that the logical end result of landfill operations is that it will eventually leave a drastically polluted planet with no canyons, and no wild space. Some futurists have stated that landfills will be the "mines of the future": as some resources become scarcer, they will become valuable enough that it would be necessary to 'mine' them from landfills where these materials were previously discarded as valueless.

In Australia, the most common method of disposal of solid waste is to landfills, because it is a large country with a low-density of population.

Incineration

Incineration involves with hazardous waste. Hazardous wastes are legally defined as those wastes that may cause adverse or chronic effects on human health or environment when not properly controlled. ***(Joseph J, Santoleri, Joseph R, Louis T, 2000).*** Incineration is the process of destroying waste material by burning. It is carried out both on a small scale by individuals and on a large scale by industry. It is recognized as a practical method of disposing hazardous waste materials, such as biological medical waste.

Though this is widely used especially in developing countries, it is said that incineration as a waste management tool is becoming controversial for several reasons, such as;

- Because it destroys not only the raw material, but also all of the energy, water, and other natural resources used to produce it. Some energy can be reclaimed as electricity by using the combustion to create steam to drive an electrical generator, but even the best incinerator can only recover a fraction of the caloric value of fuel materials.
- It creates toxic gas and ash, which can harm local populations and pollute groundwater. Modern, well-run incinerators take adequate measures to reduce the amount of waste.

Waste Management Techniques

Managing domestic, industrial and commercial waste has traditionally consisted of collection, followed by disposal. Depending upon the type of waste and the area, a level of processing is involved before collection. This processing may lead to reduce the hazard of the waste, recover material for recycling, produce energy from the waste, or reduce it in volume for more efficient disposal. However, collection methods vary widely between different countries and regions. For example, in Australia most urban domestic households have a 240 liter (63.4 gallons) bin that is emptied weekly by the local Council. In Canadian urban centers curbside collection is the most common method of disposal, whereby the city collects garbage, and or recyclables, and or organics on a scheduled basis from residential areas. In rural areas people dispose of their wastes at

transfer stations. ***(http://www.ec0zine.co.uk/Waste.htm).*** The most common methods of managing waste in the world are as follows.

Landfill

Disposing of wastes in a landfill is the most traditional method of waste disposal, and it remains a common practice in most countries. In the United States approximately 50% or 128.3 million tons of municipal solid waste generated is buried in landfills**. *(Linkov I, Wenning RJ, Kiker GA, 2007)*** Historically, landfills were often established in disused quarries, mining voids or borrow pits. Running a landfill that minimizes environmental problems can be a hygienic and relatively inexpensive method of disposing of waste materials.

Characteristics of a modern landfill include methods to contain leachate, such as lining clay or plastic liners. Disposed waste should be compacted and covered to prevent vermin and wind-blown-litter. Many landfills also have a landfill gas extraction system installed after they are closed to extract the gas generated by the decomposing waste materials. This gas is often burnt to generate power. Generally, even flaring the gas off is a better environmental outcome than allowing it to escape to the atmosphere, as this consumes the methane, which is of toxic products released in exhaust gas. But concern has increased in recent years about the levels of dioxins that are released when burning mixed waste.

Since, safe disposal of incinerator waste was a major problem, in mid-1990s, experiments in France and Germany used electric plasma torches to melt incinerator waste into inert glassy pebbles, valuable in concrete production. Incinerator ash has also been chemically separated into lye and other useful chemicals. ***(Joseph J, Santoleri, Joseph R, Louis T, 2000)***

Japan it is more common for waste to be incinerated, because the country is smaller and land is scarce.

Volume reduction

This means various techniques used to convert the waste fit into less space and easier to handle in bulk. Most waste has a low bulk density and is composed of a wide variety of objects in all sizes and shapes. Therefore, by using volume reduction methods such as using shredding machines, crushers, pulverizes, hoggers, hammer mills, and size

reduction machines convert the waste into a form more easily and economically handled for processing. Today, these machines can convert two complete automobiles per minute and capacities of largest waste shredders exceed 100 tons/hr. ***(Chereminino ff NP, 2003)***

This is usually achieved by compaction or fragmentation. Compaction is done either by using machines or heavy vehicles. Before waste being compacted in machines, workers first remove toxic materials. Even after removing dangerous components like solvents, preservatives and metals, some waste are bulky for landfills to accept. Therefore, salvage companies possess specialized tools and torches to cut up refrigerators, ovens, washers and dryers into small pieces. This is called sizing. If the pieces need even more reduction before going into the landfill, the salvager shreds them. ***(Maczulak A, 2010)***

Resource recovery techniques

There are a number of methods of recovering resources from waste materials, with new technologies and methods being developed continuously. Some of them are as follows**.** ***(Rao SR, 2006)***

Arrow Bio process

Arrow Bio is an integrated solution for the treatment of municipal solid waste. The Arrow Bio facilities and process provide unique hydro mechanical separation and preparation process, recovering 90% of recoverable materials. Arrow Bio's liquid anaerobic treatment produces rich biogas and excellent soil amendment for agricultural purposes. Arrow Bio's unique recovery process is recognized by experts as the most cost effective, ecofriendly solution available to the treatment of MSW, and Arrow Bio facilities are being built and launched with partners around the world. By this process, resources may be extracted from waste: the materials may be extracted and recycled, or the calorific content of the waste may be converted in to electricity. ***(Arrow Bio, http://www.arrowbio.com/)***

Mechanical Biological Treatment

Mechanical Biological Treatment is an alternative form of waste processing that is widely accepted on continental Europe. It is a generic term for an integration of several processes commonly found in other waste management processes such as Materials Recovery Facilities (MRFs), Refuse Derived Fuel (RDF), sorting and composting plant. ***(Waste Technology, http: //www. waste-technology.co.uk/Page1/page1.php)***

Recycling

Countries all around the world use billions of plastic bags, plastic bottles, and papers every year. Most of them are used once and thrown away. However, the cars, cell phones, electronic/electrical equipment, and computers use for longer years, but still, millions of them are thrown away yearly. The burning problem is where to dump those unwanted stuff. Leaving the trash out or open dumping is illegal. If do so, it invites pests, spread diseases and bad smells. Most trash goes into landfills where workers buried them under dirt. The bottom of landfill is lined with waterproof material. This keeps rotten and dangerous liquids from leaking into the environment. ***(Wilcox C, 2008).*** In addressing this burning issue, recycling is identified as one of the best methods for waste minimization.

Recycling involves processing of waste into new products by converting them into potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from land filling). Recycling is a key component of modern waste reduction and is the third component of the "3 R" waste hierarchy. ***(Recycling, http://en.wikipedia.org/wiki/Recycling)***

Recyclable materials include many kinds of glasses, papers, metals, plastics, textiles, and electronics. The recycling involves either collection/transportation of waste material into the collection centers or picked them up from the curbside, then sorted, cleaned, and reprocessed into new materials. However, this is difficult or sometimes expensive compared to producing the same product from raw materials or other sources. So "recycling" involves producing different materials (e.g., paperboards) instead of: the same. Another form of recycling is the salvage of certain materials from complex products, either due to their intrinsic value (e.g., lead from car batteries, or gold from computer components), or due to their hazardous nature (e.g., removal and reuse of mercury from, various items). ***(Pike K, 2006)***

Composting and digestion

Waste materials that are organic in nature, such as plant material, food scraps, and paper products, are increasingly being recycled. These materials are put through a composting and/or digestion system to control the biological process to decompose the organic matter and kill pathogens[1]. The resulting stabilized organic material is then recycled as mulch or compost for agricultural or landscaping purposes. ***(Scott N, 2007)***

There are large varieties of composting and digestion methods and technologies, varying in complexity from simple window composting of shredded plant material to automated enclosed-vessel digestion of mixed domestic waste. These methods of biological decomposition are differentiated as being aerobic in composting methods or anaerobic in digestion methods, although hybrids of the two methods also exist.

Selection of better location for composting is considered as a prime important factor. It is important to remember that efficient composting is occurred when millions of microscopic organisms such as bacteria and fungi take up residence in the composting pile, continuous devour it and digest it to produce rich material. Additionally, larger creatures such as worms and insects arrive to speed the process along. Like all living things, these organisms need a "balanced diet" water and air to sustain them, and it's up to the producers to provide these favorable conditions so that they can perform their natural role. ***(Ebeling E, 2003)***

Pyrolysis and Gasification

Pyrolysis and Gasification are two related forms of thermal treatment where materials are incinerated with limited oxygen. The process typically occurs in a sealed vessel, under high temperature and pressure. Converting material in to energy this way is more efficient than direct incineration, with more energy able to be recovered and used. Pyrolysis of solid waste converts the material into solid, liquid and gas products. The liquid oil and gas can be burnt to produce energy or refined into other products. The solid residue (char) can be further refined into products such as activated carbon. ***(S urhone LIV, T impledon MT, Marseken SF, Ma's, VDM Verlag Dr. 2010)***

Gasification is used to convert organic materials directly into a synthetic gas composed of carbon monoxide and hydrogen. The gas is then burnt to produce electricity and steam. Gasification is used in biomass power stations to produce renewable energy and heat. ***(De Souza-Santos ML, 2009)***

The discussion so far describes the practices, theories and definitions related to the solid waste management. The different techniques adopted by the developed and non-developed countries in disposing waste have been brought out with examples. Those aspects will inevitably assist to get a sound understanding. Improper solid waste management has already become a threat not only to the developing countries, but also for other countries including well developed. However, the frequent Research and

Development (R&D) studies related to the field will guide their systems not to fall into trouble. It is a known fact that the developed countries spend a considerable amount of' money for R&D, however developing countries find it difficult to allocate such money.

The other problem faced by the developing countries is ever increasing population. That inevitably contributes to increase the amount of solid waste generation. Changing of food patterns, getting used to fast food practices, increased construction, increased medical waste and commercial waste will make the present waste double while no improvement in the existing system of solid waste management. Therefore, many more endeavors are essential especially from the local government authorities to address this issue. Otherwise the aesthetic appeal of the country will be ramshackle.

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