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Solid Waste Treatment and Recycle

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ABSTRACT: Solid-waste management, the collecting, treating, and disposing of solid material that is discarded because it has served its purpose or is no longer useful. Improper disposal of municipal solid waste can create unsanitary conditions, and these conditions in turn can lead to pollution of the environment and to outbreaks of vector-borne disease—that is, diseases spread by rodents and insects. The tasks of solid-waste management present complex technical challenges. They also pose a wide variety of administrative, economic, and social problems that must be managed and solved.

In ancient cities, wastes were thrown onto unpaved streets and roadways, where they were left to accumulate. It was not until 320 BCE in Athens that the first known law forbidding this practice was established. At that time a system for waste removal began to evolve in Greece and in the Greek-dominated cities of the eastern Mediterranean. In ancient Rome, property owners were responsible for cleaning the streets fronting their property. But organized waste collection was associated only with state-sponsored events such as parades. Disposal methods were very crude, involving open pits located just outside the city walls. As populations increased, efforts were made to transport waste farther out from the cities.

KEYWORDS: solid waste treatment, recycle, pollution, environment, disposal, transport, population, administrative, economic

I.INTRODUCTION

A technological approach to solid-waste management began to develop in the latter part of the 19th century. Watertight garbage cans were first introduced in the United States, and sturdier vehicles were used to collect and transport wastes. A significant development in solid-waste treatment and disposal practices was marked by the construction of the first refuse incinerator in England in 1874. By the beginning of the 20th century, 15 percent of major American cities were incinerating solid waste. Even then, however, most of the largest cities were still using primitive disposal methods such as open dumping on land or in water.Technological advances continued during the first half of the 20th century, including the development of garbage grinders, compaction trucks, and pneumatic collection systems. By mid-century, however, it had become evident that open dumping and improper incineration of solid waste were causing problems of pollution and jeopardizing public health. As a result, sanitary landfills were developed to replace the practice of open dumping and to reduce the reliance on waste incineration. In many countries waste was divided into two categories, hazardous and nonhazardous, and separate regulations were developed for their disposal. Landfills were designed and operated in a manner that minimized risks to public health and the environment. New refuse incinerators were designed to recover heat energy from the waste and were provided with extensive air pollution control devices to satisfy stringent standards of air quality. Modern solid-waste management plants in most developed countries now emphasize the practice of recycling and waste reduction at the source rather than incineration and land disposal.

The sources of solid waste include residential, commercial, institutional, and industrial activities. Certain types of wastes that cause immediate danger to exposed individuals or environments are classified as hazardous; these are discussed in the article hazardous-waste management. All nonhazardous solid waste from a community that requires collection and transport to a processing or disposal site is called refuse or municipal solid waste (MSW). Refuse includes garbage and rubbish.

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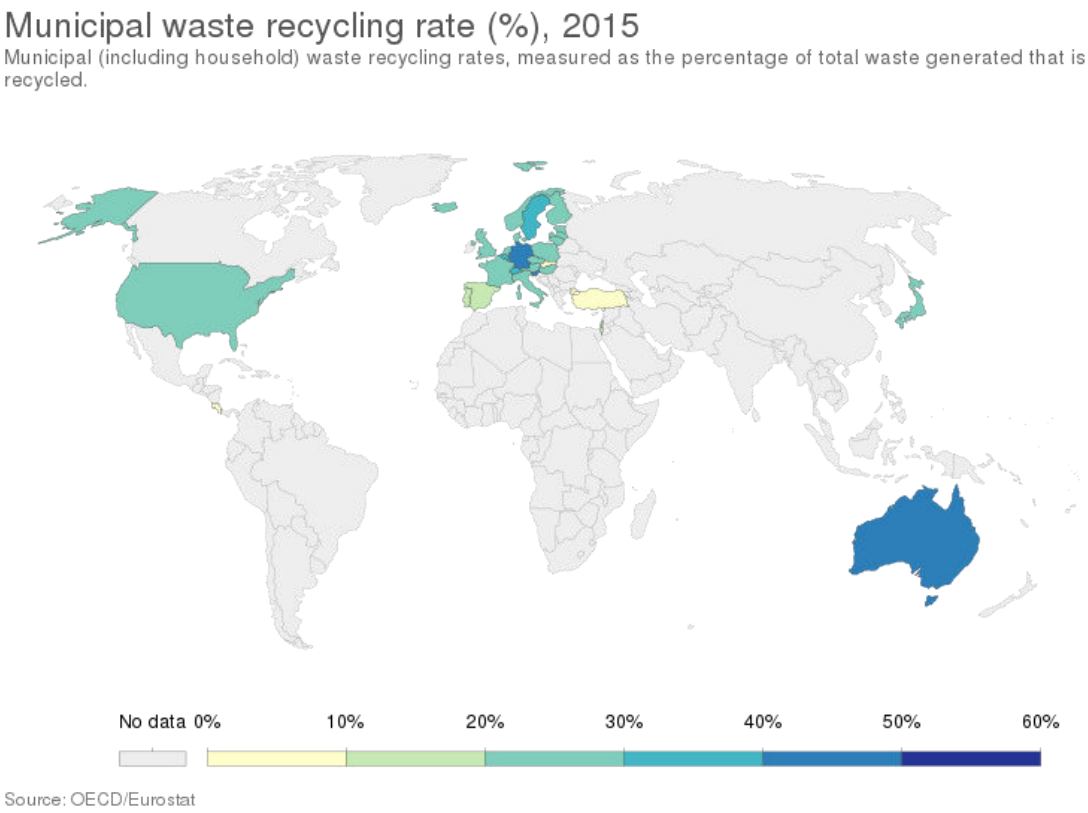

II.MUNICIPAL WASTE RECYCLING RATE (%), 2015

Garbage is mostly decomposable food waste; rubbish is mostly dry material such as glass, paper, cloth, or wood. Garbage is highly putrescible or decomposable, whereas rubbish is not. Trash is rubbish that includes bulky items such as old refrigerators, couches, or large tree stumps. Trash requires special collection and handling. Construction and demolition (C&D) waste (or debris) is a significant component of total solid waste quantities (about 20 percent in the United States), although it is not considered to be part of the MSW stream. However, because C&D waste is inert and nonhazardous, it is usually disposed of in municipal sanitary landfills.Another type of solid waste, perhaps the fastest-growing component in many developed countries, is electronic waste, or e-waste, which includes discarded computer equipment, televisions, telephones, and a variety of other electronic devices. Concern over this type of waste is escalating. Lead, mercury, and cadmium are among the materials of concern in electronic devices, and governmental policies may be required to regulate their recycling and disposal.Solid-waste characteristics vary considerably among communities and nations. American refuse is usually lighter, for example, than European or Japanese refuse. In the United States paper and paperboard products make up close to 40 percent of the total weight of MSW; food waste accounts for less than 10 percent. The rest is a mixture of yard trimmings, wood, glass, metal, plastic, leather, cloth, and other miscellaneous materials. In a loose or uncompacted state, MSW of this type weighs approximately 120 kg per cubic metre (200 pounds per cubic yard). These figures vary with geographic location, economic conditions, season of the year, and many other factors. Waste characteristics from each community must be studied carefully before any treatment or disposal facility is designed and built.Rates of solid-waste generation vary widely. In the United States, for example, municipal refuse is generated at an average rate of approximately 2 kg (4.5 pounds) per person per day. Japan generates roughly half this amount, yet in Canada the rate is 2.7 kg (almost 6 pounds) per person per day. In some developing countries the average rate can be lower than 0.5 kg (1 pound) per person per day. These data include refuse from commercial, institutional, and industrial as well as residential sources. The actual rates of refuse generation must be carefully determined when a community plans a solid-waste management project.Most communities require household refuse to be stored in durable, easily cleaned containers with tight-fitting covers in order to minimize rodent or insect infestation and offensive odours. Galvanized metal or plastic containers of about 115-litre (30-gallon) capacity are commonly used, although some communities employ larger containers that can be mechanically lifted and emptied into collection trucks.

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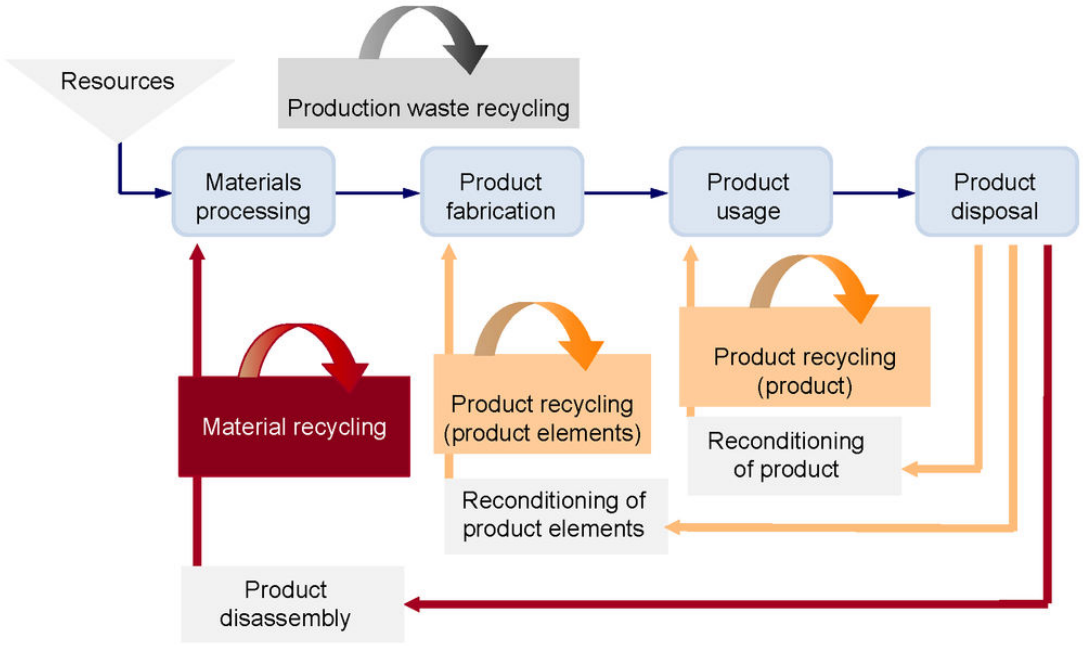

Loops for production-waste, product and material recycling

Plastic bags are frequently used as liners or as disposable containers for curbside collection. Where large quantities of refuse are generated—such as at shopping centres, hotels, or apartment buildings—dumpsters may be used for temporary storage until the waste is collected. Some office and commercial buildings use on-site compactors to reduce the waste volume.Proper solid-waste collection is important for the protection of public health, safety, and environmental quality. It is a labour-intensive activity, accounting for approximately three-quarters of the total cost of solid-waste management. Public employees are often assigned to the task, but sometimes it is more economical for private companies to do the work under contract to the municipality or for private collectors to be paid by individual home owners. A driver and one or two loaders serve each collection vehicle. These are typically trucks of the enclosed, compacting type, with capacities up to 30 cubic metres (40 cubic yards). Loading can be done from the front, rear, or side. Compaction reduces the volume of refuse in the truck to less than half of its loose volume.

The task of selecting an optimal collection route is a complex problem, especially for large and densely populated cities. An optimal route is one that results in the most efficient use of labour and equipment, and selecting such a route requires the application of computer analyses that account for all the many design variables in a large and complex network. Variables include frequency of collection, haulage distance, type of service, and climate. Collection of refuse in rural areas can present a special problem, since the population densities are low, leading to high unit costs.
Refuse collection usually occurs at least once per week because of the rapid decomposition of food waste. The amount of garbage in the refuse of an individual home can be reduced by garbage grinders, or garbage disposals. Ground garbage puts an extra load on sewerage systems, but this can usually be accommodated. Many communities now conduct source separation and recycling programs, in which homeowners and businesses separate recyclable materials from garbage and place them in separate containers for collection. In addition, some communities have drop-off centres where residents can bring recyclables.

If the final destination of the refuse is not near the community in which it is generated, one or more transfer stations may be necessary. A transfer station is a central facility where refuse from many collection vehicles is combined into a larger vehicle, such as a tractor-trailer unit. Open-top trailers are designed to carry about 76 cubic metres (100 cubic yards) of uncompacted waste to a regional processing or disposal location. Closed compactor-type trailers are also available, but they must be equipped with ejector mechanisms. In a direct discharge type of station, several collection trucks empty directly into the transport vehicle. In a storage discharge type of station, refuse is first emptied into a storage pit or onto a platform, and then machinery is used to hoist or push the solid waste into the transport vehicle. Large transfer stations can handle more than 500 tons of refuse per day.

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Once collected, municipal solid waste may be treated in order to reduce the total volume and weight of material that requires final disposal. Treatment changes the form of the waste and makes it easier to handle. It can also serve to recover certain materials, as well as heat energy, for recycling or reuse.

III.DISCUSSION

Burning is a very effective method of reducing the volume and weight of solid waste, though it is a source of greenhouse gas emissions. In modern incinerators the waste is burned inside a properly designed furnace under very carefully controlled conditions. The combustible portion of the waste combines with oxygen, releasing mostly carbon dioxide, water vapour, and heat. Incineration can reduce the volume of uncompacted waste by more than 90 percent, leaving an inert residue of ash, glass, metal, and other solid materials called bottom ash. The gaseous by-products of incomplete combustion, along with finely divided particulate material called fly ash, are carried along in the incinerator airstream. Fly ash includes cinders, dust, and soot. In order to remove fly ash and gaseous by-products before they are exhausted into the atmosphere, modern incinerators must be equipped with extensive emission control devices. Such devices include fabric baghouse filters, acid gas scrubbers, and electrostatic precipitators. (See also air pollution control.) Bottom ash and fly ash are usually combined and disposed of in a landfill. If the ash is found to contain toxic metals, it must be managed as a hazardous waste.

Municipal solid-waste incinerators are designed to receive and burn a continuous supply of refuse. A deep refuse storage pit, or tipping area, provides enough space for about one day of waste storage. The refuse is lifted from the pit by a crane equipped with a bucket or grapple device. It is then deposited into a hopper and chute above the furnace and released onto a charging grate or stoker. The grate shakes and moves waste through the furnace, allowing air to circulate around the burning material. Modern incinerators are usually built with a rectangular furnace, although rotary kiln furnaces and vertical circular furnaces are available. Furnaces are constructed of refractory bricks that can withstand the high combustion temperatures.Combustion in a furnace occurs in two stages: primary and secondary. In primary combustion, moisture is driven off, and the waste is ignited and volatilized. In secondary combustion, the remaining unburned gases and particulates are oxidized, eliminating odours and reducing the amount of fly ash in the exhaust. When the refuse is very moist, auxiliary gas or fuel oil is sometimes burned to start the primary combustion.In order to provide enough oxygen for both primary and secondary combustion, air must be thoroughly mixed with the burning refuse. Air is supplied from openings beneath the grates or is admitted to the area above. The relative amounts of this underfire air and overfire air must be determined by the plant operator to achieve good combustion efficiency. A continuous flow of air can be maintained by a natural draft in a tall chimney or by mechanical forced-draft fans.The energy value of refuse can be as much as one-third that of coal, depending on the paper content, and the heat given off during incineration can be recovered by the use of a refractory-lined furnace coupled to a boiler. Boilers convert the heat of combustion into steam or hot water, thus allowing the energy content of the refuse to be recycled. Incinerators that recycle heat energy in this way are called waste-to-energy plants. Instead of a separate furnace and boiler, a water-tube wall furnace may also be used for energy recovery. Such a furnace is lined with vertical steel tubes spaced closely enough to form continuous sections of wall. The walls are insulated on the outside in order to reduce heat loss. Water circulating through the tubes absorbs heat to produce steam, and it also helps to control combustion temperatures without the need for excessive air, thus lowering air pollution control costs.Waste-to-energy plants operate as either mass burn or refuse-derived fuel systems. A mass burn system uses all the refuse, without prior treatment or preparation. A refuse-derived fuel system separates combustible wastes from noncombustibles such as glass and metal before burning. If a turbine is installed at the plant, both steam and electricity can be produced in a process called cogeneration.Waste-to-energy systems are more expensive to build and operate than plain incinerators because of the need for special equipment and controls, highly skilled technical personnel, and auxiliary fuel systems. On the other hand, the sale of generated steam or electricity offsets much of the extra cost, and recovery of heat energy from refuse is a viable solid-waste management option from both an engineering and an economic point of view. About 80 percent of municipal refuse incinerators in the United States are waste-to-energy facilities.

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IV.RESULTS

Separating, recovering, and reusing components of solid waste that may still have economic value is called recycling.

Environmental effects of recycling

Material	Energy savings vs. new production	Air pollution savings vs. new production
Aluminium	95%	95%
Cardboard	24%	—
Glass	5–30%	20%
Paper	40%	73%
Plastics	70%	—
Steel	60%	—

One type of recycling is the recovery and reuse of heat energy, a practice discussed separately in incineration. Composting can also be considered a recycling process, since it reclaims the organic parts of solid waste for reuse as mulch or soil conditioner. Still other waste materials have potential for reuse. These include paper, metal, glass, plastic, and rubber, and their recovery is discussed here.Before any material can be recycled, it must be separated from the raw waste and sorted. Separation can be accomplished at the source of the waste or at a central processing facility. Source separation, also called curbside separation, is done by individual citizens who collect newspapers, bottles, cans, and garbage separately and place them at the curb for collection. Many communities allow "commingling" of nonpaper recyclables (glass, metal, and plastic). In either case, municipal collection of source-separated refuse is more expensive than ordinary refuse collection.

In lieu of source separation, recyclable materials can be separated from garbage at centralized mechanical processing plants. Experience has shown that the quality of recyclables recovered from such facilities is lowered by contamination with moist garbage and broken glass. The best practice, as now recognized, is to have citizens separate refuse into a limited number of categories, including newspaper; magazines and other wastepaper; commingled metals, glass, and plastics; and garbage and other nonrecyclables. The newspaper, other paper wastes, and commingled recyclables are collected separately from the other refuse and are processed at a centralized material recycling facility, or MRF (pronounced "murf" in waste-management jargon). A modern MRF can process about 300 tons of recyclable wastes per day.

At a typical MRF, commingled recyclables are loaded onto a conveyor. Steel cans ("tin" cans are actually steel with only a thin coating of tin) are removed by an electromagnetic separator, and the remaining material passes over a vibrating screen in order to remove broken glass. Next, the conveyor passes through an air classifier, which separates aluminum and plastic containers from heavier glass containers. Glass is manually sorted by colour, and aluminum cans are separated from plastics by an eddy-current separator, which repels the aluminum from the conveyor belt.

Recovered broken glass can be crushed and used in asphalt pavement. Colour-sorted glass is crushed and sold to glass manufacturers as cullet, an essential ingredient in glassmaking. Steel cans are baled and shipped to steel mills as scrap, and aluminum is baled or compacted for reuse by smelters. Aluminum is one of the smallest components of municipal solid waste, but it has the highest value as a recyclable material. Recycling of plastic is a challenge, mostly because of the many different polymeric materials used in its production. Mixed thermoplastics can be used only to make lower-quality products, such as "plastic lumber."In the paper stream, old newspapers are sorted by hand on a conveyor belt in order to remove corrugated materials and mixed papers. They are then baled or loose-loaded into trailers for shipment to paper mills, where they are reused in the making of more newspaper. Mixed paper is separated from corrugated paper for sale to tissue mills.

Although the processes of pulping, de-inking, and screening wastepaper are generally more expensive than making paper from virgin wood fibres, the market for recycled paper has grown with the establishment of more processing plants.Rubber is sometimes reclaimed from solid waste and shredded, reformed, and remolded in a process called revulcanization, but it is usually not as strong as the original material. Shredded rubber can be used as an additive in asphalt pavements and artificial turf and is also sold directly as an outdoor mulch. Discarded tires may be employed as swings and other recreational structures for use by children in "tire playgrounds."In general, the most difficult

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problem associated with the recycling of any solid-waste material is finding applications and suitable markets. Recycling by itself will not solve the growing problem of solid-waste management and disposal. There will always be some unusable and completely valueless solid residue requiring final disposal.

IV.CONCLUSIONS

Recycling is the recovery and reuse of materials from wastes. Solid waste recycling refers to the reuse of manufactured goods from which resources such as steel, copper , or plastics can be recovered and reused. Recycling and recovery is only one phase of an integrated approach to solid waste management that also includes reducing the amount of waste produced, composting , incinerating, and landfilling.Municipal solid waste (MSW) comes from household, commercial, institutional, and light industrial sources, and from some hospital and laboratory sources. In 2000 the United States produces nearly 232 million tons (210.5 million metric tons) of MSW per year, almost 4.5 lb (2 kg) per resident per day. The percentages of MSW generated in this country include paper and paperboard, 38.1%; yard wastes, 12.1%; metals, 7.8%; glass, 5.5%; rubber , textiles, leather and wood, 11.9%; food wastes, 10.9%; plastics, 10.5%; and other, 3.2%.Recycling is a significant way to keep large amounts of solid waste out of landfills, conserve resources, and save energy. As of 2000, Americans recovered, recycled, or composted 30.1% of MSW, incinerated 14.5%, and landfilled 55.3%.The technology of recycling involves collection, separation, preparing the material to buyer's specifications, sale to markets, processing, and the eventual reuse of materials. Separation and collection is only the first step; if the material is not also processed and returned to commerce, then it is not being recycled. In many parts of the country, markets are not yet sufficiently developed to handle the growing supply of collected material.

Intermediate markets for recyclable materials include scrap dealers or brokers, who wait for favorable market conditions in which to sell their inventory. Final markets are facilities where recycled materials are converted to new products, the last phase in the recycling circle.The materials recycled today include aluminum , paper, glass, plastics, iron and steel, scrap tires, and used oil. Aluminum, particularly cans, is a valuable commodity. By the late 1980s, over 50% of all aluminum cans were recycled. Recycling aluminum saves a tremendous amount of energy: it takes 95% less energy to produce an aluminum can from an existing one rather than from ore. Other aluminum products that are recycled include siding, gutters, door and window frames, and lawn furniture.Over 40% of the paper and paperboard used in the U.S. is collected and utilized as either raw material to make recycled paper, or as an export to overseas markets. Recycled paper shows up in newsprint, roofing shingles, tar paper, and insulation. Other recyclable paper products include old corrugated containers, mixed office waste, and high-grade waste paper. Contaminants must be removed from paper products before the remanufacture process can begin, however, such as food wastes, metal, glass, rubber, and other extraneous materials.The market for crushed glass, or cullet, has increased. Recycled glass is used to make fiberglass and new glass containers. About 1.25 million tons (1.14 million metric tons) of glass is recycled annually in the United States.Three types of plastic are successfully being recycled, the most common being PET (polyethylene terephthalate), or soft drink containers. Recycled PET is used for fiberfill in sleeping bags and ski jackets, carpet backing, automobile bumpers, bathtubs, floor tiles, and paintbrushes. HDPE plastic (high density polyethylene) is used for milk jugs and the bottoms of soft drink bottles. It can be recycled into trash cans and flower pots, among other items. Polystyrene foam is crushed into pellets and turned into plastic lumber for benches and walkways. Commingled plastics are recycled into fence posts and park benches.

Iron and steel are the most recycled materials used today. In 1987, 51 million tons (46 million metric tons) were recycled, more than twice the amount of all other materials combined. The material is remelted and shaped into new products.More than one billion discarded tires are stockpiled in the United States, but scrap tires can be shredded and used for asphalt-rubber or retreading; are incinerated for fuel; or used to construct artificial marine reefs.Used oil is a valuable resource, and of the 1.2 billion gal (4.5 billion L) generated annually, two-thirds is recycled. The rest, about 400 million gal (1.5 billion L), is disposed of or dumped. About 57% of used oil is reprocessed for fuel, 26% is refined and turned into base stock for use as lubricating oil, and about 17% is recycled for other uses.

Composting is the aerobic biological decomposition of organic waste materials, usually lawn clippings. Composting is not an option for a major portion of the solid waste stream , but is an important component of the resource recovery program.Recycling collection methods vary, but curbside collection is the most popular and has the highest participation rates. It is also the most expensive way for municipalities to collect recyclables in their communities. Collection centers do not yield as many recyclables because residents must do the sorting themselves, but centers offer the most affordable method of collection.Precycling is an option that is gaining widespread recognition in this country. Basically, precycling refers to the consumer making environmentally sound choices at the point of purchase. It includes avoiding products with extra packaging, or products made to satisfy only short-term needs, such as disposable

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razors.Resource recovery or materials recovery is the recycling of waste in an industrial setting. It does not involve recycling consumer waste or municipal solid waste, but includes reprocessed industrial material that, for whatever reason, is not able to be used as it was initially intended. Some consumer groups are pressing for government guidelines on labeling packaging or products "reprocessed" as opposed to "recycled."While the Environmental Protection Agency (EPA) insists that no single alternative to the municipal solid waste problem should be relied upon, its generally accepted hierarchy of waste management alternatives is 1) source reduction and 2) reusing products. Waste that is not generated never enters the waste stream.If recycling is to be used as a genuine MSW management alternative rather than a "feel good" way to conserve resources, then materials must be recovered and made into new products in large quantities. For some materials, however, an insufficient market exists, so communities must pay to have some recyclable materials taken away until a market is developed. Recycling programs depend on the will of the community to follow through, and in many areas, response is weak and enforcement lacking. However, dwindling landfill space in the 1990s may force communities to mandate recycling programs.Recent EPA regulations seriously affected the number of operable landfills. The requirements include installing liners, collecting and treating liquids that leach, monitoring groundwater and surface water for harmful chemicals , and monitoring the escape of methane gas. These regulations will increase the number of corporate-run landfills, but the cost of building and maintaining a landfill that adheres to the regulations will top $125 million. The end cost to consumers to have trash hauled away may also force many garbage makers to become reducers, reusers, and recyclers.

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