Solid Waste Management:

Introduction & Concepts

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How Clean is Clean??

Natural Laws:

- I am, therefore I pollute.
- Complete waste recycling is impossible.
- Proper disposal entails conversion of offensive substances into environmentally compatible earthenlike materials.
- Small waste leaks are unavoidable and acceptable.
- Nature sets the standards for what is compatible and for what are small leaks.

Definitions:

- Ecosystem: the interaction/conversion/transformation between the living beings (biotic) and non-living beings (abiotic: soil, air, water and their compositions)

- Human activities generate waste materials that are often discarded because they are considered useless.

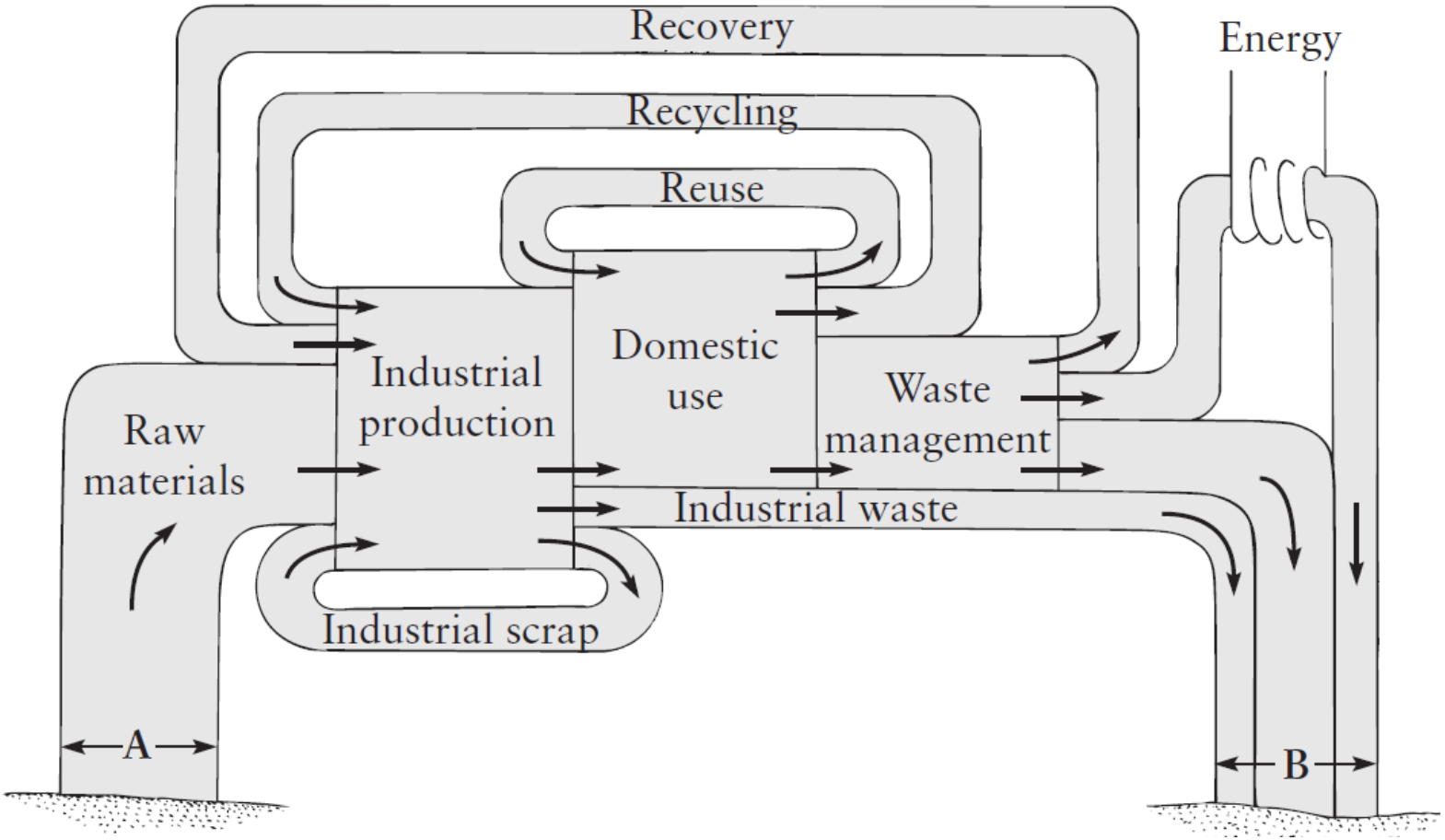
- The term “solid waste” means any garbage, refuse, sludge … or other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining and agricultural operations…but does not include solid or dissolved material in domestic sewage … or industrial discharges which are point sources …

- Waste: any item to be refused since it has no value, useless, and unwanted!

- Municipal Solid Waste or MSW: solid wastes produced by communities.

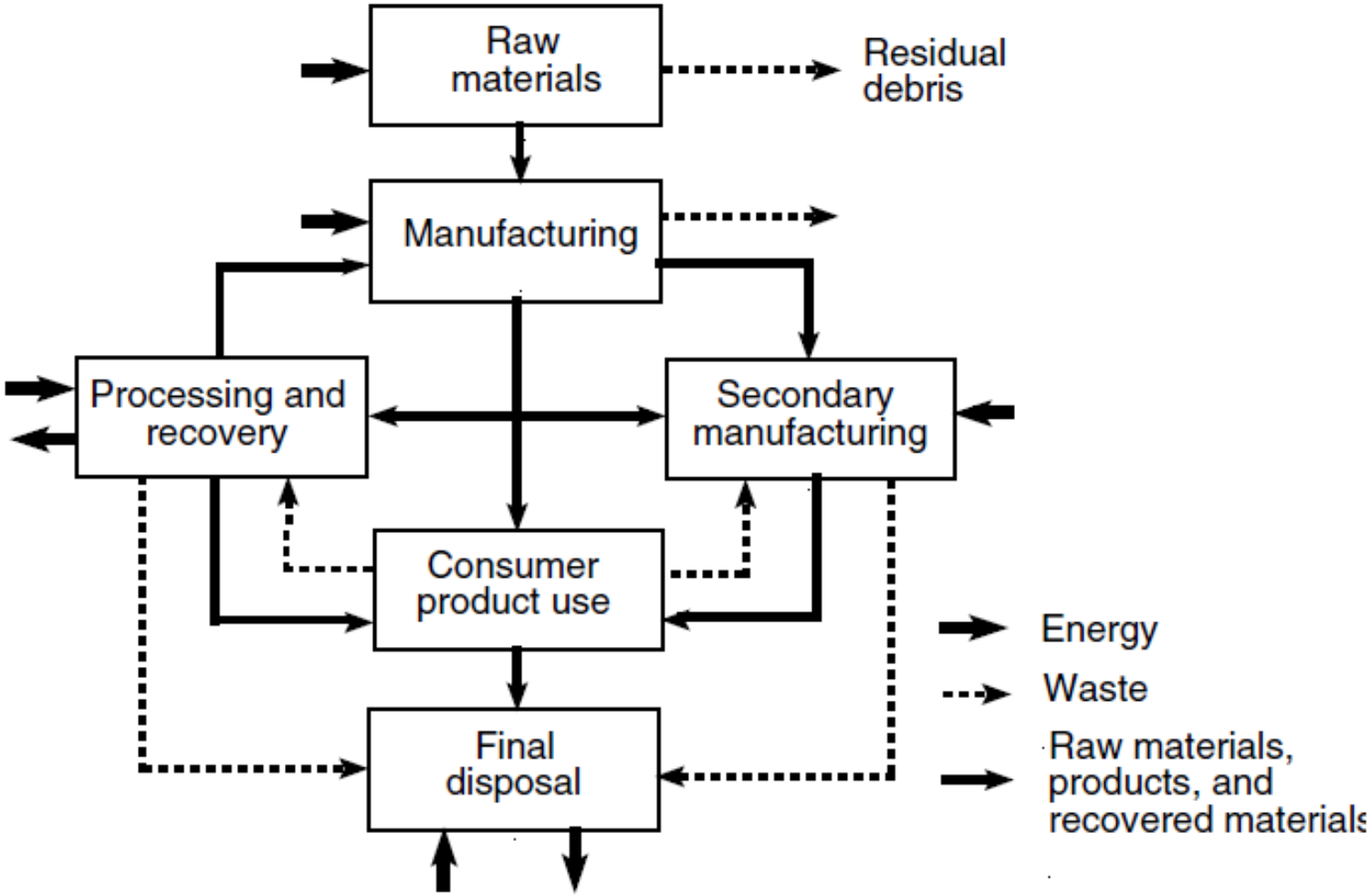
- Materials Flow - The best way to reduce solid wastes is not to create them in the first place. Other methods include: decrease consumption of raw material and increase the rate of recovery of waste materials.

Ecosystem: Source & Sink



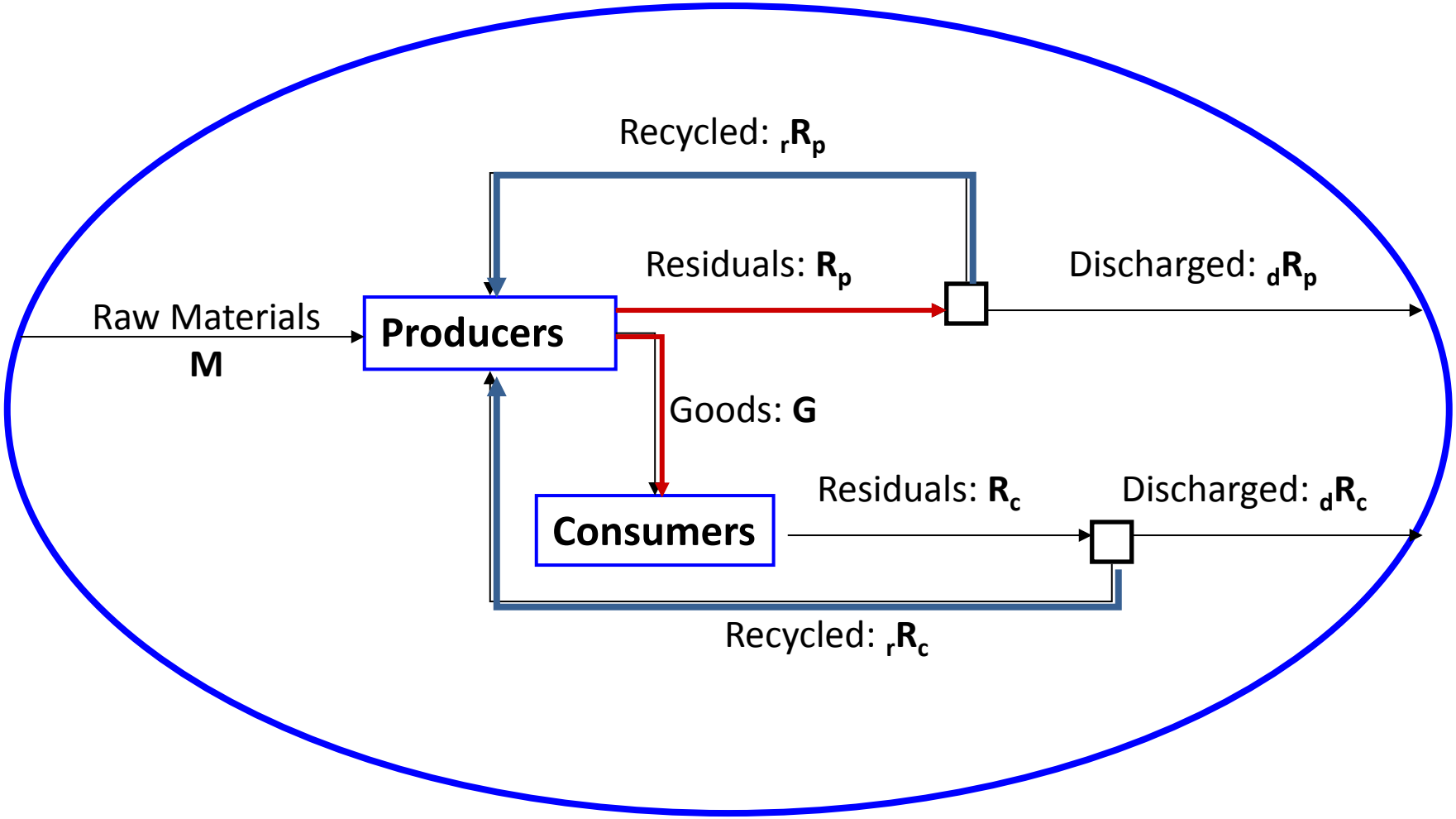
Source: Ch.1 Figure 1.2 WW PV

Flow of materials and waste in an industrial society



Source: Ch.1 Figure 1.1 G. Tchobanoglous

Fundamental Balance



$$M = {}_dR_p + {}_dR_c \longrightarrow M = G + R_p - ({}_rR_p + {}_rR_c)$$

Materials Flow

$$M = G + R_p - ({}_rR_p + {}_rR_c)$$

- 3 Ways of Reducing M
  - Reduce G
    - Reduce “consumerism”
    - Zero population growth?
  - Reduce R_p
    - Reduce residual intensity of production
  - Increase $({}_rR_p + {}_rR_c)$
    - Mandatory content requirements

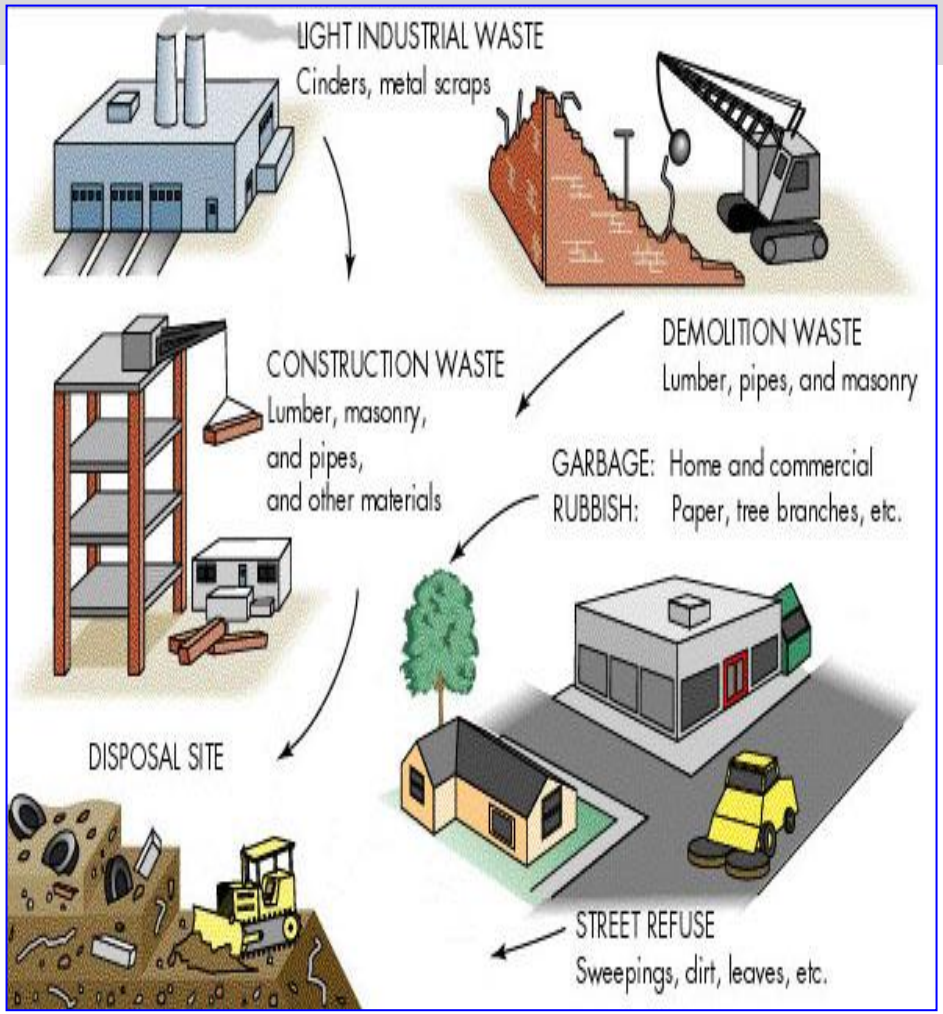
MSW

MSW has the following components:

- Mixed household waste
- Recyclables, such as:
  - Newspapers
  - Aluminum cans
  - Milk cartons
  - Plastic soft drink bottles
  - Steel cans
  - Corrugated cardboard

Other material collected by the community

- Household hazardous waste
- Commercial waste
- Yard (or green) waste
- Litter and waste from community trash cans
- Bulky items (refrigerators, rugs, etc.)
- Construction and demolition waste



Source: Ch.2 WW PV

Source	Typical facilities, activities, or locations where wastes are generated	Types of solid wastes
Residential	Single-family and multifamily dwellings; low-, medium-, and high-density apartments; etc.	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, tin cans, aluminum, other metal, ashes, street leaves, special wastes (including bulky items, consumer electronics, white goods, yard wastes collected separately, batteries, oil, and tires), and household hazardous wastes
Commercial	Stores, restaurants, markets, office buildings, hotels, motels, print shops, service stations, auto repair shops, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metal wastes, ashes, special wastes (see preceding), hazardous wastes, etc.
Institutional	Schools, hospitals, prisons, governmental centers, etc.	Same as for commercial
Industrial (nonprocess wastes)	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metal wastes, ashes, special wastes (see preceding), hazardous wastes, etc.
Municipal solid waste*	All of the preceding	All of the preceding
Construction and demolition	New construction sites, road repair, renovation sites, razing of buildings, broken pavement, etc.	Wood, steel, concrete, dirt, etc.
Municipal services (excluding treatment facilities)	Street cleaning, landscaping, catch-basin cleaning, parks and beaches, other recreational areas, etc.	Special wastes, rubbish, street sweepings, landscape and tree trimmings, catch-basin debris; general wastes from parks, beaches, and recreational areas
Treatment facilities	Water, wastewater, industrial treatment processes, etc.	Treatment plant wastes, principally composed of residual sludges and other residual materials
Industrial	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition, etc.	Industrial process wastes, scrap materials, etc.; nonindustrial waste including food wastes, rubbish, ashes, demolition and construction wastes, special wastes, and hazardous waste
Agricultural	Field and row crops, orchards, vineyards, dairies, feedlots, farms, etc.	Spoiled food wastes, agricultural wastes, rubbish, and hazardous wastes

Source: Ch.1 Table 1.1 G. Tchobanoglous

Refuse

For many reasons it is convenient to define refuse as

- Solid waste generated by households, including mixed non-sorted waste
- Recyclables (whether or not they are collected separately)
- Household hazardous wastes if these are not collected separately
- Yard (or green) waste originating with individual households
- Litter and community trash, because the material is produced by individuals
- Commercial waste, because it often contains many of the same items as household waste

By our definition, refuse does not include:

- Construction and demolition debris
- Water and wastewater treatment plant sludges
- Leaves and other green waste collected from community streets and parks in the fall
- Bulky items such as large appliances, hulks of old cars, tree limbs, and other large objects that often require special handling

Source: Ch.2 WW PV

- The fraction of refuse that is generated but not collected is called ***diverted* refuse**. The ***as-generated* refuse** is always larger than the ***as-collected* refuse**, and the difference is **the *diverted* refuse.**

In summary:

(MSW) = (refuse) + (C & D waste) + (leaves) + (bulky items)

- Sometimes diversion is defined on the basis of MSW instead of refuse. When defined in this way, **diverted MSW is that fraction of MSW that is generated but does not find its way to the landfill**. The objective is to increase the life of a landfill or to reduce the cost of disposal.
- One major diversion is the collection of recyclables (aluminum cans, newspapers, etc.) that can be sold on the secondary materials market. The EPA has challenged communities to increase their diversion to 35%—up from the 25% originally suggested in 1988. California has set an even higher goal of 50% diversion.
- When communities are under state mandates to increase the recycling of consumer products, the calculation often is made using the MSW as the denominator instead of the refuse, thereby achieving large diversion rates.

Source: Ch.2 WW PV

EXAMPLE

A community produces the following on an annual basis:

Fraction	Tons per year
Mixed household waste	210
Recyclables	23
Commercial waste	45
Construction and demolition debris	120
Leaves and miscellaneous	36

The recyclables are collected separately and processed at a materials recovery facility. The mixed household waste and the commercial waste go to the landfill. The leaves are composted, and the C & D wastes are processed and used on the next project. Calculate the diversion.

If the calculation is on the basis of MSW

$$\frac{23 + 120 + 36}{434} \times 100 = 41\%$$

if calculated as that fraction of the *refuse*

$$\frac{23}{210 + 23 + 45} \times 100 = 8.3\%$$

Source: Ch.2 Example 2.1 WW PV

Philosophy of Waste Disposal and Management

- **Philosophy #1-- Out of sight out of mind: Mid-night-dumping**
  widespread environmental damage, the philosophy persists, and continues to pose serious problems

- **Philosophy #2 -- Dilute and Disperse ("the solution to pollution is dilution"):**
  First century of Industrial Revolution, no longer suitable for waste disposal; many environments have reached their maximum compensation points

- **Philosophy #3 -- Concentrate and Contain:**
  the most popular today, very energy intensive and expensive

- **Philosophy #4 -- Resource Recovery:**
  waste converted to useful material, requires technology, and volumes too large

- **Philosophy #5 -- Integrated Waste Management:**
  Complex set of alternatives: source reduction, recycling, composting, landfill, and incineration

Minimization of material use & waste generation

- The feasible options for achieving reduced material use and waste generation are known as the four R's:

1. Reduction

2. Reuse

3. Recycling

4. Recovery

Source: Ch.2 page: 11-16 WW PV

1. Reduction

Waste reduction can be achieved in three basic ways:

1. Reducing the amount of material used per product without sacrificing the utility of that product,
2. Increasing the lifetime of a product,
3. Eliminating the need for the product.

2. Reuse

- Many of our products are reused without much thought given to ethical considerations.
- These products simply have utility and value for more than one purpose.
- For example, paper bags obtained in the supermarket are often used to pack refuse for transport from the house to the trash can or to haul recycleables to the curb for pickup. Newspapers are rolled up to make fireplace logs, and coffee cans are used to hold bolts and screws.

3. Recycling

- The process of recycling requires that the owner of the waste material first separate out the useful items so that they can be collected separately from the rest of the solid waste.

- Theoretically, vast amounts of materials can be recycled from refuse, but this is not an easy task regardless of how it is approached. In recycling, a person about to discard an item must first identify it by some characteristics and then manually segregate it into a separate bin. The separation relies on some readily identifiable characteristic or property of the specific material that distinguishes it from all others. This characteristic is known as a *code*

4. Recovery

- Recovery is defined as the process in which the refuse is collected without prior separation and when the recyclable materials in the refuse are separated from the non-recyclable materials at a central facility.

- A typical mixed-waste materials recovery facility (MRF):