INNOVATIONS IN RECYCLING OF PLASTICS PACKAGING AND OTHER PACKAGING MATERIALS FOR FOOD

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The Environment Protection Agency (EPA) analyzes municipal solid waste in two ways:

- **By materials:** paper and paperboards, glass, metals, plastics, rubber and leather, textiles, wood, food scraps, and yard trimmings

- **By major product categories:** containers and packaging (mainly waste from food packaging, such as soft drink cans, milk cartons, and cardboard boxes); nondurable goods (newspapers, office paper, tissues, paper plates and cups, etc); durable goods (household appliances, furniture, carpets, rubber tires); and other wastes

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**Solid Waste**

*Waste* (also known as *rubbish, refuse, garbage, junk*) is unwanted or useless materials. In biology, waste is any of the many unwanted substances expelled from living organisms, metabolic waste; such as urea and sweat.
## Structure of Solid Waste

<table>
<thead>
<tr>
<th>Solid Waste</th>
<th>Refuse</th>
<th>Trash</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Garbage</strong></td>
<td><strong>Bulky wastes</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(TV, refrigerators,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>goods, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Rubbish</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Broken furniture, etc.)</td>
</tr>
<tr>
<td>Vegetables, Meats, food</td>
<td>Degradable organic wastes</td>
<td></td>
</tr>
<tr>
<td>Wastes and other readily Degradable organic wastes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-degradable (glass, rubber, Metals, plastics non-metal set)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Slowly degradable (paper, wood Products, textiles etc.)</td>
<td></td>
</tr>
</tbody>
</table>
Kinds of Wastes

- **Solid wastes**: wastes in solid forms, domestic, commercial and industrial wastes
  Examples: *plastics, bottles, cans, papers, scrap iron, and other trash*

- **Liquid Wastes**: wastes in liquid form
  Examples: *domestic washings, chemicals, oils, waste water from ponds, manufacturing industries and other sources*

- **Bio-degradable**: wastes can be degraded (paper, wood, fruits and others)

- **Non-biodegradable**: wastes cannot be degraded (plastics, bottles, old machines, cans, Styrofoam containers and others)

- **Hazardous wastes**: Substances unsafe to use commercially, industrially, agriculturally, or economically and have any of the following properties- ignitability, corrosivity, reactivity & toxicity

- **Non-hazardous**: Substances safe to use commercially, industrially, agriculturally, or economically and do not have any of those properties mentioned above. These substances usually create disposal problems
Solid Waste in India

- 7.2 million tonnes of hazardous waste
- One Sq km of additional landfill area every-year
- Rs 1600 crore for treatment & disposal of these wastes
- In addition to this industries discharge about 150 million tones of high volume low hazard waste every year, which is mostly dumped on open low lying land areas
MSW Generation from the Metropolitans of India

<table>
<thead>
<tr>
<th>State/Union Territory</th>
<th>City</th>
<th>Urban Population in Lakhs (2001)</th>
<th>MSW generated (MT/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>Hyderabad</td>
<td>3829753</td>
<td>957</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>Visakhapatnam</td>
<td>982904</td>
<td>246</td>
</tr>
<tr>
<td>Bihar</td>
<td>Patna</td>
<td>1961532</td>
<td>588</td>
</tr>
<tr>
<td>Delhi</td>
<td>New Delhi</td>
<td>350000</td>
<td>272</td>
</tr>
<tr>
<td>Delhi</td>
<td>Delhi</td>
<td>13363471</td>
<td>6000</td>
</tr>
<tr>
<td>Gujarat</td>
<td>Ahmedabad</td>
<td>4215497</td>
<td>1265</td>
</tr>
<tr>
<td>Gujarat</td>
<td>Surat City</td>
<td>2433835</td>
<td>730</td>
</tr>
<tr>
<td>Gujarat</td>
<td>Vadodara</td>
<td>1491045</td>
<td>447</td>
</tr>
<tr>
<td>Karnataka</td>
<td>Bangalore</td>
<td>1304008</td>
<td>326</td>
</tr>
<tr>
<td>Kerala</td>
<td>Kochi</td>
<td>275225</td>
<td>69</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>Mumbai</td>
<td>11914398</td>
<td>7500</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>Nagpur</td>
<td>2040175</td>
<td>700</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>Pune</td>
<td>2540000</td>
<td>1000</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>Bhopal</td>
<td>1482718</td>
<td>445</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>Indore</td>
<td>1550880</td>
<td>465</td>
</tr>
<tr>
<td>Punjab</td>
<td>Ludhiana</td>
<td>1429709</td>
<td>500</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>Jaipur</td>
<td>1870771</td>
<td>561</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>Chennai</td>
<td>4343645</td>
<td>1086</td>
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<tr>
<td>Tamil Nadu</td>
<td>Coimbatore</td>
<td>1501373</td>
<td>375</td>
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<tr>
<td>Tamil Nadu</td>
<td>Madurai</td>
<td>1233083</td>
<td>308</td>
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<tr>
<td>Uttar Pradesh</td>
<td>Kanpur</td>
<td>2725207</td>
<td>954</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>Lucknow</td>
<td>2262369</td>
<td>792</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>Varanasi</td>
<td>1250039</td>
<td>438</td>
</tr>
<tr>
<td>West Bengal</td>
<td>Kolkata</td>
<td>4572876</td>
<td>1143</td>
</tr>
<tr>
<td>Grand Total</td>
<td></td>
<td>70924513</td>
<td>27167</td>
</tr>
</tbody>
</table>
Waste Management & Hierarchy

There are 2 ways that nature can cope with the issue of excess waste:

- End of pipe waste treatment - waste such as water is treated before it is returned to waterways
- Recycle as much material as possible
3R’s stands for Reduce, Reuse and Recycle;

• **Reduce – Minimal Packaging:** Packaging should be reduced prior to the manufacturing stage, by designing and marketing products for the first "R". This means reducing the number of layers, materials and toxins at source.

• **Reuse - Reusable Packaging:** Packaging should be designed to be reusable, refillable, returnable and durable to the greatest extent possible.

• **Recycle – Recycle Packaging:** Packaging should be designed to be recyclable and/or made with recycled content. A package or packaging material is considered to be "recyclable" if there is a widely available and economically viable collection, processing and marketing system for the product/material.

Environment Protection Agency (EPA) framed 3R’s for the control of packaging material solid waste and as also legislated the Life Cycle Assessment (LCA) for the new packaging materials developed.
**REDUCE**

**REDUCTION MEANS TO MAKE - SOMETHING SMALLER**

**USE SOMETHING LESS OFTEN**

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**Advantages of REDUCE**

- **Resin of container:**
  - Reduction: 50% reduction
  - **CO₂ emissions:**
    - Reduction: 55% reduction (per one load)

- **Resin of container:**
  - Reduction: 35% reduction
  - **CO₂ emissions:**
    - Reduction: 35% reduction (per one load)

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- **4.5% reduction in carbon impact of packaging**
- **35% reduction in CO₂ emissions**
- **15.6% reduction in water use**
- **No significant change in supply chain waste**
- **CO₂ 4.3% reduction in transport emissions**
This includes conventional reuse where the item is used again for the same function, and new-life reuse where it is used for a new function.

To reuse is to use an item more than once.

**Materials can be reused:**
- Paper
- Rubber bands
- Buttons
- Paper clips
- Empty food containers
- Water bottles
- Card board boxes
- Gift bags
Methods to REUSE

- Reuse envelopes
- Reuse single-sided paper for scratch paper
- Reuse foam peanuts and other packaging material
- Use remanufactured or surplus office equipment
- Use rechargeable batteries
- Use rechargeable fax and printer cartridges
- Compost grass clippings and food waste
- Donate toys and other items to charity
Recycling means the processing of used materials or waste into new product!

Key component of modern waste reduction & the third component of waste hierarchy

Recycling is a process to change (waste) materials into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from land filling) by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to plastic production.
Recycling

- **Recycling conserves our valuable natural resources**: Recycling helps to conserve our natural resources such as oil, metal and water. For example plastic bottles can be recycled into new plastic bottles and polyester fibers for use in fleece jumpers and car mats.

- **Recycling saves energy**: Recycling aluminum saves 95% of the energy required to produce aluminum from raw materials. Recycling just one plastic bottle will save enough energy to power a 60 watt light bulb for 3 hours!

- **Recycling protects the environment**: Recycling helps to conserve energy, so less greenhouse gases are emitted. Recycling reduces our dependence on landfill. With less materials going to landfill, less harmful emissions like methane gas are released into the earth's atmosphere.

- **Recycling can save you money**: By putting more recyclable materials into your recycling bin you reduce the amount of times you have to put your general refuse or black bin out for collection. It is usually more expensive to collect the black bin than the recycling bin, so recycling can save you money.
Why RECYCLE?

- **PRESERVES NATURAL RESOURCES**
  - Recycling the print run of a single Sunday issue of the New York Times would spare 75,000 trees.

- Recycling 1 ton of aluminum saves 4 tons of bauxite.
- Using recycled paper, 60% of the water normally needed in paper manufacturing is saved;
- by using recycled steel, there is a 40% water savings.

WHY recycle?

**REDUCES ENERGY CONSUMPTION**

Making new steel from old scrap offers up to 75% energy savings.

Producing aluminum from scrap instead of bauxite ore cuts energy use by 95%.

Paper recycling saves up to 70% of the energy needed to create paper from new timber.

Less energy consumption = less air pollution + less Mercury.
Recycling- Advantages

- Prevents waste of potentially used materials
- Reduce the consumption of fresh raw materials
- Reduce energy usage
- Reduce air & water pollution
- Recycling of a material would produce a fresh supply of the same material

Ex: Paper recycling
## Packaging - Effect on Environment

<table>
<thead>
<tr>
<th>Positive Practice</th>
<th>Affect on the environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass manufacturers recycle glass to make new products</td>
<td>Fewer raw materials used</td>
</tr>
<tr>
<td></td>
<td>Reduction in landfill</td>
</tr>
<tr>
<td>Resealable plastic bags</td>
<td>less plastic film used to rewrap products once they are opened</td>
</tr>
<tr>
<td>Lightweight plastic used in place of glass. E.g. honey &amp; peanut butter</td>
<td>Plastic is recyclable</td>
</tr>
<tr>
<td></td>
<td>Less energy used to make plastic</td>
</tr>
<tr>
<td>Tetra Pak ‘s can be recycled. Paper - pulped, plastic &amp; aluminium returned to supplier</td>
<td>Less energy used in the production, distribution &amp; handling (lightweight)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Negative Practice</th>
<th>Affect on the environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overpackaging</td>
<td>Increased landfill</td>
</tr>
<tr>
<td></td>
<td>More resources used to produce extra layers of packaging</td>
</tr>
<tr>
<td>Prepackaged foods</td>
<td>Food wastage</td>
</tr>
<tr>
<td>E.g. mushrooms in a styrofoam tray and shrink wrapped</td>
<td></td>
</tr>
<tr>
<td>Package too large for product it contains E.g. Corn chips have large head space to protect contents</td>
<td>Wastage of packaging materials and resources used to create them</td>
</tr>
</tbody>
</table>
Recycling steps in India

Households/Shops/Establishment

Municipal Waste Storage Depot

Transportation

Treatment Plant

Rejects

Disposal site

ORGANIC

Recycling Industry

Waste Purchaser Depot

Semi whole seller/Whole seller’s depot
Process of Waste Recycling
Plastics

- Plastic is the general common term for a wide range of synthetic or semi-synthetic materials used in a huge, and growing, range of applications.
- The demand of plastics is increased every year; growth rate is 5-6% every year
- In 2015, the demand will reach 297.5 Mtonnes; and reach until 400 Mtonne in 2020
- The main production countries: China, Japan, European and other countries

Plastic-The Fact, 2013
Plastics
Six resins account for almost 97 percent of all plastic used in packaging

Polyethylene terephthalate (PET) – 9%
High-density polyethylene (HDPE) – 29%
Low-density polyethylene (LDPE) – 32%
Poly-vinyl chloride (PVC) – 5%
Poly-propylene (PP) – 11%
Polystyrene (PS) – 11%
## Types of Plastic and Application

<table>
<thead>
<tr>
<th>Plastic ID code</th>
<th>Name</th>
<th>Color</th>
<th>Density (g/ml)</th>
<th>Application</th>
<th>Recycled product</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PET-Polyethylene Terephthalate</td>
<td>Green</td>
<td>1.35</td>
<td>Fizzy drink bottles, frozen meal packages, water bottle, bear bottle, mouthwash bottle.</td>
<td>Fiberfill in coats, Carpet, Camera film, Lumber</td>
</tr>
<tr>
<td>2</td>
<td>HDPE-High-Density Polyethylene</td>
<td>Red</td>
<td>1.00-0.93</td>
<td>Milk, washing-up liquid bottles, detergent bottles, oil bottles, toys, plastic bags.</td>
<td>Trash cans, Floor tile, Flower pots, Garden furniture</td>
</tr>
<tr>
<td>3</td>
<td>PVC-Polyvinyl Chloride</td>
<td>...</td>
<td>1.40</td>
<td>Food trays, cling film, bottles for squash, mineral water, shampoo, vegetable oil bottles, blister packaging</td>
<td>Floor mats, Flexible hoses, Playground equipment</td>
</tr>
<tr>
<td>4</td>
<td>LDPE-Low-Density Polyethylene</td>
<td>White Bead</td>
<td>0.93-0.86</td>
<td>Carrier bags, bin liners, bread bags, clothing, carpet, furniture, garment bags, shrink-wrap.</td>
<td>Floor tile, Furniture, Garbage can liners</td>
</tr>
<tr>
<td>5</td>
<td>PP-Polypropylene</td>
<td>Purple</td>
<td>0.90</td>
<td>Microwaveable meal trays.</td>
<td>Videocassette cases, Lawn mower wheels, battery cable, Landscape boards</td>
</tr>
<tr>
<td>6</td>
<td>PS-Polystyrene</td>
<td>Translucent white</td>
<td>1.05</td>
<td>Yoghurt pots, foam meat or fish trays, hamburger boxes, egg cartons, vending cups, plastic cutlery, protective packaging for electronic goods and toys.</td>
<td>Flower pots, Trash cans, Thermometers, Rulers</td>
</tr>
<tr>
<td>7</td>
<td>Others</td>
<td>...</td>
<td>...</td>
<td>The plastics that don't fall into any of above categories, such as Melamine.</td>
<td>...</td>
</tr>
</tbody>
</table>

- 7 types of Plastics
- SPI have coded each type of plastic by number from 1 until 7
- Every kind of Plastic can be recycled according to their component and give different recycled products
Types of Plastic and Application

Different type of Plastic with different needs

Plastic-The Fact, 2013
Environmental Impact of plastics

Plastic also has a positive impact on the environment. Consider the following fact:

- When comparing the manufacturing processes of polystyrene and paper cups, it was found the paper cups use
  - 15 times more chemicals
  - More than 6 times more steam
  - 13 times more electricity
  - 30% more cooling water
  - 170 times more process water
- The lightweight nature of plastics results in fewer truckloads and less fuel usage
Environmental Impact of plastics

- Negative impact of plastic on the environment
- Plastic in the oceans is responsible for the deaths of millions of sea animals
- Plastic never degrades
- Incinerating plastic contributes to greenhouse gases
- Plastics contain harmful chemicals
- Making new plastic requires significant amounts of fossil fuels
- People in the U.S. throw away 2.5 million plastic bottles an hour
Life Cycle of Plastic-Water Bottle

- Water bottle—Mainly made from PET
- The Life Cycle of Water Bottle:
  - Raw materials extraction
  - Manufacturing
  - Production process
  - Product distribution and Usage
  - End-of life
    - Reuse
    - Recycle
    - Landfill
    - Energy recovery
Plastics are recycled less frequently than glass and aluminum

Plastics are not biodegradable
# Plastic Recycling

## Categories for recycling:

<table>
<thead>
<tr>
<th>Categories</th>
<th>Number</th>
<th>Recycled Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easiest</td>
<td>1-PET</td>
<td>Fiberfil for coats, sleeping bed</td>
</tr>
<tr>
<td></td>
<td>2-HDPE</td>
<td>Toys, piping</td>
</tr>
<tr>
<td>Less commonly</td>
<td>3-PVC</td>
<td>Baby bottle nipples</td>
</tr>
<tr>
<td></td>
<td>4-LDPE</td>
<td>Wrapping films, grocery, sandwich gabs</td>
</tr>
<tr>
<td></td>
<td>5-PP</td>
<td>(not so acceptable for recycling)</td>
</tr>
<tr>
<td>Useful</td>
<td>6-PS</td>
<td>Meat tray, packing peanuts...</td>
</tr>
<tr>
<td>Hardest</td>
<td>7-Others</td>
<td>Most difficult to recycle</td>
</tr>
</tbody>
</table>

[Image showing various products made from recycled plastic, including PET, PVC, and HDPE.]
Recycling Process

• Collection/Selection
• Separation
• Processing
• Manual Sorting
• Free of contamination
Example of Disposal Routes for a Plastic Water Bottle

1. Plastic water bottle production from raw materials
2. Labeling, packaging, distribution
3. Use
   - Refill with tap water and reuse
   - Throw in trash
   - Throw in recycle bin
4. Recycling of plastic and reforming into water bottles

Disposal Options
Plastic Recycling

Processing Plant of Recycled Plastic

Plastic recycling, 2014 (http://biophysics.sbg.ac.at/waste/plastic.htm)
Plastic Recycling Process-Extruder

The melting equipment of plastics: Melting system: Shear heating system
The purpose is to separate different kinds of plastic homogenously from mixture of plastic and other wastes.

Several techniques applied in recycling plastic:

- **Sink-float separation technique**
- **Electrostatic separation**
- A dry separation technique that utilizes the electrical charging of particles
Plastic Recycling

Recycling Techniques – ABS, PS, PP separation process

Air Table:
- Density of PVC = 1.4 g/ml; and PP = 0.9 g/ml
- Velocity of airflow: 1.6 m/s
- Frequency of deck: 11.95/s
- End slope $\alpha=4.4^\circ$; side slope $\beta=2.5^\circ$
- Sample size: 2.38–3.36 mm
  - PVC, high density => settle on the bed
  - PP, low density => Float on the top of the bed
Plastic Recycling

Recycling Techniques – ABS, PS, PP separation process

Triboelectric cyclone separator:

- Separate ABS from ABS/PS
- DC power supply
- Based on the different charge of Plastic types
- ABS goes to negative part, PS goes to Positive Part

<table>
<thead>
<tr>
<th>Polymer type</th>
<th>Density (kg/m³)</th>
<th>Contact angle with water (°)</th>
<th>Triboelectrostatic series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylonitrile–butadiene–styrene, ABS</td>
<td>1060</td>
<td>87.3</td>
<td>End positive (+)</td>
</tr>
<tr>
<td>Polyethylene terephthalate, PET</td>
<td>1350</td>
<td>76.5</td>
<td></td>
</tr>
<tr>
<td>Polystyrene, PS</td>
<td>1050</td>
<td>86.3</td>
<td></td>
</tr>
<tr>
<td>Polyethylene, PE</td>
<td>960</td>
<td>96.8</td>
<td></td>
</tr>
<tr>
<td>Polypropylene, PP</td>
<td>900</td>
<td>95.0</td>
<td></td>
</tr>
<tr>
<td>Polyvinyl chloride, PVC</td>
<td>140</td>
<td>86.4</td>
<td>End negative (-)</td>
</tr>
</tbody>
</table>
**Recycling Techniques – ABS, PS, PP separation process**

**Sink-float and flotation:**

- PET’s density = 1.35 g/ml, PE’s density = 0.96 g/ml, lower than water’s.

- Reagent Dodecylamine (DAA) = 0.02 kg/m3, for PE to float out and Pet is sink as hydrophilic stage.

- Sample size: from 2.38– 3.36 mm, is the size after shredders
## Plastic Recycling

Recovery efficiency of various recycling techniques

<table>
<thead>
<tr>
<th>Types</th>
<th>PVC from PVC/PP</th>
<th>ABS from ABS/PS</th>
<th>PET from PET/PE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>Air Table</td>
<td>Triboelectric cyclone separator</td>
<td>Sink-float and Flotation</td>
</tr>
<tr>
<td>Recovery</td>
<td>97.1% PP; 99.5% PVC</td>
<td>100%PS; 74% ABS</td>
<td>90.3% PET</td>
</tr>
<tr>
<td>Grade</td>
<td>99.3% PP; 99.3% PVC</td>
<td>----</td>
<td>99.7% PET</td>
</tr>
</tbody>
</table>
Solid waste disposal method

- Disposal of refuse
- Land filling
- Incineration
- Disposal into sea
- Composting

- In this method refuse is carried out and dumped into low lying area
### Solid waste and disposal methods

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food waste</td>
<td>Fruit or vegetable residues (garbage) decompose rapidly</td>
</tr>
<tr>
<td>Rubbish</td>
<td>Combustible or non combustible solid wastes excluding food wastes or other putrescible materials. Combustible rubbish includes paper, cardboard, plastics, rubber etc. Non combustible rubbish includes glass, crokery, tin cans etc</td>
</tr>
<tr>
<td>Ashes and residues</td>
<td>Materials remaining from the burning of wood, coal and other combustible wastes</td>
</tr>
<tr>
<td>Demolition and construction wastes</td>
<td>Wastes from razed buildings and other structures are classified as demolition waste. Wastes from the construction and repairing of residential, commercial and industrial buildings and similar structures are classified as construction wastes</td>
</tr>
<tr>
<td>Special wastes</td>
<td>Wastes such as street sweepings, roadside litter, dead animals and abandoned vehicles are classified as special wastes</td>
</tr>
<tr>
<td>Treatment Plant Wastes</td>
<td>The solid and semisolid wastes from water, wastewater and industrial treatment facilities</td>
</tr>
</tbody>
</table>
Sanitary landfills
Composting (in-vessel)

- Grass cuttings and straw allow air in.
- Warm air rises.
- Older, bottom parts contain black crumbly compost.
- Air: Inside the heap, micro-organisms breakdown the organic materials which generates heat.
- Cover keeps heat in and prevents water from entering.
- Walls have small gaps keep heat in; they allow air circulation.
Composting has 3 phases

- **Mesophilic** (pseudomonads)
- **Thermophilic** (*Bacillus*, then *Thermus*)
- **Cooling/maturation** (*Bacillus*, pseudomonads, others)
Heat recovery efficiency – 70%

Amount of steam produced varies from 1.0 to 3.5 kg/kg of MSW
Compaction

- Waste is compacted or compressed. It also breaks up large or fragile items of waste.

- This process is conspicuous in the feed at the back end of many garbage collection vehicles. Deposit refuse at bottom of slope for best compaction and control of blowing litter.
Pyrolysis

Pyrolysis is defined as thermal degradation of waste in the absence of air to produce char, pyrolysis oil and syngas, e.g. the conversion of wood to charcoal also it is defined as destructive distillation of waste in the absence of oxygen. External source of heat is employed in this process.
Pyrolysis

1. Pyrolysis Reaction
   - Recycled Gases
   - Produced Raw Gases
   - Pretreated Biomass
   - Air Inlet
   - Combustor
   - Ash

2. Char Collection
   - Raw Gases + Char
   - Cyclone
   - Char Collector

3. Quench System
   - Quench Water
   - Raw Gases
   - Recycled Gas
   - Bio-oil
Waste Management Policies

- Environment protection act, 1986
- Hazardous waste rule, 1989
- Bio-medical waste rule, 1998
- Municipal solid waste rule, 2000
- Waste management act, 1996
- Solid waste policy in India, 2006
Thanks!