

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



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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.

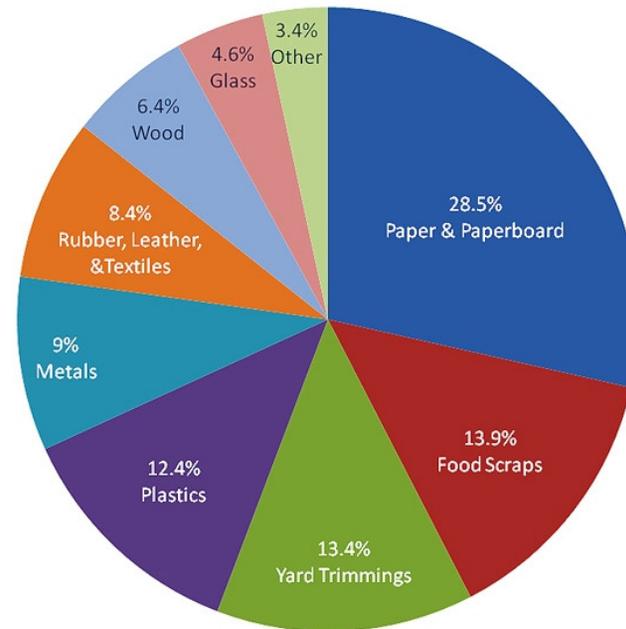
The Environment Protection Agency (EPA) analyzes municipal solid waste in two ways:

- **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



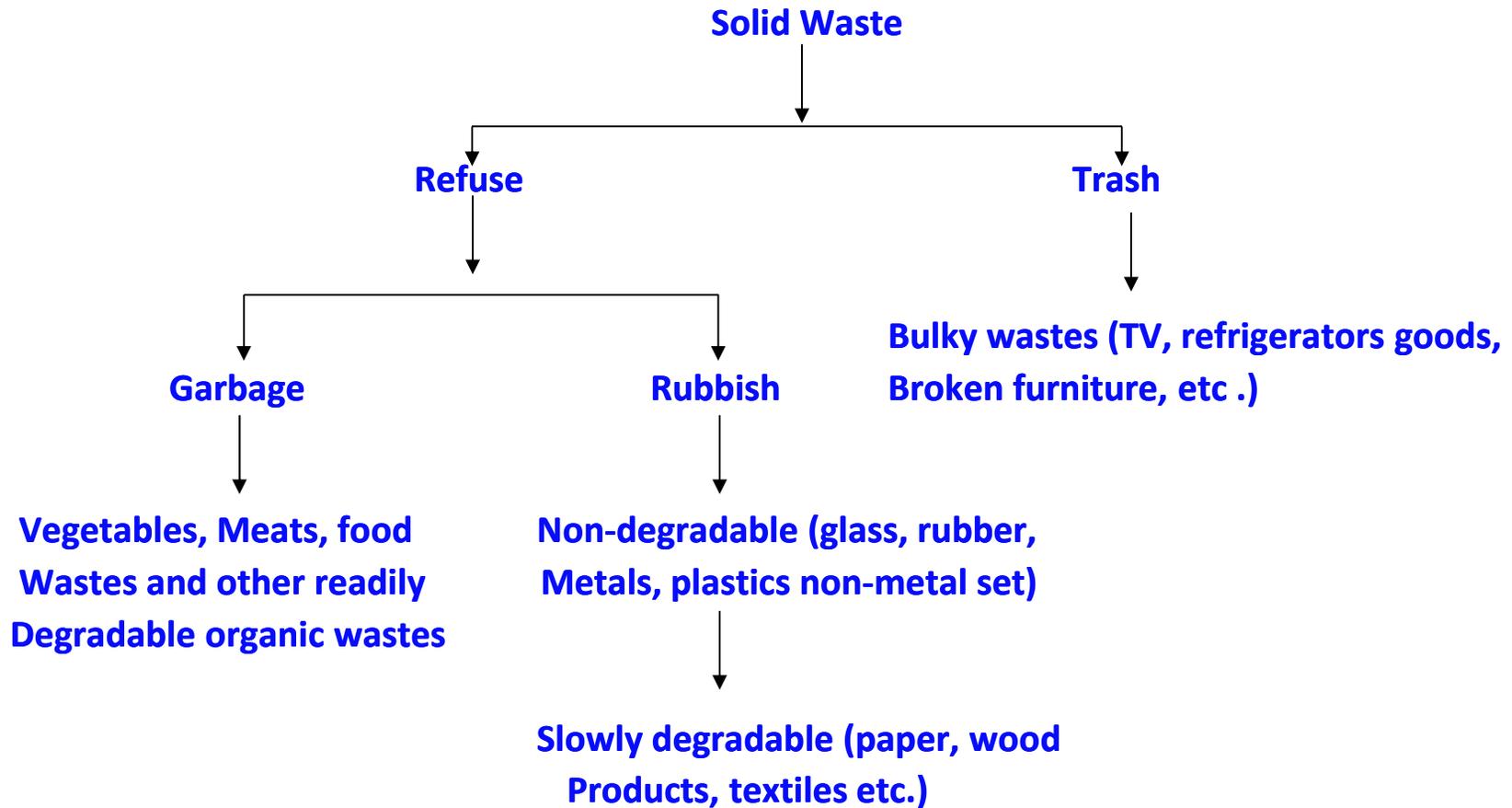
Sources of Wastes



- Paper and Paperboard
- Food Scraps
- Yard trimmings
- Plastics
- Metals
- Rubber, Leather, & Textiles
- Wood
- Glass
- Other



Structure of Solid Waste



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

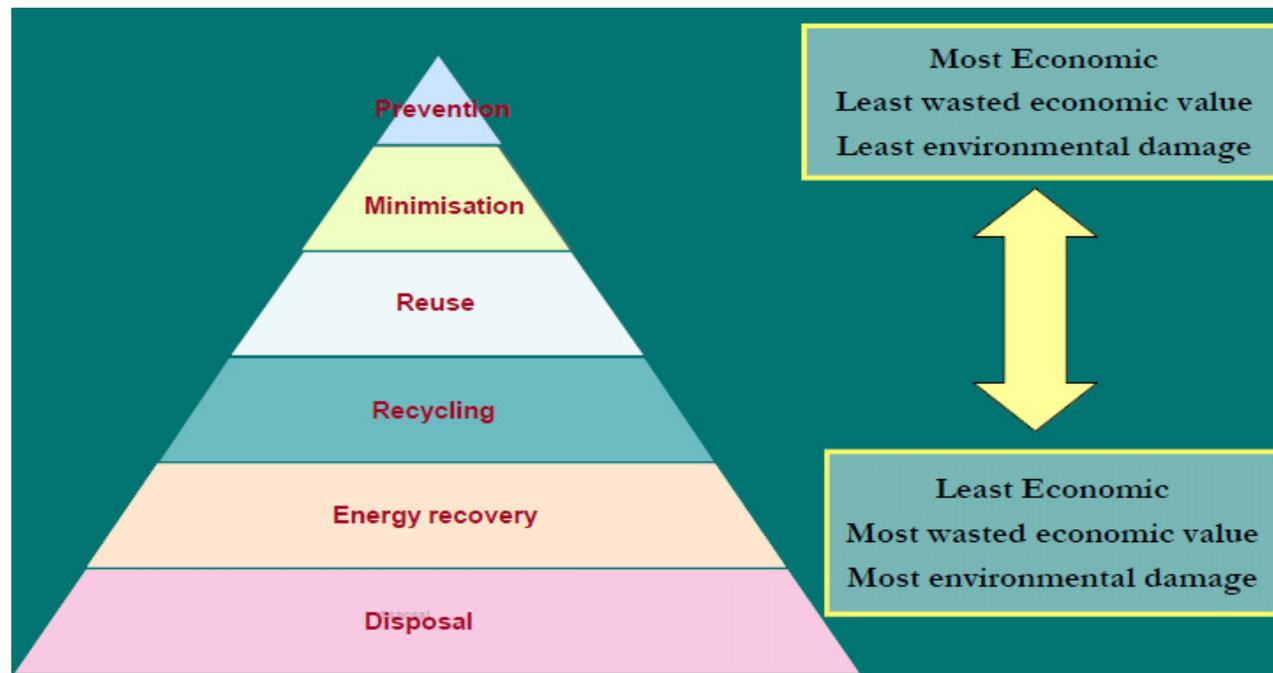
MSW Generation from the Metropolitans of India

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

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



Concept of 3R's

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

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.



REDUCE

REDUCTION MEANS TO MAKE - SOMETHING SMALLER
USE SOMETHING LESS OFTEN

Advantages of REDUCE

<Bottle>

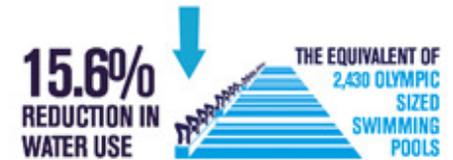


Resin of container:
56% reduction
↓
CO₂ emissions:
55% reduction
(per one load)

<Refill>



Resin of container:
35% reduction
↓
CO₂ emissions:
35% reduction
(per one load)



REUSE

- ❖ 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



RECYCLE

- 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

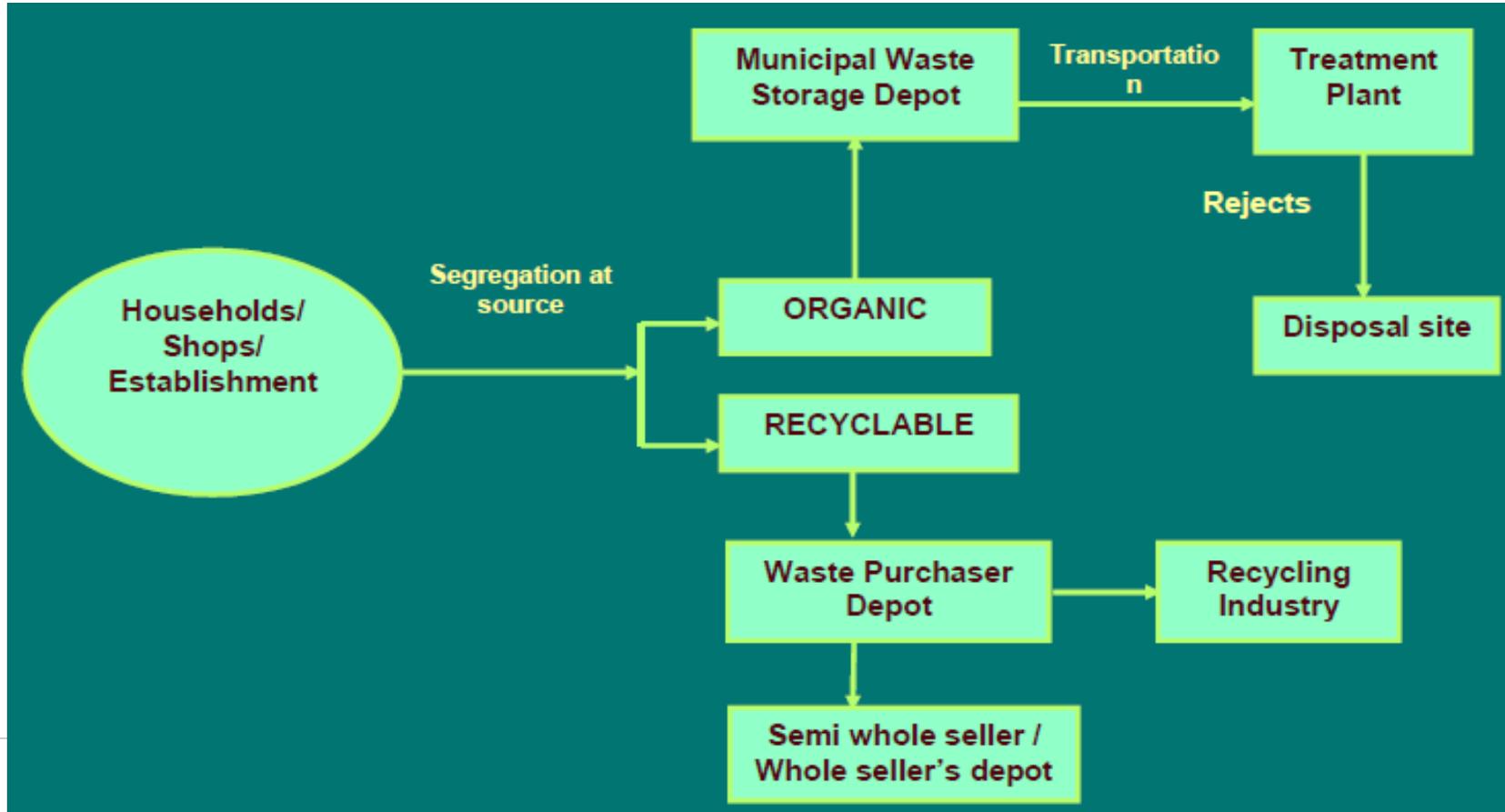
- ⦿ Prevents waste of potentially used materials
- ⦿ Reduce the consumption of fresh raw materials
- ⦿ Reduce energy usage
- ⦿ Reduce air & water pollution
- ⦿ Recycling of a material would produce a fresh supply of the same material

Ex: Paper recycling

Packaging- Effect on Environment

Positive Practice	Affect on the environment
Glass manufacturers recycle glass to make new products	Fewer raw materials used Reduction in landfill
Resealable plastic bags	less plastic film used to rewrap products once they are opened
Lightweight plastic used in place of glass. E.g. honey & peanut butter	Plastic is recyclable Less energy used to make plastic
Tetra Pak 's can be recycled. Paper - pulped, plastic & aluminium returned to supplier	Less energy used in the production, distribution & handling (lightweight)
Negative Practice	Affect on the environment
Overpackaging	Increased landfill More resources used to produce extra layers of packaging
Prepackaged foods E.g. mushrooms in a styrofoam tray and shrink wrapped	Food wastage
Package too large for product it contains E.g. Corn chips have large head space to protect contents	Wastage of packaging materials and resources used to create them

Recycling steps in India

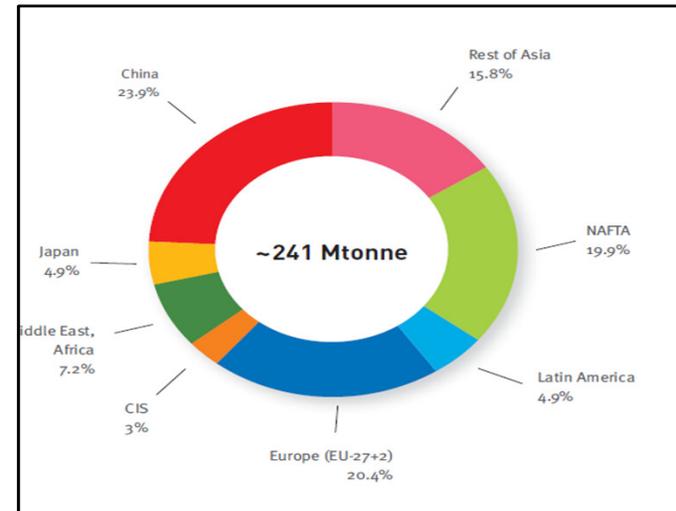
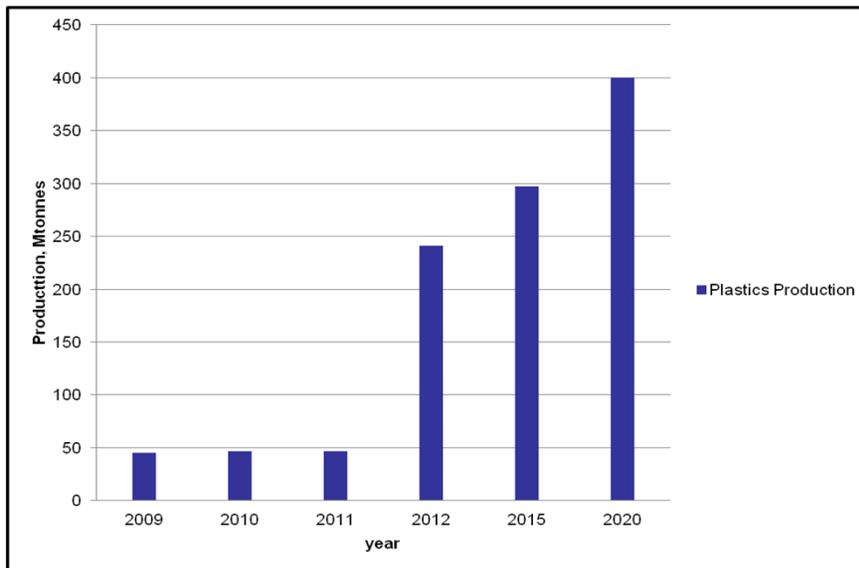


Process of Waste Recycling



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



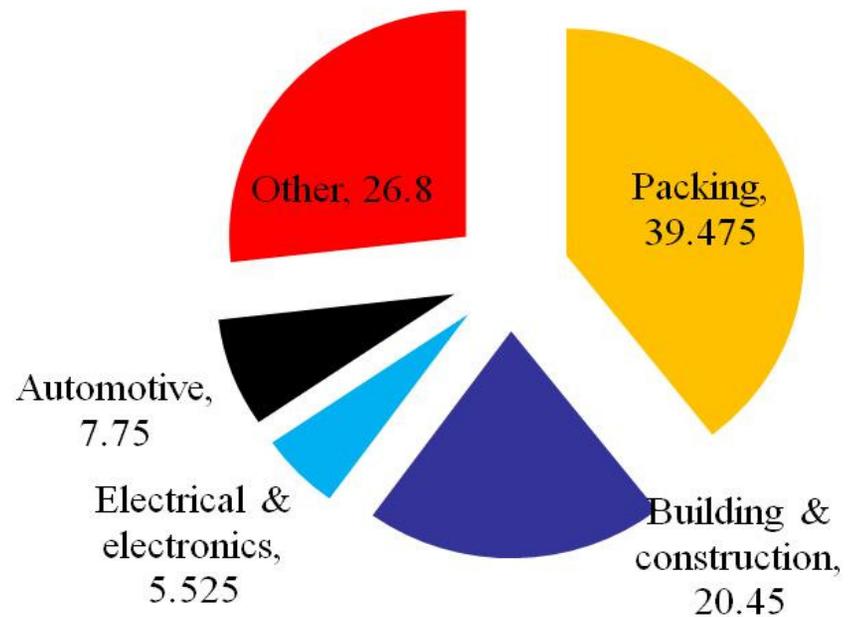
Plastic-The Fact, 2013

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%

Different uses of plastic, (%)



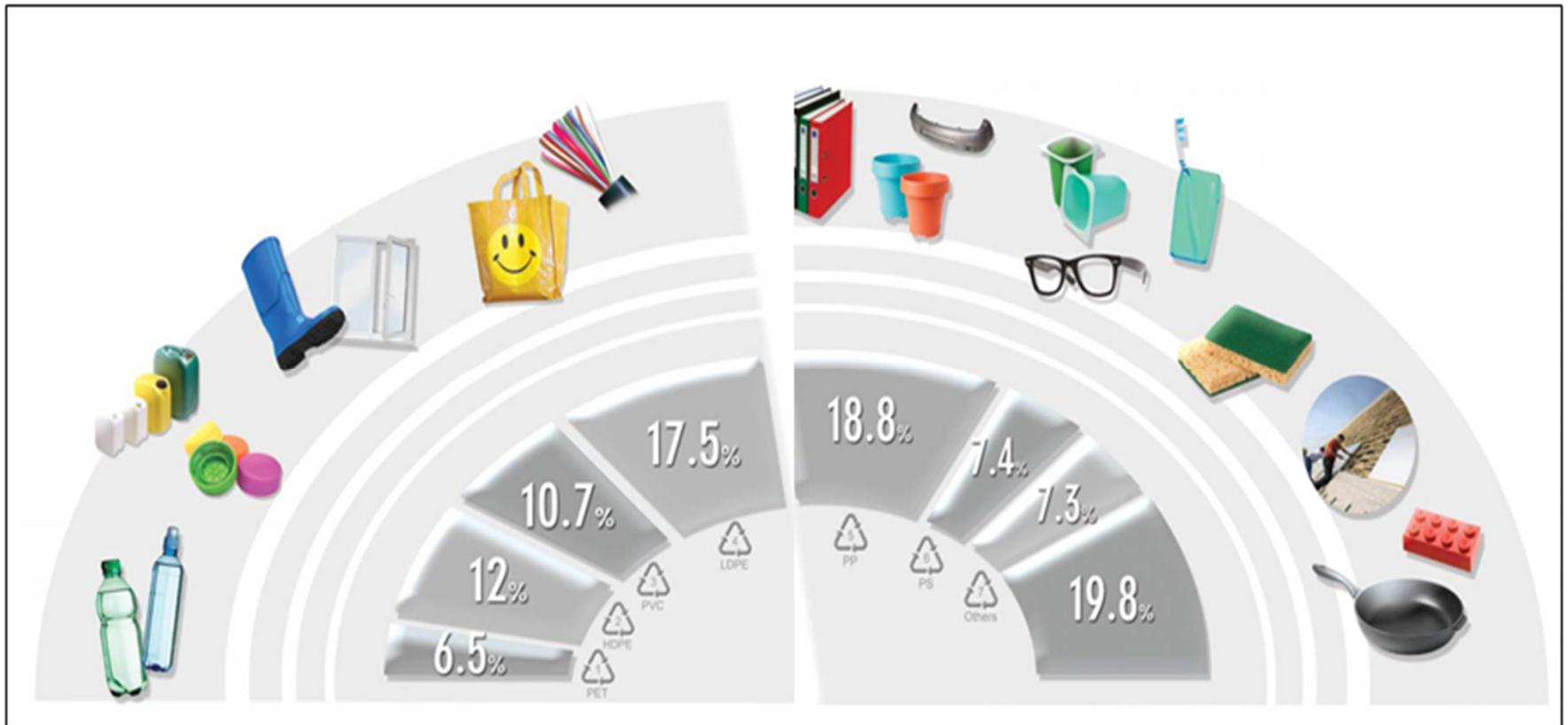
Types of Plastic and Application

- 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

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

Types of Plastic and Application

Different type of Plastic with different needs



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

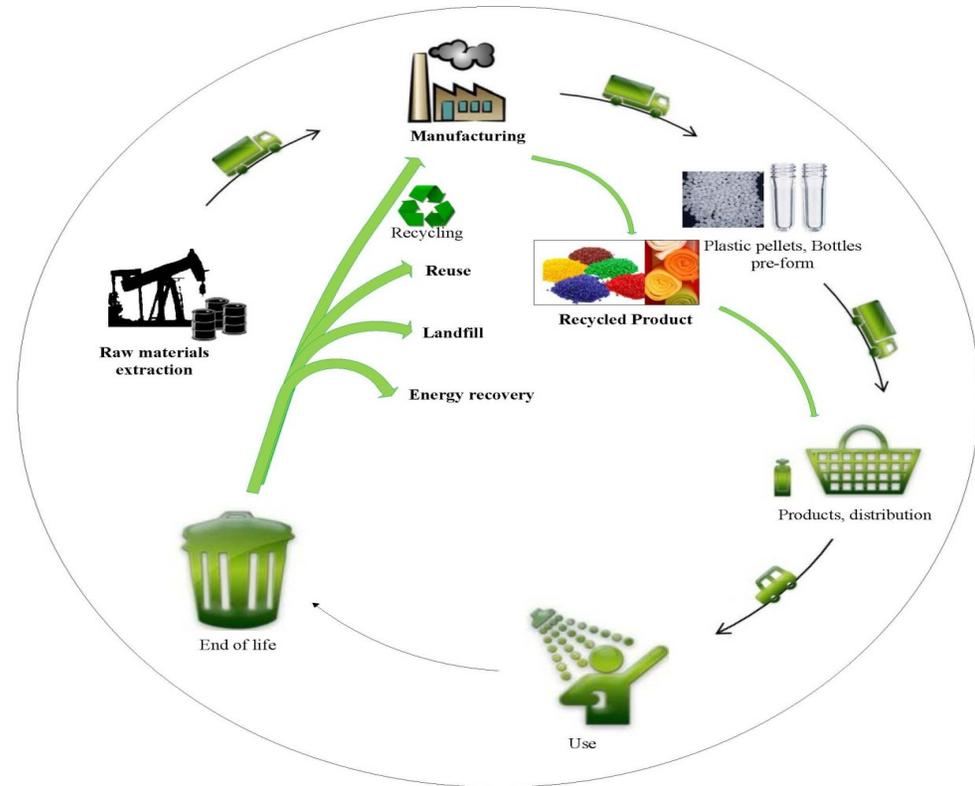
- Negative impact of plastic on the environment
- Plastic in the oceans is responsible for the deaths of millions of sea animals
- Plastic never degrades
- Incinerating plastic contributes to greenhouse gases
- Plastics contain harmful chemicals
- Making new plastic requires significant amounts of fossil 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

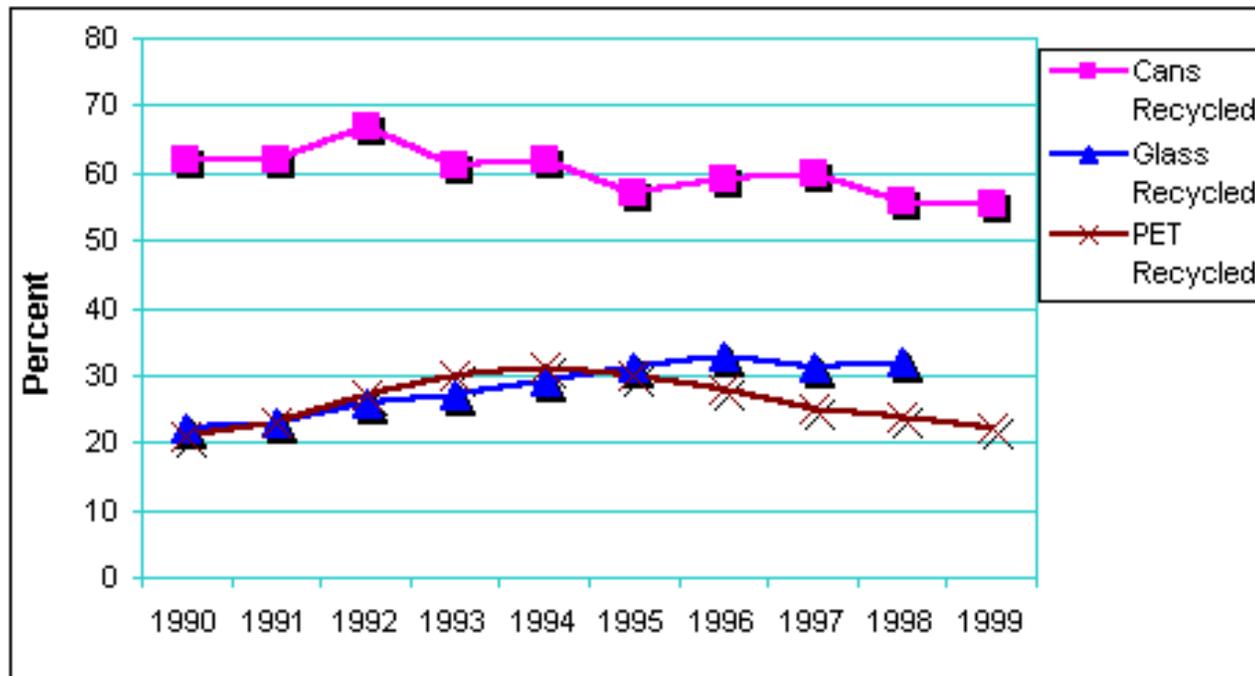
The Life Cycle of Water Bottle:

- Raw materials extraction
- Manufacturing
- Production process
- Product distribution and Usage
- End-of life
 - Reuse
 - Recycle
 - Landfill
 - Energy recovery



Plastic Recycling

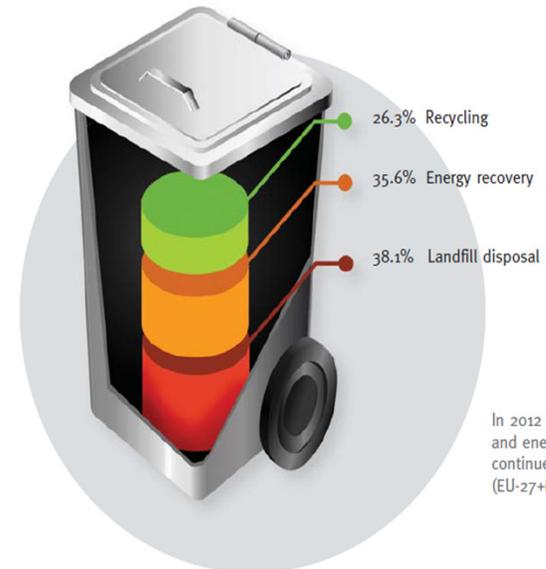
- Plastics are recycled less frequently than glass and aluminum
- Plastics are not biodegradable



Plastic Recycling

Categories for recycling:

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



In 2012 plastics recycling and energy recovery rate continues to increase. (EU-27+N/CH)

Recycled Product



PET

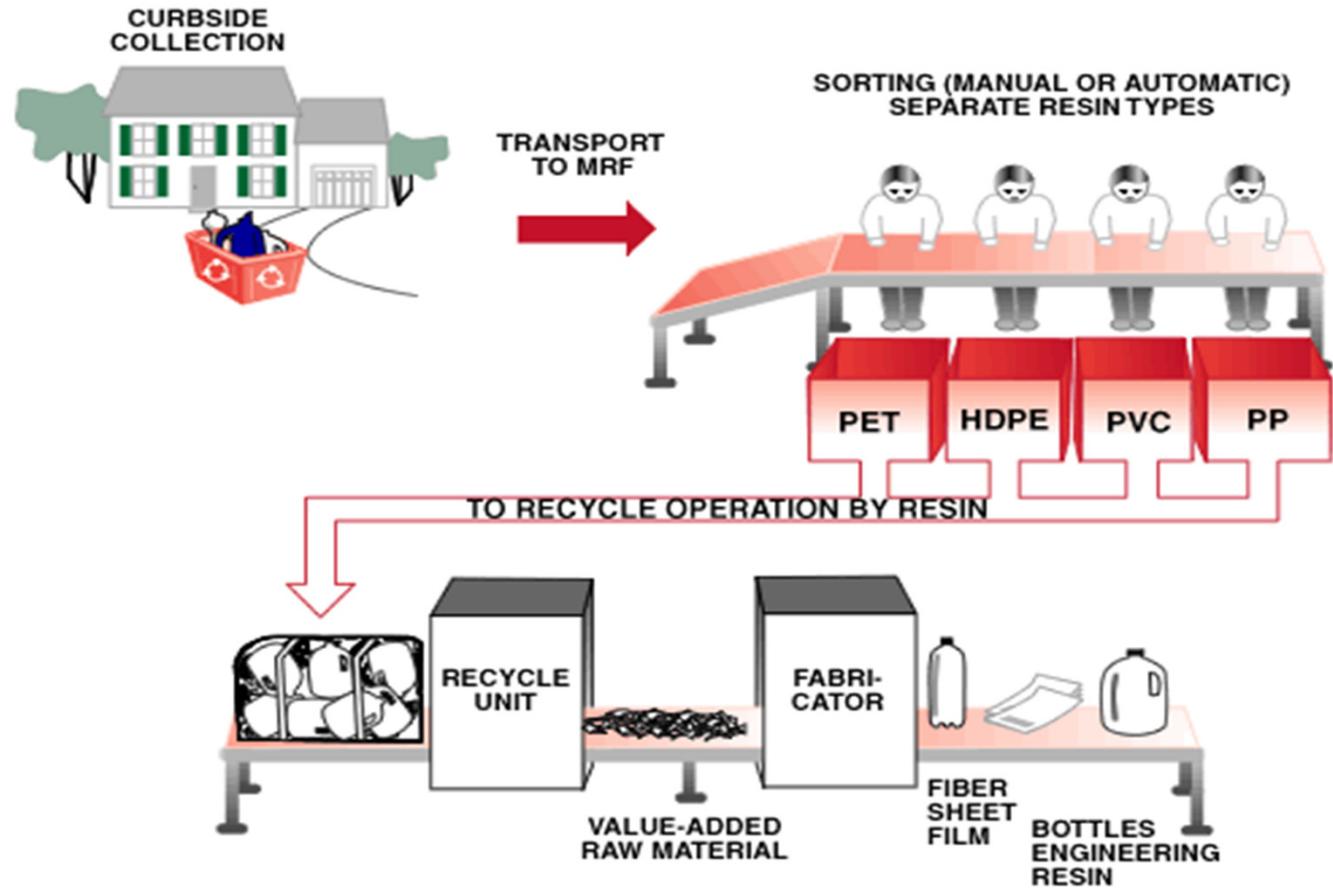


PVC



HDPE

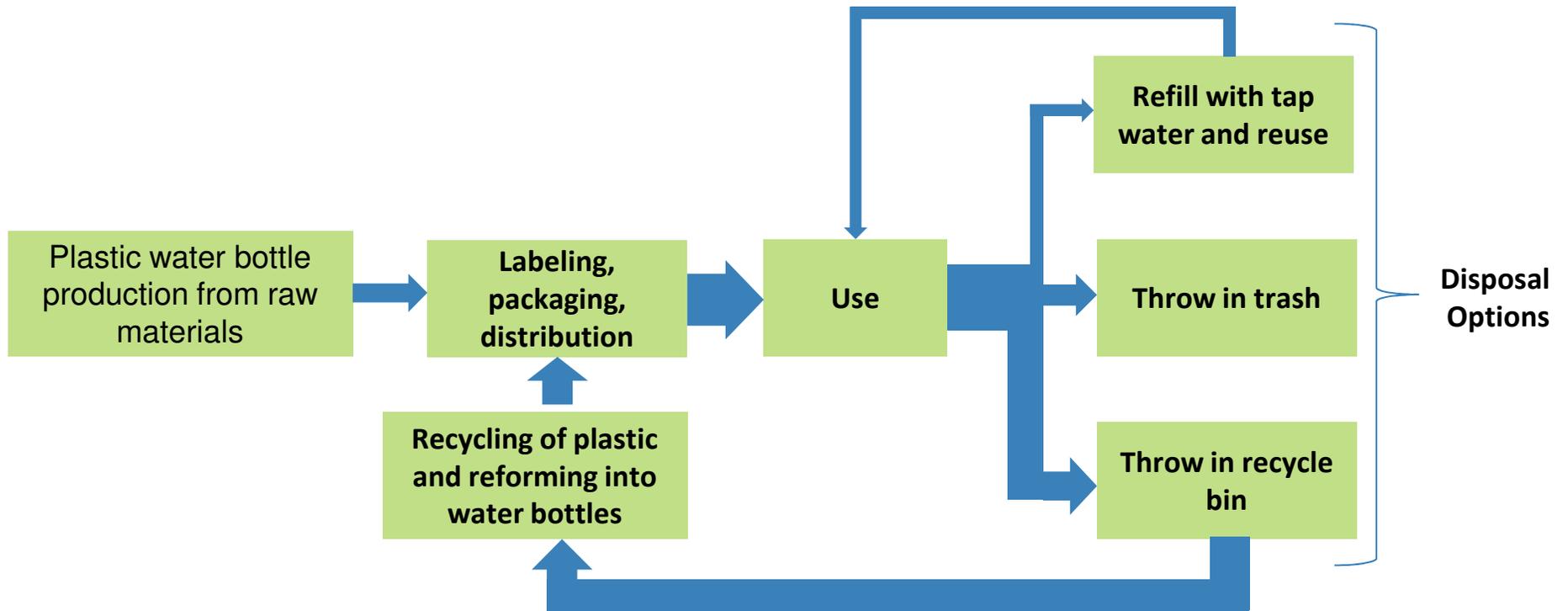
Plastic Recycling



Recycling Process

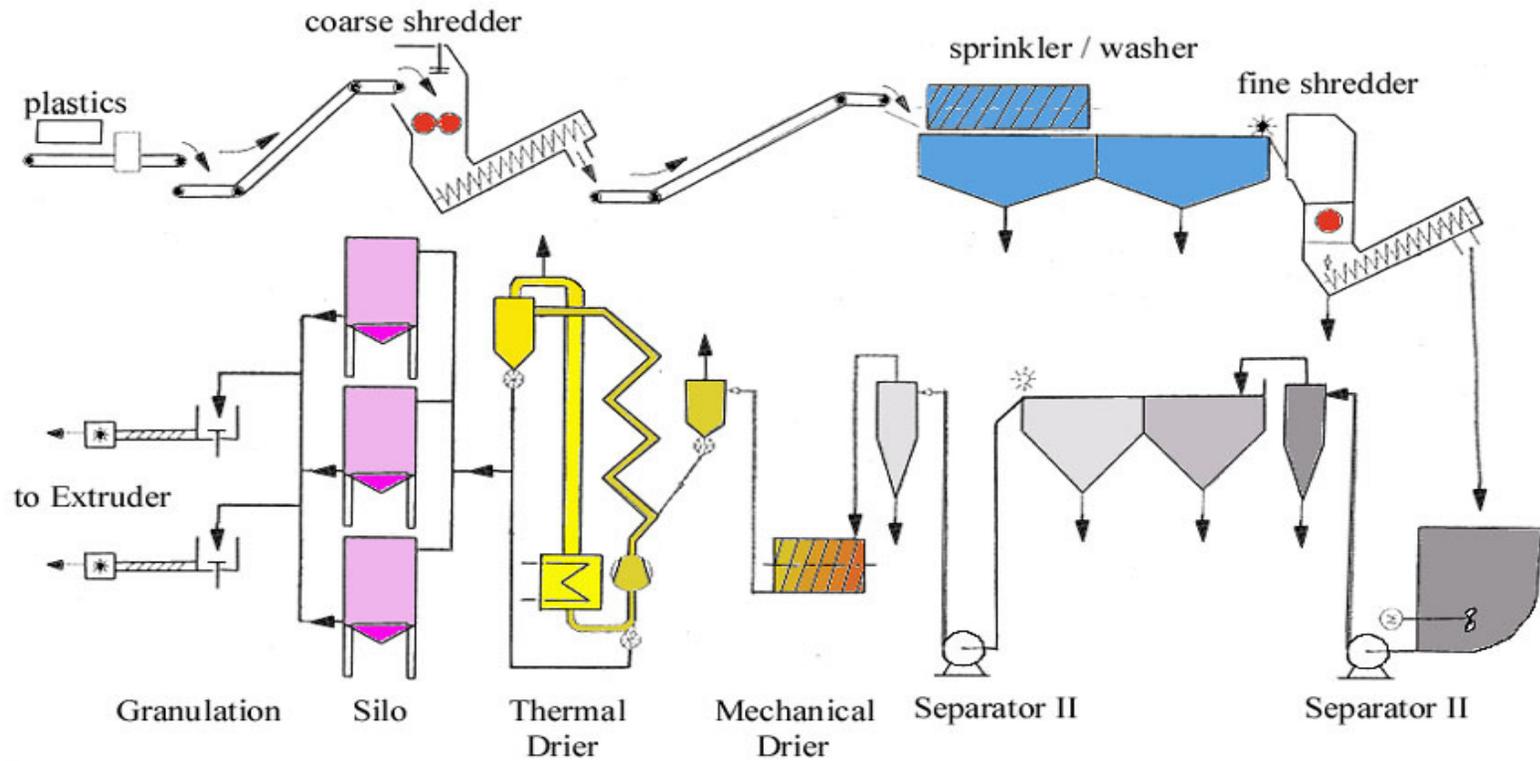
- Collection/Selection
- Separation
- Processing
- Manual Sorting
- Free of contamination

Example of Disposal Routes for a Plastic Water Bottle



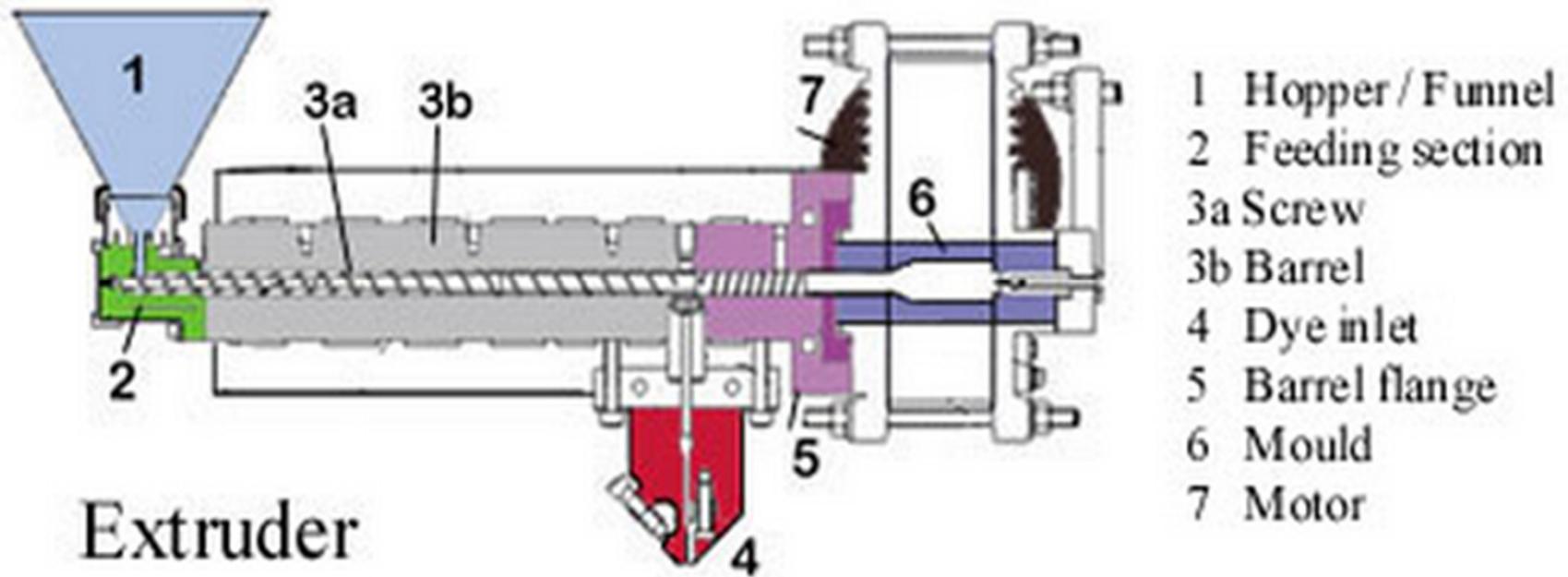
Plastic Recycling

Processing Plant of Recycled Plastic



Plastic Recycling Process-Extruder

The melting equipment of plastics: Melting system: Shear heating system



Plastic Recycling Techniques

● The purpose is to separate different kinds of plastic homogeneously from mixture of plastic and other wastes

Several techniques applied in recycling plastic:

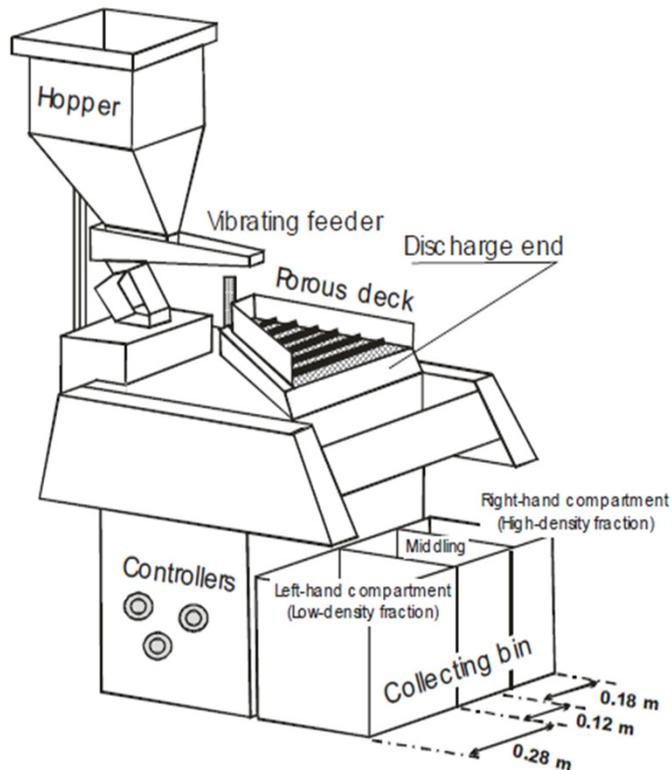
■ Sink-float separation technique

■ Electrostatic separation

■ A dry separation technique that utilizes the electrical charging of particles

Plastic Recycling

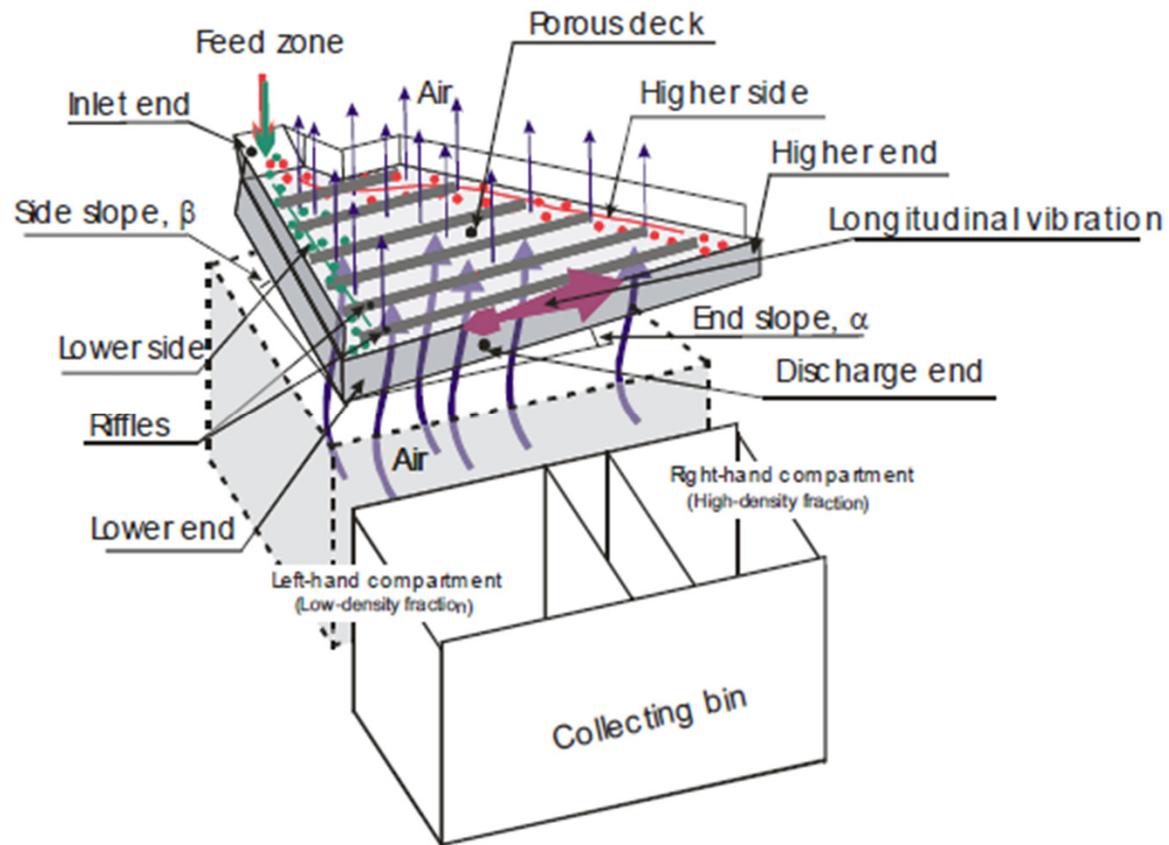
Recycling Techniques – ABS, PS, PP separation process



Air Table:

- Density of PVC = 1.4 g/ml; and PP = 0.9 g/ml
 - Velocity of airflow: 1.6m/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

Configuration of Air Table



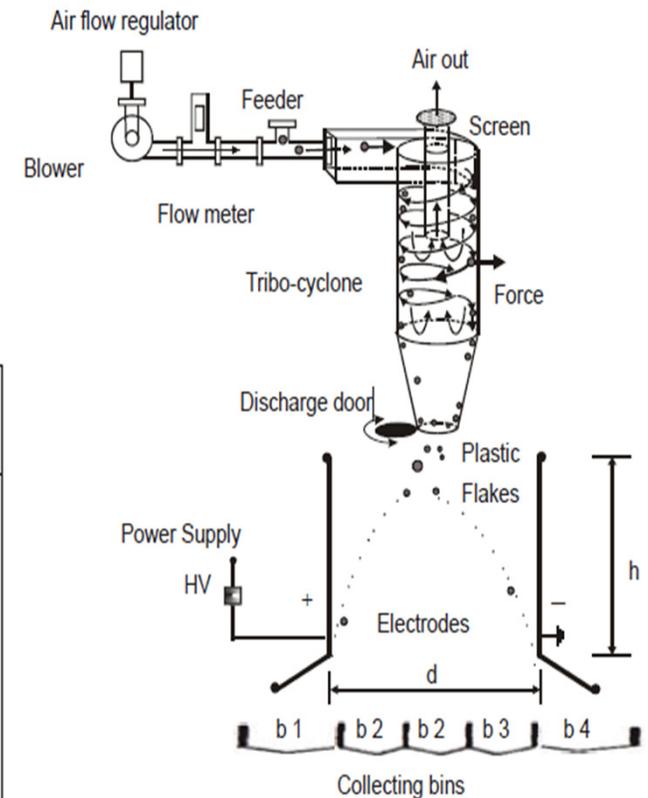
Plastic Recycling

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

Polymer type	Density (kg/m ³)	Contact angle with water (°)	Triboelectrostatic series
Acrylonitrile-butadiene-styrene, ABS	1060	87.3	End positive (+)  End negative (-)
Polyethylene terephthalate, PET	1350	76.5	
Polystyrene, PS	1050	86.3	
Polyethylene, PE	960	96.8	
Polypropylene, PP	900	95.0	
Polyvinyl chloride, PVC	140	86.4	



Plastic Recycling

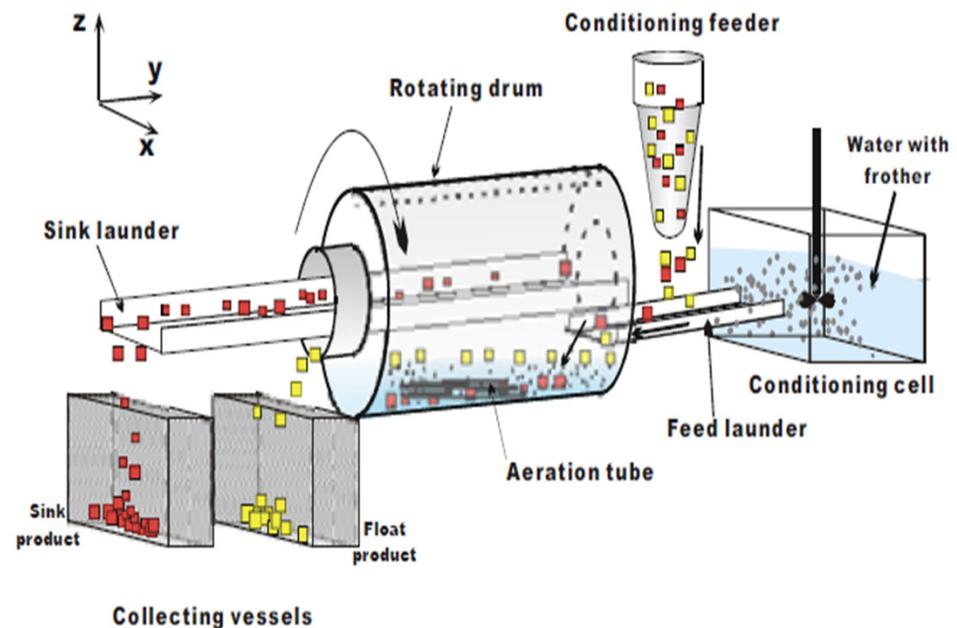
Recycling Techniques – ABS, PS, PP separation process

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



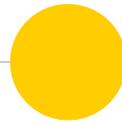
Plastic Recycling

Recovery efficiency of various recycling techniques

Types	PVC from PVC/PP	ABS from ABS/PS	PET from PET/PE
Method	Air Table	Triboelectric cyclone separator	Sink-float and Flotation
Recovery	97.1% PP; 99.5% PVC	100%PS; 74% ABS	90.3% PET
Grade	99.3% PP; 99.3% PVC	----	99.7% PET

Solid waste disposal method

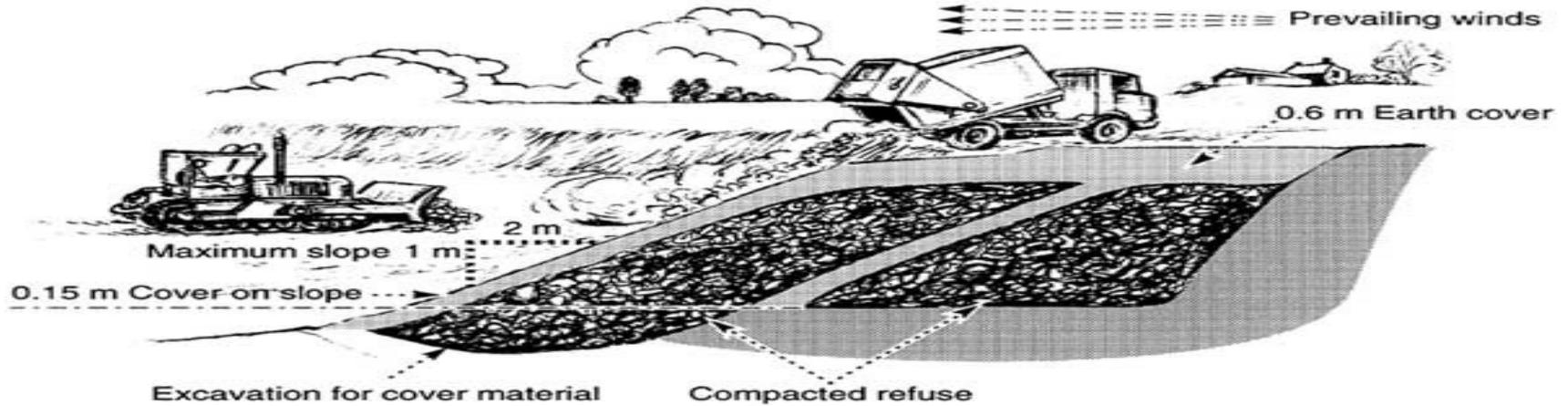
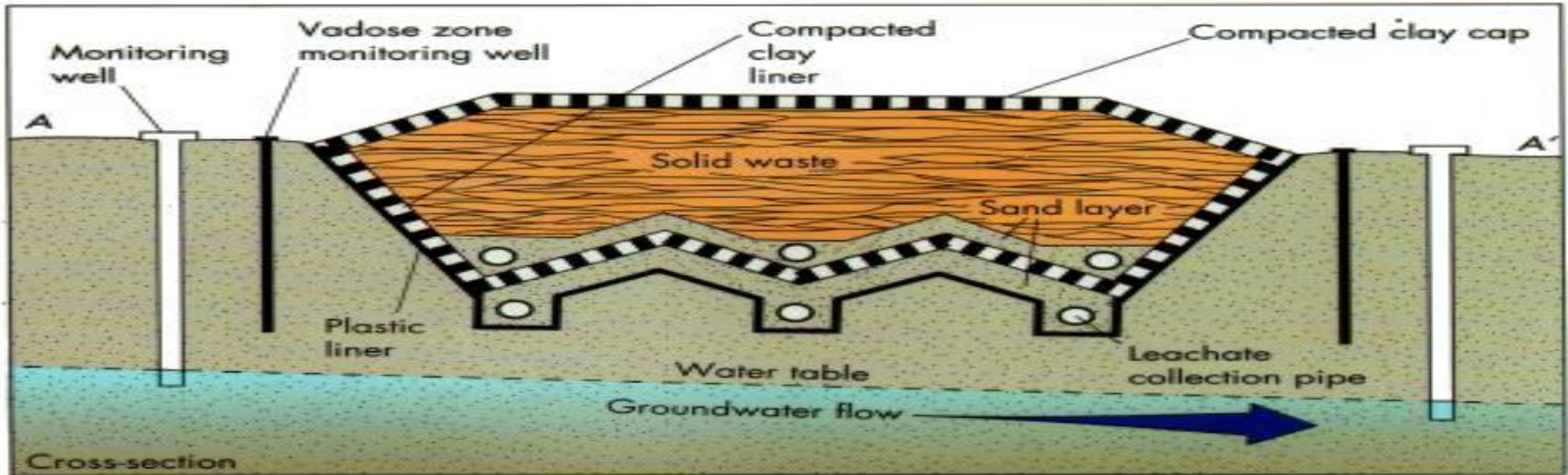
- Disposal of refuse
- Land filling
- Incineration
- Disposal into sea
- Composting
- In this method refuse is carried out and dumped into low lying area



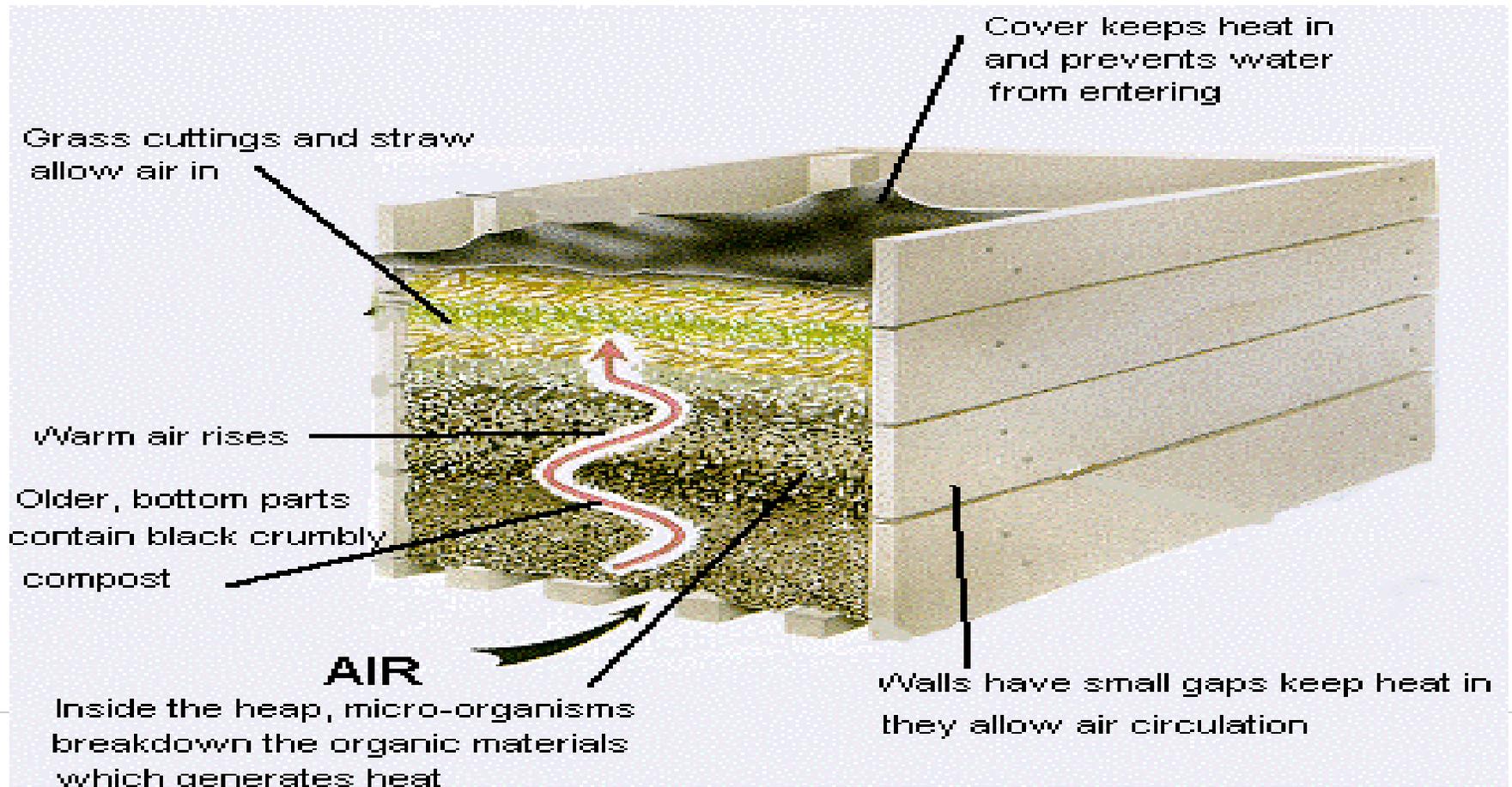
Solid waste and disposal methods

Food waste	Fruit or vegetable residues (garbage) decompose rapidly
Rubbish	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
Ashes and residues	Materials remaining from the burning of wood, coal and other combustible wastes
Demolition and construction wastes	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
Special wastes	Wastes such as street sweepings, roadside litter, dead animals and abandoned vehicles are classified as special wastes
Treatment Plant Wastes	The solid and semisolid wastes from water, wastewater and industrial treatment facilities

Sanitary landfills

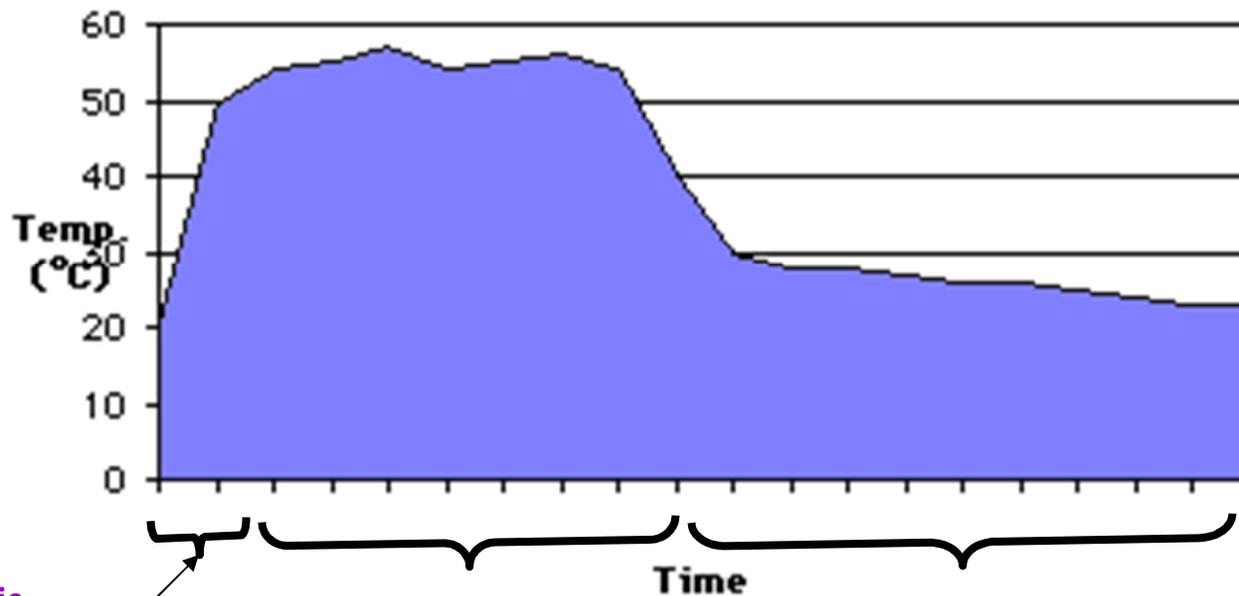


Composting (in-vessel)



Composting has 3 phases

Compost Temperature

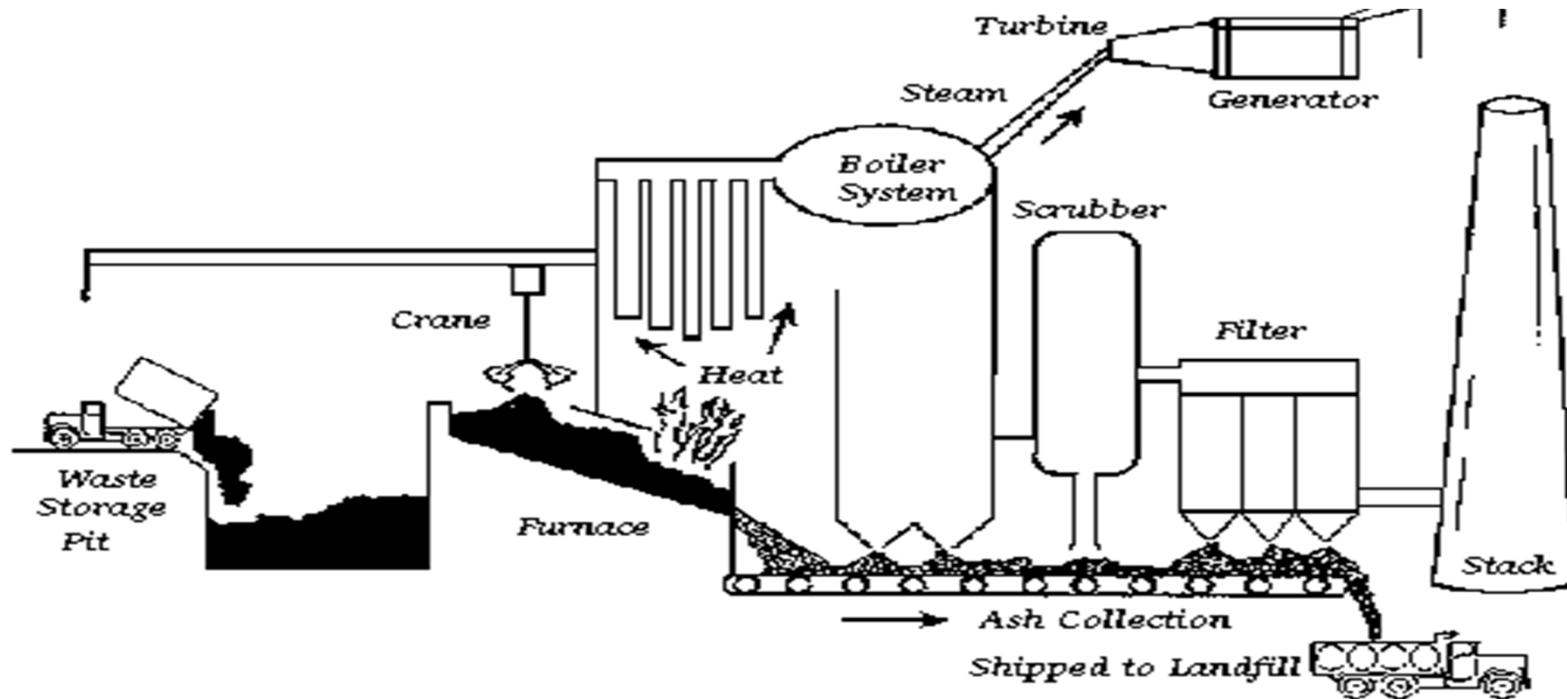


Mesophilic
(pseudomonads)

Thermophilic
(*Bacillus*, then
Thermus)

Cooling/maturation
(*Bacillus*, pseudomonads,
others)

Incineration



- Heat recovery efficiency – 70%
- Amount of steam produced varies from 1.0 to 3.5 kg/kg of MSW

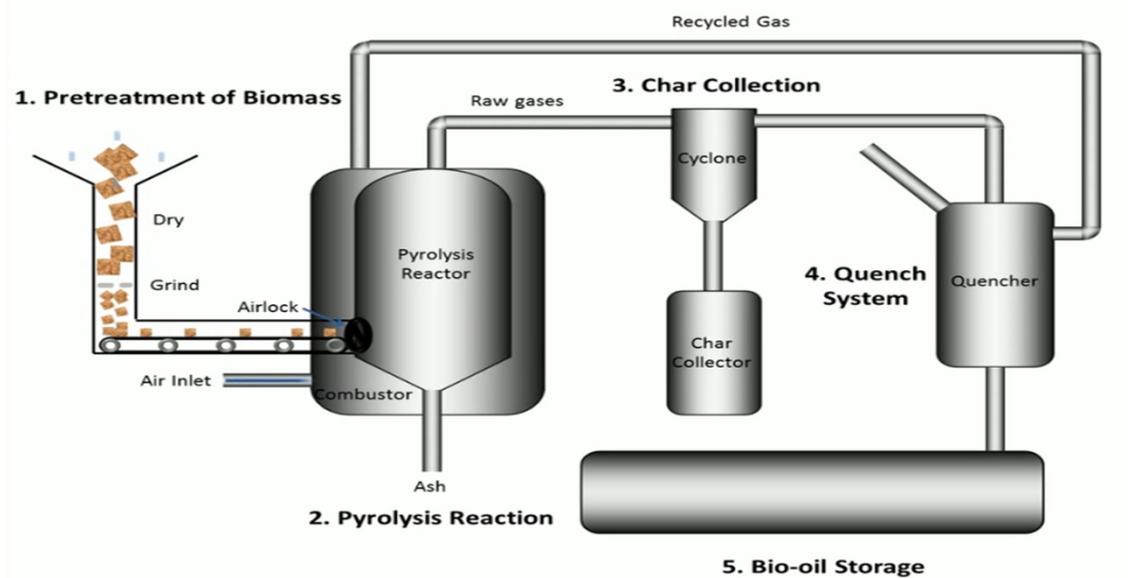
Compaction

- ▶ 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.

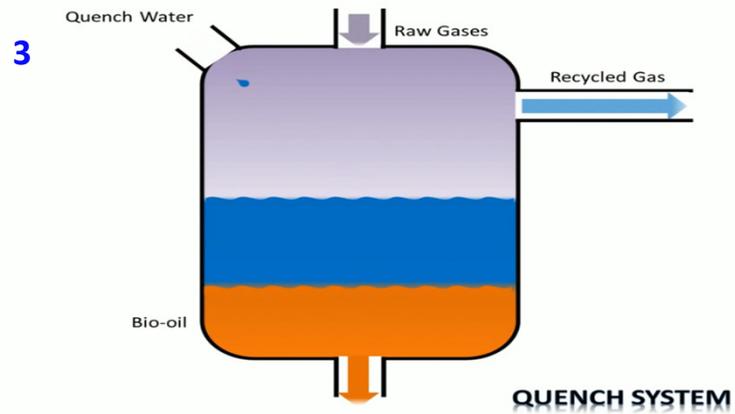
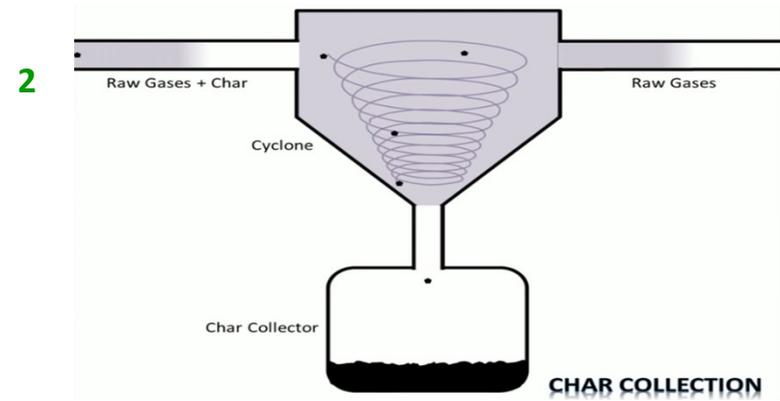
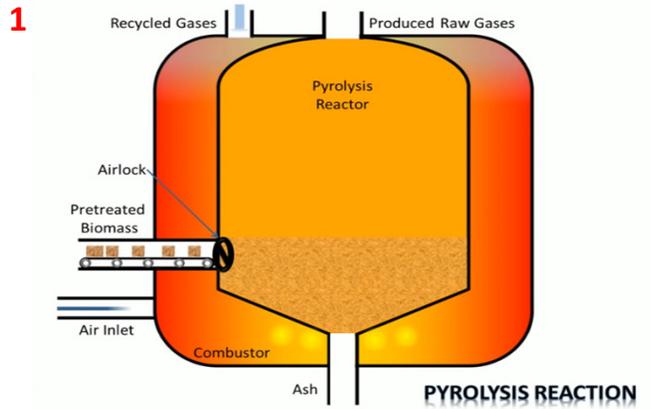


Pyrolysis

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.

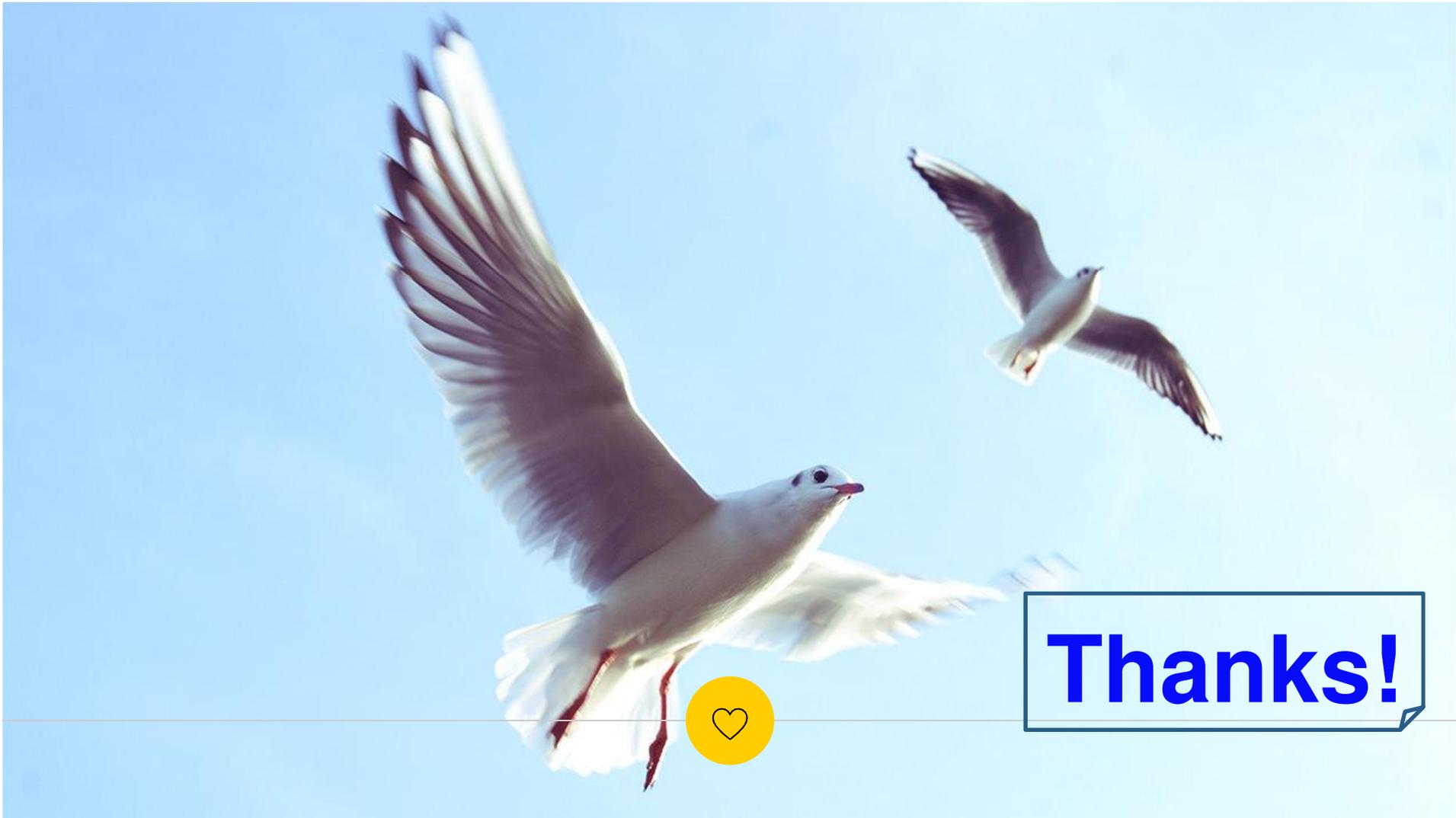


Pyrolysis



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!