PLASTIC RECYCLING:
A GREENER APPROACH

CONTENTS:

INTRODUCTION

PLASTIC:

A wide range of synthetic or semi synthetic organic solid materials suitable for the manufacture of industrial products.

Plastics are polymers of high molecular weight.

They may contain other substances to improve performance and/or reduce costs.

RESISTANT

DURABLE

INEXPENSIVE

EASY TO PRODUCE

ELASTIC

TYPES OF PLASTICS

- **THERMOPLASTICS**

  Plastics that do not undergo chemical change in their composition when heated.

  Can be molded again and again.

  Examples:

  Polyethylene Tetraphthalate Polypropylene (PP)

  Poly Vinyl Acetate (PVA)

  Poly Vinyl Chloride (PVC) Polystyrene (PS)

- **THERMOSET PLASTICS**

  Plastics that are permanently "set" once, they're initially formed and can't be melted.

  Examples:

  Bakelite

  Melamine

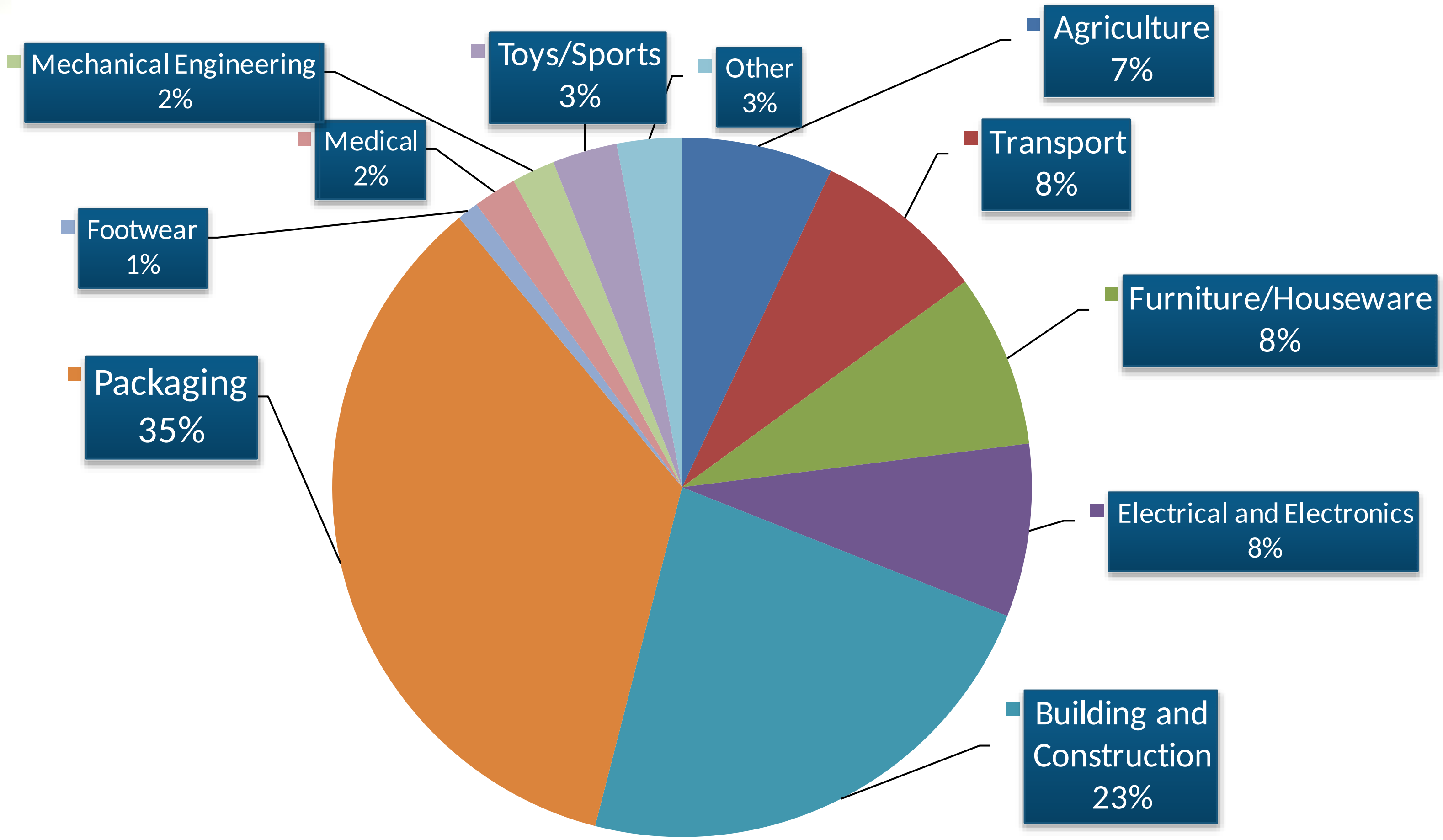
  Polyester

  Polyurethane

  Urea – Formaldehyde

Plastics > Statistics

Percentage of Plastic used in different fields



Disadvantages of Plastic

- Decomposition
- Non-Renewable
- Hard to Reuse
- Difficult to classify
- Toxic
- Threat to Animals

PLASTIC POLLUTION

PLASTIC POLLUTION

- It is the accumulation of plastic products in the environment that adversely affects wildlife, wildlife habitat, or humans.
- Plastic composed of:

  Toxic chemicals

  Non biodegradable substances
- Polyethylene, polyvinyl chloride, polystyrene is largely used in the manufacture of plastics.
- These materials have molecular weight ranging from several thousands to 1, 50,000.
- Excessive molecular size is mainly responsible for the resistance of these chemicals to biodegradation and their persistence in soil environment for a long time.

- Many plastic products are reaching the end of their lifecycle, forming non-biodegradable mountains of plastic waste.
- Some constituents of plastic such as Benzene
- Vinyl chloride cause:

a. Cancer

b. Birth defects

c. Damage to nervous and immune system

d. Adversely affect the blood and the kidneys

- The noxious substances emitted during the production of plastic :

Ethylene oxide, xylenes and some gases that affect both air and soil.

Plastic is slow to degrade……

- Three major forms of plastic contributing to plastic pollution: **Micro-plastics** (2 µm and 5 mm in size) **Macro-plastics**(size>20mm) **Mega-plastics**
- The mega- and macro-plastics are found in packaging, footwear, and other domestic items that have been washed off of ships or discarded in landfills.
- Micro-plastics include items such as plastic grocery bags. They often end up in ocean waters through rivers and streams.
- Plastic debris that starts off as meso- or macro-debris can become micro-debris through degradation and collisions that break it down into smaller pieces.
- Micro-plastics can easily end up released into the environment during production because of their small size.

Micro-plastics

Macro-plastics

Mega-plastics

PLASTIC WASTE DECOMPOSITION

- Plastics contribute to approx. 10% of discarded waste.
- In the MSW, the contribution of Thermoplastics is about 80% and Thermoset constitutes approx. 20% of the total plastics waste generated.
- Plastic waste is mainly decomposed in landfills where it may take up to 1,000 years to decompose, and potentially leak pollutants into the soil and water.
- Plastic requires high energy ultra-violet light to break down,so the amount of plastic waste in our oceans is steadily increasing.
- Polymer degradation takes much longer as a result of haline environments and the cooling effect of the sea.**(Barnes et.al,2009)**

ILL EFFECTS OF BISPHENOL A

Reproductive disorders - BPA exposure can affect egg maturation in humans.

Male impotence - BPA exposure may raise the risk of erectile dysfunction. Sexual desire and problems with ejaculation were also linked to BPA exposure among men.

Heart disease (females) - BPA can cause heart disease in women.

Sex hormones in men – BPA exposure can lead to changes in sex hormones in men.

Type 2 diabetes – A study linked higher levels of urinary BPA to type 2 diabetes, cardiovascular disease and liver-enzyme abnormalities.

National Toxicology Program, U.S. Department of Health and Human Services (September 2008). "CERHR Expert Panel Report for Bisphenol A" (PDF). Retrieved May 2013.

Are we surprised…?

- Global production of plastics is approximately **225 mt yr −1 .**
- In 2008, our global plastic consumption worldwide has been estimated at 260 million tons, and, according to a 2012 report by Global Industry Analysts, plastic consumption is to reach 297.5 million tons by 2015.
- More resources used - **more plastic waste generated**
- **The United Nations Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP)**, estimated that land-based sources account for up to 80 percent of the world's marine pollution, 60 to 95 percent of the waste being plastics debris.
- **WORLD'S MAJOR POLLUTERS: China** tops the list, having sent an estimated 1.32 to 3.53 MMT of plastic trash into the sea, **Indonesia** comes a distant second at 0.48 to 1.29 MMT, followed by The Philippines, Vietnam, and Sri Lanka. **India** is twelfth on the list, Brazil is at 16, and for a change, the **US** is at 20.

PLASTICS CONSUMPTION IN INDIA:

- More than one fourth of the consumption in India is that of PVC.
- Poly bags and other plastic items except PET contributes to host of problems in India such as choked sewers, animal deaths and clogged soils.
- India generates 56 lakhtonnes of plastic waste annually, with Delhi accounting for a staggering 689.5 tonnes a day.
- **1 tonne=20,000 plastic bottles**
- In India waste plastics **posing problems** to the environment and human health due to the lack of environmentally sound disposal practices.

SOURCES OF PLASTIC WASTES

- **Discarded fishing gear**: Responsible for up to 90% of plastic debris
- **Landfills**: Leaks toxins and contaminates the nearby soil and water
- **Plastic thrown on land**: Enter into drainage lines and chokes them resulting into floods as experienced in Mumbai, India in 1998.
- **Agriculture:** Includes films - used for mulch, greenhouse covers, and to wrap bales, tubing and pipes. It also includes nursery containers, pesticide containers, silage bags.

PLASTIC'S ADVERSE EFFECTS ON OUR ENVIRONMENT

Plastic pollute beaches &oceans:

- A lot of plastic waste found in oceans. This is caused by ship dumping wastes off the coasts and dumping of the land.
- In 2012, it was estimated that there was approximately 165 million tons of plastic pollution in the world's oceans.

- Plastics degradation releases toxic chemicals such as **bisphenol A** and **polystyrene** which leach into waters from some plastics.
- **Polystyrene pieces** and **nurdles** are the most common types of plastic pollution in oceans.**(Biello et.al,2011)**
- **Plastic to phytoplankton ratio has increased to 6:1 which is the fundamental source in food chain**.

Biello, David (June 5, 2011). "Are Biodegradeable Plastics Doing More Harm Than Good?". Scientific American. Retrieved 1 August 2013.

IMPACTS: INGESTION

- **187 species shown to ingest large plastic pieces.**
- Turtles mistake floating transparent plastic bags for jellyfish and eat them.
- **About 100,000 animals such as dolphins, turtles whales, penguins are killed every year due to plastic bags.**
- Sea turtles, have been found to contain large proportions of plastics in their stomach.
- Plastic in an animal’s gut can prevent food digestion and can lead to a very slow and painful death.
- Seven of the world's turtle species are already either endangered or threatened for a number of reasons.
- **The ingested plastic bag remains intact even after the death and decomposition of the animal.**

- Seabird's often mistake trash floating on the ocean's surface as prey.
- Toxic chemicals called ***polychlorinated biphenyls* (PCBs)** become concentrated on the surface of plastics at sea and are released after seabirds eat them.**(Lytle et.al,2015)**
- These chemicals accumulates in body tissues and have serious lethal effects on a bird's reproductive ability, immune system, and hormone balance.
- Floating plastic debris can produce ulcers, infections and lead to death
- These seabirds choose red, pink, brown and blue plastic pieces because of the similarities they share with their natural food source.
- As a result of plastic ingestion, the digestive tract can be blocked resulting in starvation. The windpipe can also be blocked, which

What Is Great Pacific Garbage Patch?

- **An island of plastic 6 times the size of Vietnam in Central North Pacific Ocean.**
- Over 300,000 pieces of plastic/sq. mile.
- Plastic outnumbers plankton 6 to 1.
- 80% of plastic from land-based sources, 20% from ships.
- All the plastic waste products have been accumulated in the pacific ocean causing lots of danger to the marine life.

Estimates of size range from 700,000 square km to more than 15,000,000 square km (*0.41% to 8.1% of the size of the Pacific Ocean*).

Plastic bags litter the landscape

Once they are used, most plastic bags go into landfill, or rubbish tips. Each year more and more plastic bags are ending up littering the environment. Once they become litter, plastic bags find their way into our waterways, parks, beaches, and streets. And, if they are burned, they infuse the air with toxic fumes.

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WHY RECYCLE?

- In landfill, both synthetic and naturally occurring polymers don’t get the necessary exposure to UV and microbes to degrade.
- Landfills not destroy plastics , **it preserve the poison forever.**
- The toxic chemicals escape from the landfills and contaminates the water sources.
- When there are too many plastic in landfills, they are often destroyed in incineration factories.
- Consequently it:
  - ❖ Contributes to Greenhouse Effect
  - ❖ Causes Lung Cancer
  - ❖ Contaminates Soil

PLASTIC RECYCLING

- **Plastic recycling** is the process of recovering scrap or waste plastic and reprocessing the material into useful products, sometimes completely different in form from their original state.
- Recycling is a viable alternative in getting back some of the energy stored in the polymers.
- As petroleum prices increase it is becoming financially viable to recycle polymers rather than produce them from raw materials.
- the energy required to yield recycled plastics may be less than that consumed in the production of the same resins from virgin feedstocks.**(Curlee et.al,1991)**
- Conserves both **energy** and **material**.
- Beverage containers and plastic bags are recycled more often.
- **Reduction of carbon-dioxide (CO2), nitrogen-oxides (NOx) and sulphur-dioxide (SO2) emissions**.

Curlee TR, Das S. Plastic Wastes (Management, Control, Recycling and Disposal). New Jersey, NJ: Noyes Data Corporation, 1991.

RECYCLING PROCESS

Recycling can be categorized into 4 different processes:

- **PRIMARY RECYCLING or PLASTIC EXCRUSION:**
- Converts plastic materials from solid to liquid states and reconstitutes them as finished components.
- Plastics transform without sacrificing their distinctive properties.
- Scrap parts can be ground and re-extruded with minimal degradation.**(Perdon ,2004)**
- Uses less energy and fewer resources.
- Most popular method employed for recycling.

- **SECONDARY or MECHANICAL RECYCLING:**
- Recovers plastic solid waste (PSW) for the re-use in manufacturing plastic products via mechanical means .**(Mastellone,1999)**
- It is reprocessing of the used plastics to form new similar products.
- Can only be done a few times before the polymers break down and the quality of the plastic degrades.
- Simple approach of waste plastic conversion to grocery bags, pipes, gutters, window .

STEPS INVOLVED IN MECHANICAL RECYCLING:

- Cutting/shredding
- Contaminant separation
- Floating
- Milling
- Washing and drying
- Chemical washing
- Agglutination
- Extrusion
- Quenching

Aznar, M.P., Caballero, M.A., Sancho, J.A., Francs, E., 2006. Plastic waste elimination by co-gasification with coal and biomass in fluidized bed with air in pilot plant. Fuel Processing Technology 87 (5), 409–420.

CHEMICAL or TERTIARY RECYCLING:

- Advanced technology processes which convert plastic materials into smaller molecules which are suitable for use as a feedstock for the production of new petrochemicals and plastics. **(Mastellone, 1999)**
- Products of chemical recycling have proven to be useful as fuel.
- **METHODS INVOLVED:**

✓ **THERMAL DEPOLYMERIZATION:**

Depolymerization process using hydrous pyrolysis for the reduction of complex organic materials into light crude oil.

Under pressure and heat, long chain polymers of hydrogen, oxygen, and carbon decompose into short-chain petroleum hydrocarbons.

Polyethylene teraphthalate (PET) and certain polyamides (nylon 6 (PA 6) and nylon 66) can be efficiently depolymerised.

✓ **HEAT COMPRESSION:**

It takes all unsorted, cleaned plastic in all forms, from soft plastic bags to hard industrial waste, and mixes the load in tumblers.

Benefit :all plastic is recyclable, not just matching forms.

Mastellone, M.L., 1999. Thermal treatments of plastic wastes by means of fluidized bed reactors.

ENERGY RECOVERY

- It is burning of waste to produce energy in the form of heat, steam and electricity.
- A very sensible way of waste treatment, when material recovery processes fail due to economical constrains.
- Plastic materials possess a very high calorific value when burned.
- Since the heating value of plastics is high, they make a convenient energy source.
- Producing water and carbon-dioxide upon combustion make them similar to other petroleum based fuels. **(Dirks, 1996)**
- The destruction of foams and granules resulting from PSW also destroys CFCs and other harmful blowing agents present. **(Zia et al., 2007)**

ADVANTAGES OF RECYCLING

- Waste reduction
- Conservation of energy
- Save money
- Create new jobs
- Generate revenues
- Provides a sustainable source of raw materials to industry

DISADVANTAGES OF RECYCLING

- Recyclable materials might be in contact with radioactive materials
- The recycling requires plastics to be of nearly identical composition to mix efficiently
- Widespread use of dyes, fillers, and other additives in plastics makes recycling difficult
- Impossible to recycle at 100%

GREEN RECYCLING:TURNING PLASTIC INTO ENVIRONMENTAL FRIENDLY PRODUCTS

REMEDIATING PLASTIC WASTE INTO CARBON NANOTUBES

- Polyethylene-based used plastics needs hundreds of years to degrade in atmospheric conditions.
- **Vilas Ganpat Pol** at Argonne National Lab developed a novel process to systematically degrade **HDPE and LDPE wastes**, which converts them into valuable **Multi Wall Carbon NanoTubes**.
- Characteristic properties of MWCNTs:

a. Semiconducting or metallic electrical behaviour
b. High mechanical strength
c. Interesting chemical and surface properties

- The process involves **thermal decomposition** of PW in the presence of catalysts at **700^{0}C** in a closed reactor under an inert or air atmosphere, followed by cooling.
- When **Cobalt acetate (CoAc)** is used during degradation of PW, this process produces MWCNTs.
- The Cobalt acetate acts as a catalyst to increase the graphitic order of the carbonaceous material under the experimental conditions.
- The interesting 1D morphology and growth of MWCNTs results from the autogenic pressure that arises during the thermal degradation of PW in a closed system.
- This invention presents an opportunity to use PW as a raw material for the production of MWCNTs.

PROCESS INVOLVED

- Thermal decomposition of 1 g pieces of used HDPE containing 20 wt% $C_4H_6CoO_4$, cobalt acetate (CoAc) catalyst, by introducing them into a 5 cc autoclave at room temperature in a nitrogen atmosphere.
- The closed autoclave, filled with used HDPE, was placed at the centre of a furnace, heated it at 700 ^{0} C for an optimised time, and allowed the material to cool gradually.
- The chemical reaction took place under created autogenic pressure during the thermolysis of HDPE in the presence of CoAc, lead to the growth of MWCNTs.
- The MWCNTs settle nicely at the bottom of the autoclave for easy collection.
- In the system, not only the temperature but also the autogenic pressure plays an important role in the growth of MWCNTs.

- Mass Spectrometer measurements:

a. Decomposition of PW starts at about 300ºC and the products have masses correlating to water vapour, CO_2, and molecules with 2–5 carbon atoms formed.

b. At temperatures above 600 ºC, small amounts of hydrogen, water vapour, and larger amounts of hydrocarbons are recorded.

c. At 700ºC, species with a mass greater than 36 disappeared(all the C–H and C–C bonds seem to break), leaving only smaller species with 1–3 carbon atoms along with hydrogen.

- The main decomposition of the PW occurs in a temperature range of 600 to 700 ºC.
  - Dry black powder with **~40% yield** was collected.

- Diameter of MWCNTs : **80 nm**.
- MWCNTs can be grown randomly and the cobalt nanoparticles are trapped inside the tubes.
- To achieve pure MWCNTs, acidic treatment will be required to dissolve the cobalt particles.
- The scanning electron micrographs demonstrate the 1D fiber-like entities, the transmission electron micrographs further confirmed the hollow tubular structures of MWCNTs.
- X-ray diffraction (XRD) pattern of MWCNTs prepared from the mixture of LDPE and CoAc confirms that the MWCNTs are comprised of graphitic carbon and trapped cobalt.
- The autogenic pressure and mass spectrometry measurements confirmed that HDPE or LDPE completely dissociate at 700^{o}C, forming a mixture of carbon, CO2, and hydrocarbons in a closed system.

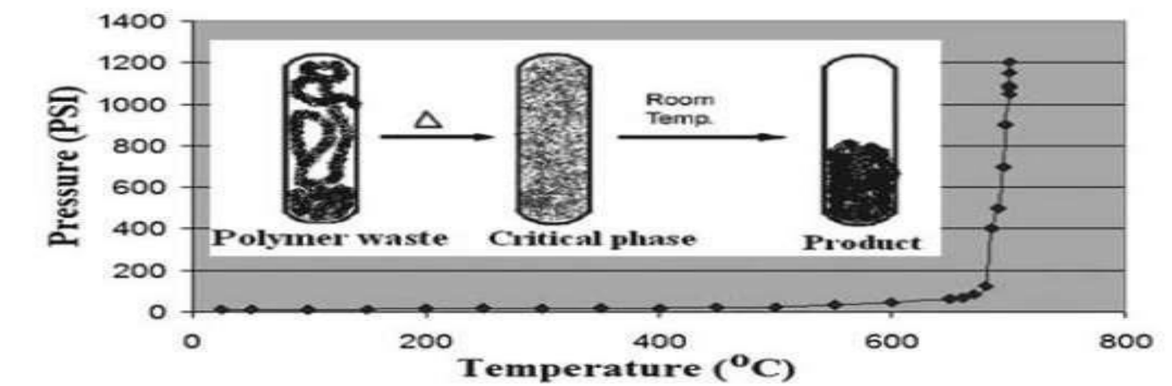
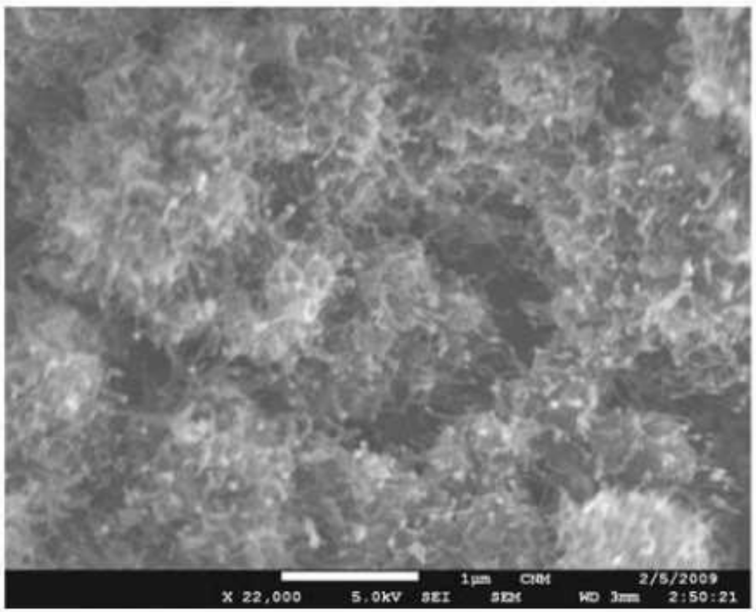
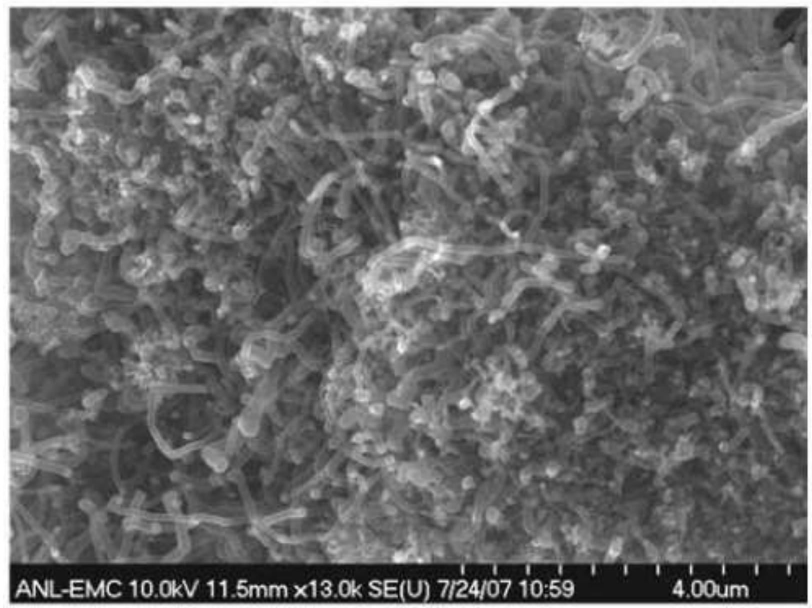


Fig. 1 Temperature *vs.* autogenic pressure during the decomposition of waste HDPE bags with CoAc catalyst (insert shows the scheme of the degradation of PW in the presence of catalyst in a closed system to produce MWCNTs).



HRSEM image of as-prepared MWCNTs using a mixture of HDPE and CoAc



FE-SEM of MWCNTs prepared from LDPE

APPLICATIONS OF MWCNTs

- Lithium Ion Batteries
- Water Purification
- Mechanical actuators
- Electronics
- Catalysis
- Sensors
- High-strength composites
- Adsorbents

A. C. Dillon and M. J. Heben, Appl. Phys. A: Mater. Sci. Process., 2001, 72, 133.

Upcycling: Converting Waste Plastics into Paramagnetic, Conducting, Solid, Pure Carbon Microspheres

- **Vilas Pol** developed a novel process that systematically degrades single or mixed polymers (LDPE, HDPE,PET,andPS) via upcycling .
- The presented solid-state, solvent-less, environmental friendly process remediates a variety of WP into value-added paramagnetic, conducting, solid, pure **Carbon MicroSpheres**.
- LDPE bags, HDPE bags, and PS are the most common sources of WP.
- The smooth CMSs are pure, conducting, and paramagnetic.

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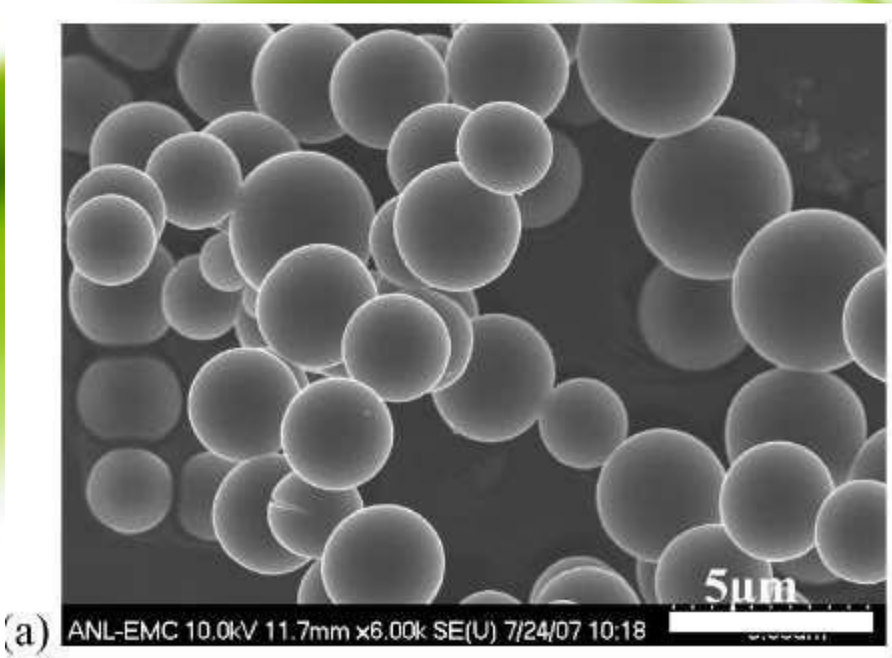
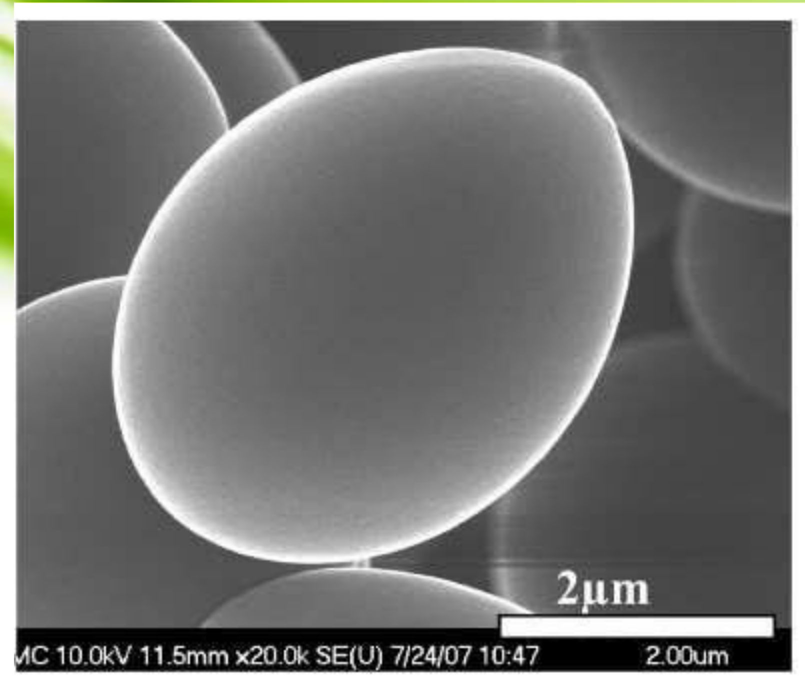
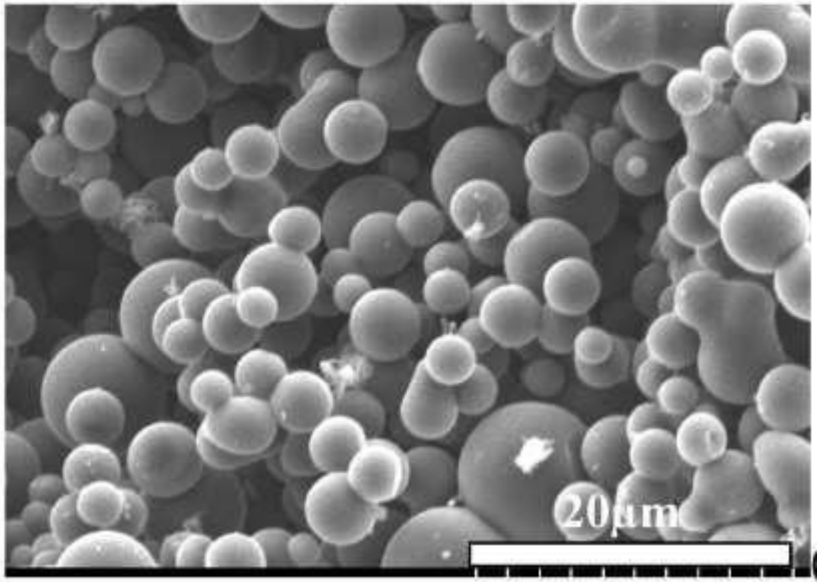
PROCESS INVOLVED

- 1 g of WP was introduced in a 5cc reactor at room temperature either in an air or inert atmosphere.
- The partially filled reactor with WP was closed tightly and heated uniformly. The temperature of the furnace was increased to **700 °C** at a rate of 20 °C/min and maintained at the high temperature for an optimized time.
- After the autogenic reaction, the reactor was allowed to naturally cool, and opened.
- **Dry black powder with ~40% yield was collected.**
- The carbon sheets settled on the surface of preformed circular carbon nuclei, maintaining the spherical shape at an autogenic pressure.
- The CMSs obtained are pure, they are directly characterized further without additional processing.







SEM of CMSs synthesized using HDPE,LDPE, PS waste.

- To check the stress/strain effect on CMSs, 5000-psi pressure was applied for 10 min by means of an automatic press. Under this pressure no changes in the size or shape of the carbon moieties were observed in SEM analysis. Therefore, the as-prepared **CMSs** were **certainly solid and not hollow.**
- CMSs are not only solid but also **exceptionally hard**. This is due to meticulous sp2 and/or sp3 bonding and assembly of carbon layers in a closed reactor at 1000 psi pressure.
- The **electrical conductivity** of an individual carbon sphere is measured attaching two nanoprobes with imaging by scanning electron microscopy.
- The SEM image of an individual carbon sphere shows a shiny surface. When probes (100-*μA current) were attached to* the carbon sphere, the current flow was evidenced by the darkness around the sphere. The untouched initial shiny carbon sphere immediately turned black after the current flow.

APPLICATIONS

- Paint industry
- Tire industry
- Toners
- Printers
- Batteries
- Lubricants

UPCYCLING PLASTIC WASTE INTO PETROLEUM PRODUCTS

- The researchers from the Illinois Sustainable Technology Center (ISTC) at the University of Illinois used a process known as **Pyrolysis** , which involves heating the plastic bags in an oxygen-free chamber.
- The researchers fractionated the crude oil into different petroleum products.
- The researchers were able to produce **natural gas, naphtha, gasoline, waxes, and lubricating oils, such as engine oil and hydraulic oil.**
- They also produced **Diesel** that can be blended with existing ultra-low-sulfur diesels and biodiesels, which were tested for compliance with US standards.
- This diesel mixture had an **equivalent energy content**, a **higher Cetane number** (a measure of the combustion quality of diesel requiring compression ignition) and **better lubricity** than ultra-low-sulfur diesel.

- Only **50 to 55% fuel** can be obtained from the distillation of **petroleum crude oil**. Since this **plastic** is made from petroleum in the first place, we can recover almost **80% fuel** from it through distillation.
- Benefit of pyrolysis : **Conversion of low energy density substrates into higher density liquid (bio-oil) and solid (biochar) fractions. A low-density volatile (syngas) fraction is also produced.**
-

- **Fast and flash pyrolysis** maximizes **bio-oil production**, **Slow pyrolysis** augments the yield of **biochar** and **Gasification** maximizes **syngas** production.**(Venderbosch 2010,Mohan D. et.al ,2006)**

PROCESS INVOLVED

- Pyrolysis performed in a system containing a 2 L reactor and oil collection system using approximately 500 g of plastic grocery bags each time.
- The pyrolysis reactor has two heating zones (upper and lower); the **upper** and **lower temperatures** were set to **420** and **440 °C**, respectively.
- Once the reactor reached the set temperatures, a reaction time of 2 hr was employed from that point on.
- Vapors produced as a result of pyrolysis were condensed over water as plastic crude oil (PCO). The upper oil layer was separated and weighed.
- Distillation of PCO was performed in a plastic to oil system.
- Different products were collected at different temperatures and filtered to remove the residual solid particles.
- **RESULT:** These temperatures resulted in decomposition reactions of HDPE to provide hydrocarbons of different chain lengths. Pyrolysis of waste plastic grocery bags at temperatures of 420–440 °C provided **74% yield** of liquid product referred to as **Plastic Crude Oil.(Miskolczi et.al,2009)**

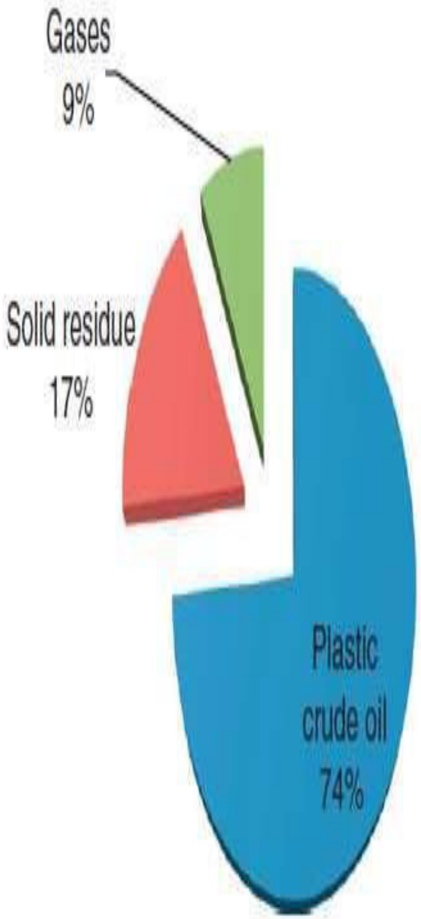


Fig. 1. Product yield from pyrolysis of plastic grocery bags.

Table 3
Elemental analysis of waste plastic grocery bags and plastic oil distillates. (The numbers shown are average of two measurements, while oxygen is determined by difference).

Samples	C, %	H, %	N, %	O, %	Cal. HHV[a], MJ/kg
Waste plastic grocery bags					
Waste GB	83.9	14.9	0.50	0.74	49.42
PCO5 fractions					
MG	84.6	14.4	0.34	0.63	49.01
PPEH-L	85.0	14.5	0.40	0.11	49.33
PPEH-H	85.3	14.8	0.31	0.00	49.88
VGO	85.3	15.1	0.45	0.00	50.27
PCO4 fractions					
MG	84.2	14.9	0.48	0.43	49.58
PPEH-L	84.2	14.7	0.37	0.73	49.31
PPEH-H	85.7	15.0	0.37	0.00	50.38
VGO	84.8	14.9	0.21	0.08	49.87

Use of Waste Plastic in Flexible Pavements-Green Roads

- No wonder scientists have even derived a way of recycling the waste plastics in constructing the pavements for increasing their **strength** and d**urability**.
- It is very effective step towards eco-friendliness compared to conventional and traditional techniques of flexible pavements construction.
- The waste plastic gets coated over the surface of aggregate by heating (140˚C - 160˚C) as plastics like PE, PS, PP used in PET Bottles, disposal glasses, handbags, etc soften up to 160˚C.
- The LDPE can only be used in this technique as it gets softened at the desired temperature *i.e.*, 160˚C and coated over the aggregates.
- **This is an effective technique of plastic waste recycling as no fuel consumption takes place**.
- Use of waste plastic in bitumen increase the binding property as compared to the conventional bitumen**.** It improves the properties of bitumen resulting in increase in Softening Point and decrease in Penetration value thus improving the durability**.(Punith,2010)**

PROCESS INVOLVED

DRY PROCESS (Lab test-D.B.M II Grade)

1) Plastic wastes are cleaned and dried (For ex: disposed carry bags, glasses etc) with a thickness of 60 microns is shredded into small pieces (2.36 mm - 4.75 mm size).
2) Aggregate are weighed and heated to 160˚C in a pan.
3) Shredded plastic is added to the hot mix. The plastic gets softened and coated over the surface of the aggregate in 30 - 60 seconds.
4) Hot Bitumen (heated up to a maximum of 160˚C) is added immediately and the contents are mixed thoroughly.
5) As the plastics are heated to a maximum temperature of 165˚C, there is no evolution of any gas. When heated above 270˚C, the plastics get decomposed and above 750˚C they get burnt and produce harmful noxious gases.
6) The moulds are preheated and then the mix is poured in the preheated mould.
7) The moulds are marked and kept for 24 hours in air and weighed.
8) Samples are kept in 60˚C hot water bath and then tested for Marshall Stability and Flow value just after taking out from water bath **.(Bale A.S,2011)**

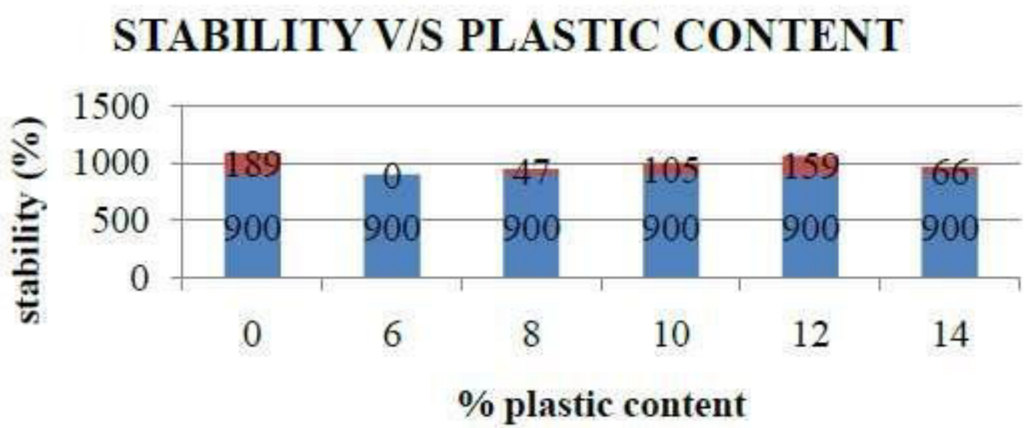
- **Results and Discussion:**
- 1) Utilisation of waste plastic improves the binding property of mix.
- 2) The optimum result of waste plastic came out to be **8%** from the experiments conducted.
- 3) The properties of bitumen such as penetration, softening point improved with the addition of the waste fibre.
- 4) Plastic roads can also be constructed in the areas having high temperatures (50˚C).
- 5) Waste plastic in roads increases the stability value and durability to a great extent.
- 6) This technique is very eco-friendly as it uses the waste plastic which is being disposed in oceans, landfills etc.
- 7) Replacement of bitumen with plastic reduces the cost of construction significantly.
- 8) When durability and stability of roads will improve, then its future maintenance cost will be saved too.

Prepared specimens.

Performing marshal stability test.

Characteristic values of the specimens at 4.5% bitumen content.

MOULD NO	BITUMEN CONTENT	PLASTIC CONTENT (%)	STABILITY (KG)	FLOW VALUE (MM)
1	4.50%	0	1098	2.8
2		6	861	2.77
3		8	947	2.6
4		10	1005	2.87
5		12	1059	3.23
6		14	966	3.5
LIMIT AS PER MORTH SPECIFICATIONS			900	2 - 4



MEALWORMS : A SOLUTION TO DEGRADE PLASTIC WASTE NATURALLY

- Researchers at Stanford University reveals a species of **MEALWORMS** capable of consuming and digesting polystyrene foam, often referred to as "styrofoam."
- **These are small, brownish, squirmy ,larvae form of the darkling beetle**.
- Mealworms are the first reported insect capable of degrading and mineralizing a common persistent petroleum-based plastic.
- The scientists placed 100 mealworms on top of blocks of styrofoam, where they subsisted on nothing but the plastic, foam-like material for 30 days.
- 100 mealworms eat 34 to 39 milligrams of polystyrene per day, which is equivalent to the weight of a small pill.
- Mealworms' safe digestion of styrofoam suggests that their stomach contain special enzymes or bacteria that can break down polystyrene.**(Yu Yang et.al ,2010)**

- They examined the mealworms' excrement, and discovered that the polystyrene had mineralized: What hadn't been converted to carbon dioxide or biomass turned into fecal matter.
- The waste is **safe for reuse in soil** on crops.

MAKING PLASTICS FROM PLANTS!! WOW!

- Scientists have come up with a new technology of making plastic from plant.
- Three bacterial enzymes have been introduced by the scientists in the model plant ***Arabidopsis thaliana***.
- When the two enzymes are combined with the plant, an organic polymer known as **Polyhdroxybutyrate-co- polyhydroxyvalerate** (PHBV) is produced.
- PHBV is extensively used to produce variety of products like grocery bags, soda bottles, flatware and disposable razors.
- The plastic when discarded are **easily degraded**.

OUR RESPONSIBILITY

It's impossible to eliminate most plastic from daily life, but it's prudent for our health and that of our environment to curb the use of some.

Overall reduction in plastic usage, proper management for disposal and public awareness would bring a great difference in present situation.

Separate .. Store..and hand over for proper recycling or disposal.

Do not let plastic litter the environment.

"Stop the Plastic Pollution, Be Part of the Solution"


TRASH


RECYCLE


RECYCLABLE
ITEMS ONLY


PAPER
GLASS
METAL
E-WASTE
PLASTIC
ORGANIC

Packaging symbols explained

The 'Mobius Loop' shows it can be recycled

Widely recycled by 75% or more of Local Authorities (LAs)

Not collected by all LAs so check locally

Indicates packaging is recycled by less than 20% of LAs

Product is made from recyclable aluminium

Recyclable glass. Remember to separate colours

The number indicates the resin code for the type of plastic used

Wood-based products from forests that are well managed

Producer contributes to a packaging recovery scheme

Reminder to be tidy and dispose of an item appropriately

Which?


1
PETE
2
HDPE
3
PVC
4
LDPE
5
PP
6
7


1 PETE
OK for single use applications
2 HDPE
Releases virtually no chemicals
3 PVC
Releases 2 toxic chemicals
4 LDPE
At risk of leaching chemicals
5 PP
Relatively safe, doesn't melt when heated
6 PS
OK for single use but releases carcinogenic substances when heated
7 OTHER
Most dangerous form of plastic
mrwatergeek.com

Most commonly used plastics

	What is it used for?	Next life	Ease of recycling
Polyethylene Terephthalate (PET) 1	Soft drink bottles, food packaging such as punnets	Used to make more PET products	Easy
High Density Polyethylene (HDPE) 2	Milk cartons, cleaning products, yoghurt pots, soap dispensers	Garden furniture, pipes and more milk cartons	Easy
Polyvinyl Chloride (PVC) 3	Pipe fittings, window fittings, thermal insulation, car parts	Used to make more PVC products	Difficult
Low Density Polyethylene (LDPE) 4	Food bags, shopping bags, magazine wrapping	Bin liners, plastic furniture and floor tiles	Manageable
Polypropylene (PP) 5	Margarine tubs, microwave meal trays, fibres and filaments for carpet, wall coverings, vehicle upholstery	Clothing fibres, food containers, speed humps	Easy
Polystyrene (PS) 6	Some yoghurt pots, takeaway boxes, plastic cutlery, protective packaging, insulation	As more packaging	Difficult
Other 7	This includes other forms of plastic including composites, such as salad bags and crisp packets	Goes to landfill	Very difficult

Recyclable

Recyclable at specialist points

Not easily recyclable

METAL INDUSTRY AND RECYCLING

What is Metal???

- A substance that has a bright luster and is a good conductor of heat and electricity
- An opaque but good reflector of light when polished
- Basically classified in two types : ferrous and non ferrous metal

Indian Metal Industry

- Indispensable part of the economy
- Acts as Backbone of industrial development
- Started with Tata Iron and Steel Company (TISCO) at Jamshedpur in 1907
- 5th largest producer of crude steel
- Accounts to 2.5% of India's GDP

Titans of Metal Industry

Jamshedji Tata

J.R.D Tata

Ratan Tata

The Lord Bagri

Kumar Mangalam Birla

Lakshmi Mittal

Types of metal waste

Iron

Copper

Brass

Aluminium

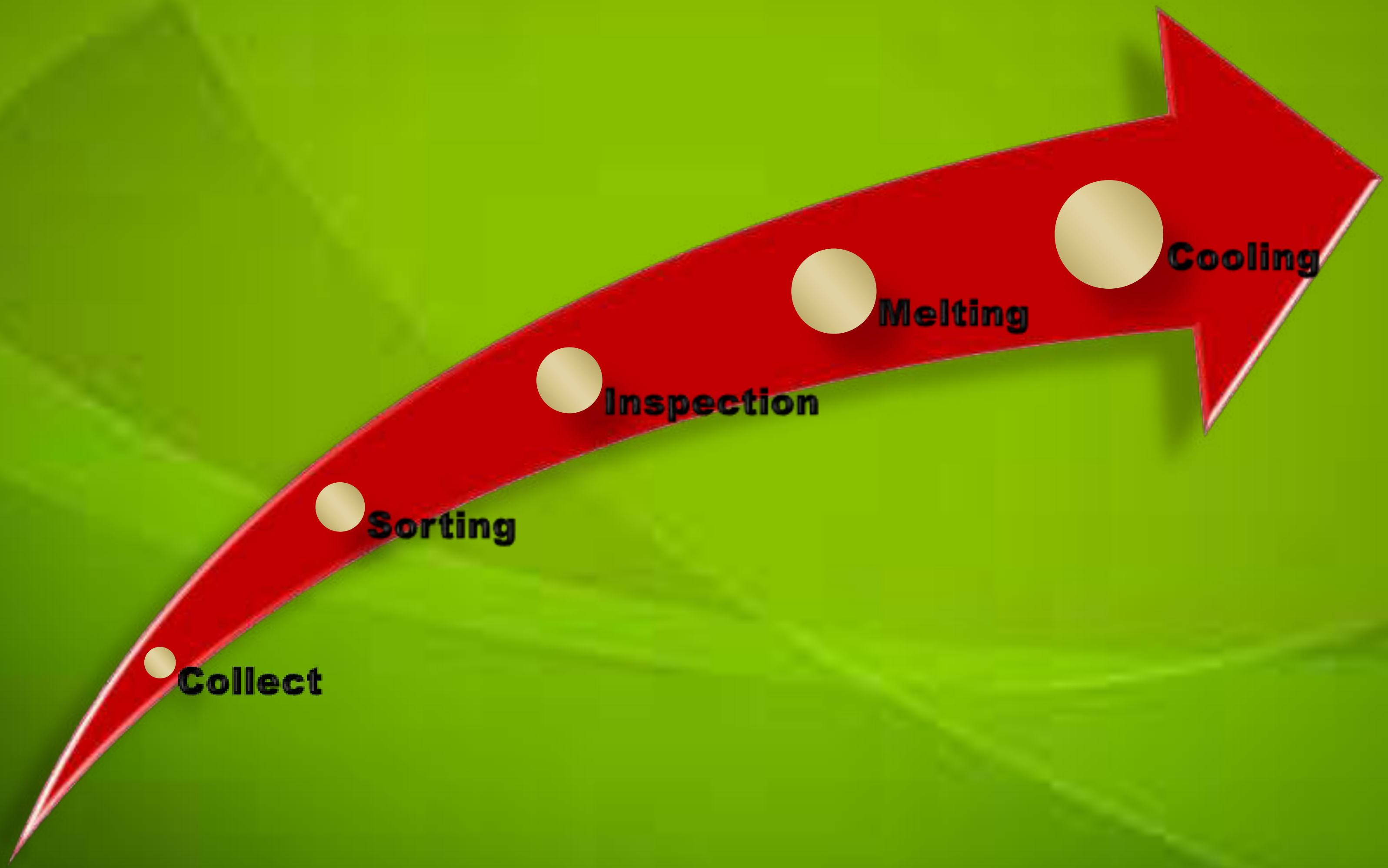
Steel

Lead

What is Metal Recycling???

- **Process of reusing old metal material, to make new products**
- **“Infinite recyclability”**
- **Recycling old metal products uses 95% less energy than manufacturing it from new materials.**
- **100% recyclable**

Recycling process



The recycled metals are further gives…

Iron

- Iron is used in a variety of products : pots, pans, fences, ornamental items

- Majority of iron is used in the production of steel, used as a structural material projects like bridges and buildings, in fasteners, cookware, automotive parts, trains and railways

Aluminium

- Used as a basic metal or as an alloy for utensils, engineering, electrical equipment, cooking foil



Copper

- Used widely in making wire for use as an electrical conductor as it is one of the best yet cheapest materials for this application
- It is used in police badges, and that is why they are called "cops"



Steel

Steel is mainly use in building houses or small furniture.

It is also used in all sorts of kitchen appliances.

Steel is used mostly in railway tracks and train trailers

Brass

- Brass is a metal and can be used for a wide range of different uses such as making musical instruments, doorknobs, mailboxes, and ornaments. US Navy sailors wear brass belt buckles because brass will not spark if scratched

Lead

- Used for storage batteries, a coloring element in ceramic glazes, lead glass, piping, electrodes in electrolysis, TV tubes, bullets, tanks and chambers in the lead-chamber

Benefits of Recycling???

- You can go to scrap metal recycling facilities and get paid for what you bring
- Reduces greenhouse gas emissions
- Can be recycled over and over again
- Decreases environmental damage
- Less land and water pollution

- Saves energy
- Reduction in raw materials used
- Less in air pollution
- Decrease in usage of water and water pollution
- Creating private sector jobs
- Reduces need of mining

Negatives of Metal Recycling???

- **Recycling sites can become unhygienic**
- **Damages the surrounding environment**
- **Harmful chemicals in the trash, can mix into water and soil**
- **When it gets mixed with rainwater, a poisonous mixture known as "Leachate"**

Benefits of recycling supasses the negatives and so…

Sustainability and Recycling goes hand in hand

Aluminum Recycling

Aluminum Recycling

Road Map

- Aluminium
- Aluminum recycling
- World wide aluminum recycling rate
- History
- Advantages
- Aluminum Cans
- How aluminium cans is recycled
- Aluminum recycling factory in Bangladesh
- Ideas to increase aluminum recycling
- Conclusion

ALUMINIUM

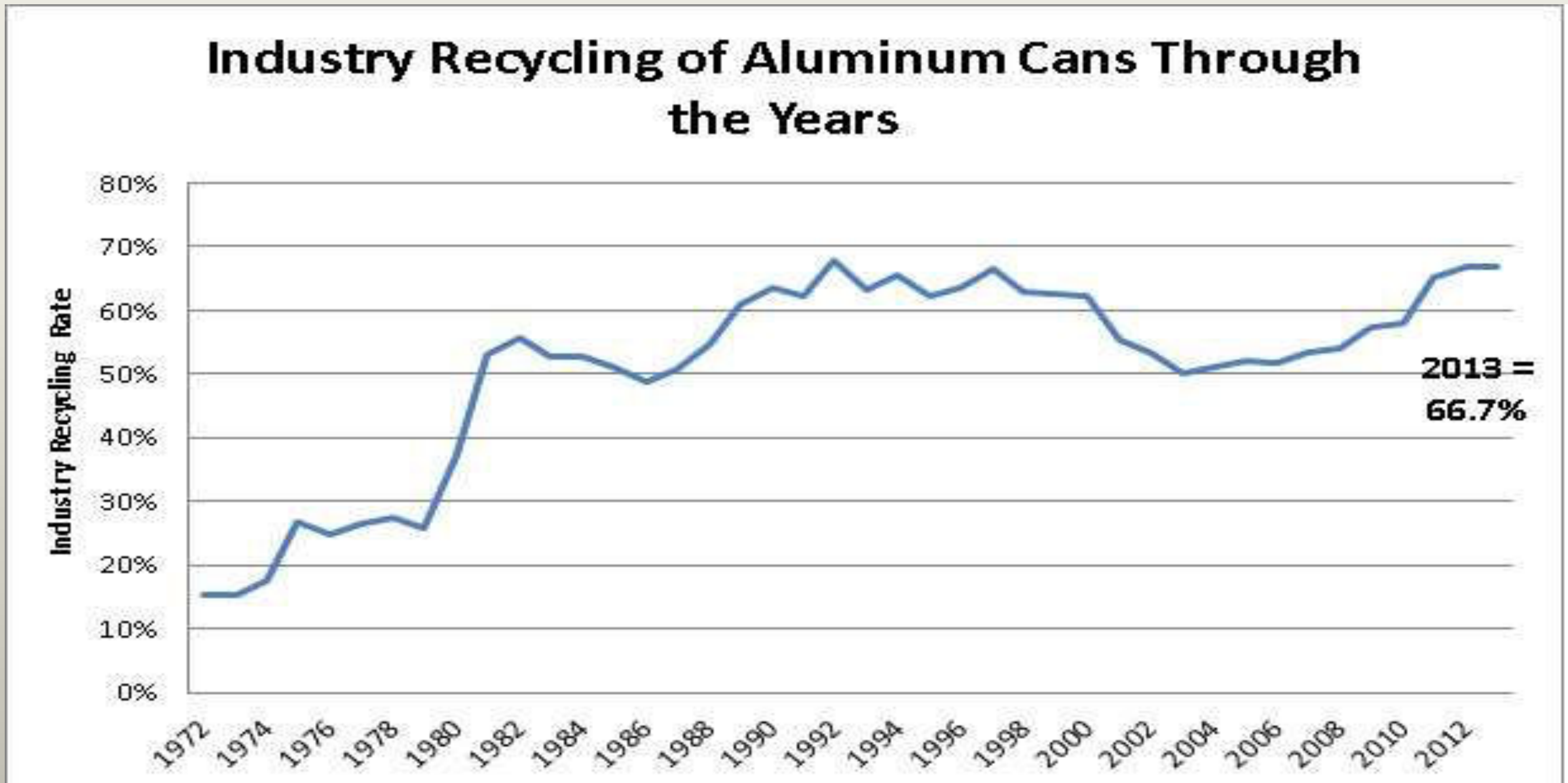
Aluminum is a chemical element in the boron group with symbol Al and atomic number 13. It is a silvery-white, soft, nonmagnetic, elastic metal. Aluminum is the third most rich element in the Earth's crust (after oxygen and silicon) and its most rich metal.

ALUMINUM RECYCLING

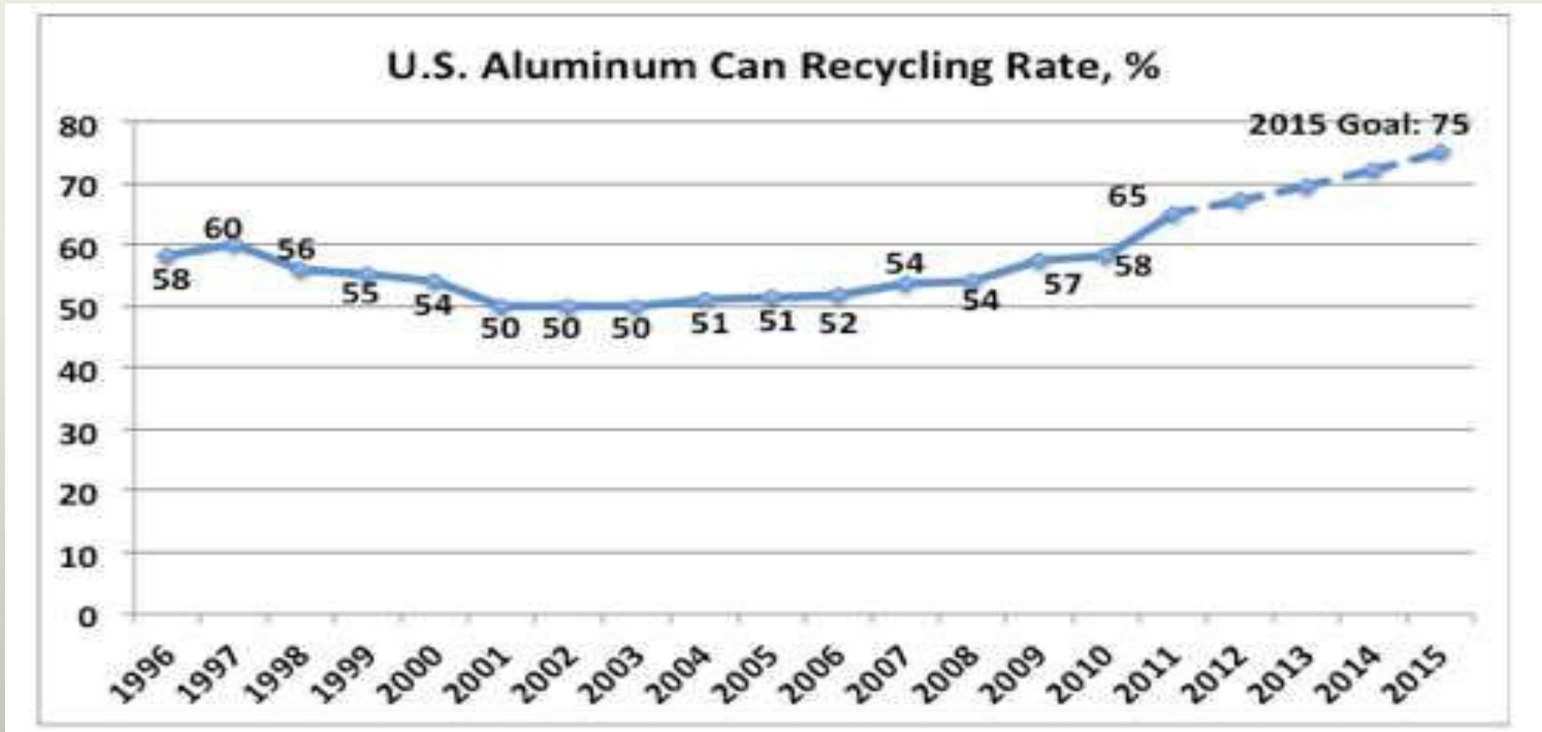
Aluminium recycling is the process by which scrap aluminium can be reused in products after its primary production. Recycling scrap aluminium requires only 5% of the energy used to make new aluminium.

WORLD WIDE ALUMINUM RECYCLING RATE

Brazil recycles 98.2% of its aluminium can production, equivalent to 14.7 billion beverage cans per year, ranking first in the world, more than Japan's 82.5% recovery rate. Brazil has topped the aluminium can recycling charts eight years in a row.



U.S. ALUMINUM CAN RECYCLING RATE FROM 1996 TO 2011, WITH A 2015 GOAL OF 75%



History

A common practice since the early 1900s and far capitalized during World War II, aluminium recycling is not new.

Sources for recycle aluminium for include aircraft, automobiles, bicycles, boats, computers, cookware, gutters, siding, wire, and many other products that need a strong lightweight material, or a material with high thermal conductivity.

ADVANTAGES

Energy savings

Recycling aluminium uses about 5% of the energy required to create aluminium from bauxite; the amount of energy required to convert aluminium oxide into aluminium can be brightly seen when the process is reversed during the burning of thermite or ammonium perchlorate composite propellant.

Environmental savings

Recycled aluminium uses 5% of the energy that would be needed to create a comparable amount from raw materials. The benefit with respect to emissions of carbon dioxide depends on the type of energy used. Canada, Brazil, Norway, and Venezuela have 61 to 99% hydroelectric power and are major aluminium producers.

ALUMINUM CANS

- Aluminum cans is one of the most sustainable metals we use.
- A recycled aluminum can may be back on a grocery shelf, in one from another in as few as sixty days.
- It takes about four hundred years for an aluminum can to break down naturally.

Aluminum Cans Recycling

- Aluminum cans are often made with recycled aluminum; about 68% of a standard North American can is recycled aluminum.
- In 2012, 92% of the aluminum beverage cans sold in Switzerland were recycled.
- Cans are the most recycled beverage container, at a rate of 69% worldwide.

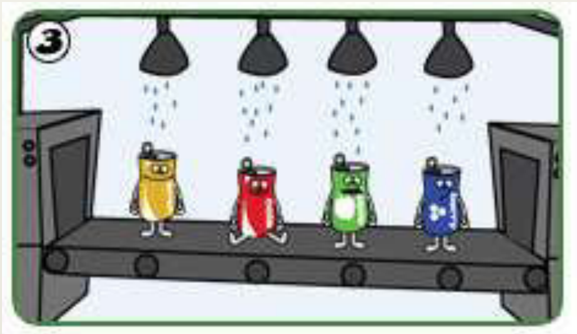
HOW ALUMINIUM CANS IS RECYCLED

Aluminium beverage cans are usually recycled by the following method :

1. The consumer throws aluminium cans and foil into a recycle bin.

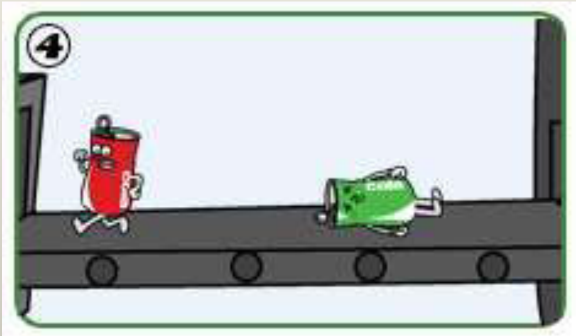
2.The aluminium is then collected and taken to a treatment plant.

How aluminium cans is recycled



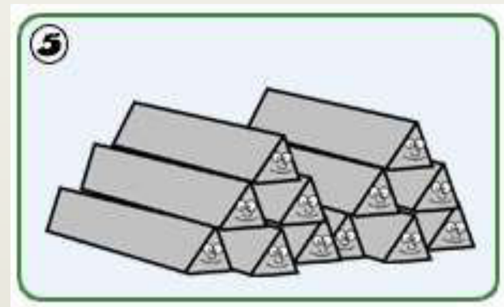
3. In the treatment plant the aluminium is sorted and cleaned ready for reprocessing.

4. It then goes through a re-melt process and turns into molten aluminium, this removes the coatings and inks that may be present on the aluminium.

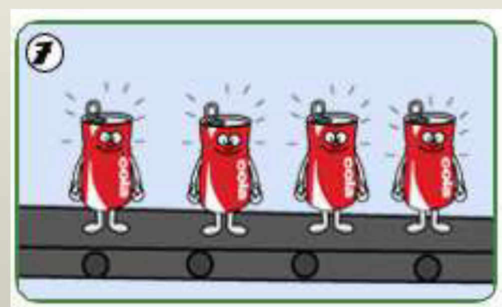


How aluminium cans is recycled

5.The aluminium is then made into large blocks called ingots. Each ingot contains about 1.6 million drinks cans.



6.This is then made into aluminium products such as cans, chocolate wrapping and ready meal packaging.



How aluminium cans is recycled

7. In as little as 6 weeks, the recycled aluminium products are then sent back to the shops ready to be used again.

ALUMINUM RECYCLING FACTORY IN BANGLADESH

Labors work in hazardous conditions at an aluminum recycling factory on the out borders of Dhaka.

IDEAS TO INCREASE ALUMINUM RECYCLING

- People need more information about the benefits of aluminum recycling.
- More containers where to put aluminum cans that can be recycled.
- Open more places, where people can hand in aluminum, so aluminum recycling would be more accessible.

CONCLUSION

In conclusion, recycling aluminum is the process of saving costs and opens the way for the further industrial production and recycling helps save the economy in one. This is by teaching and learning how to reuse aluminums and other recycling products and save the plant and the environment and keep its all safe.

Thank you