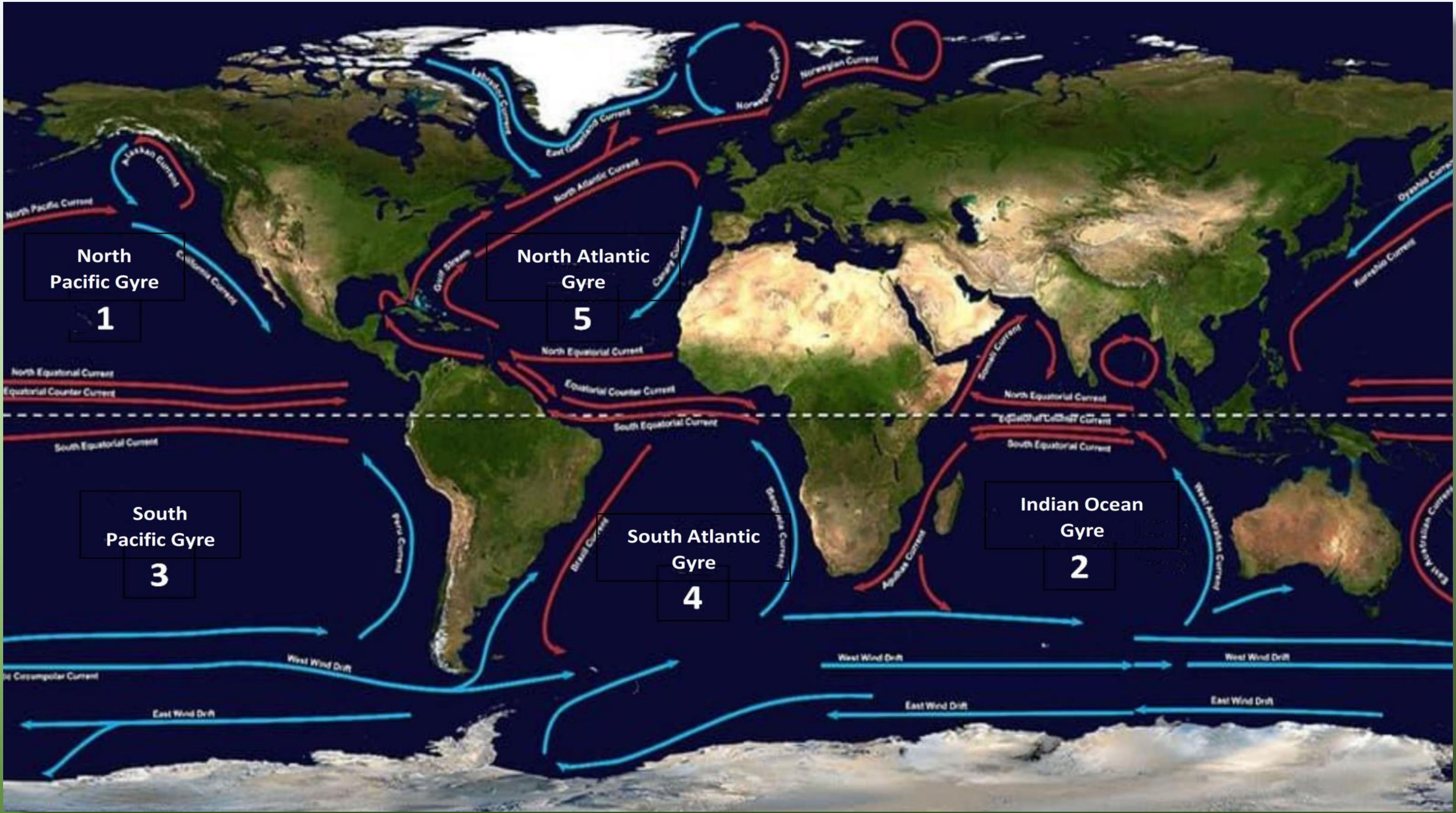
# Issues and Challenges in Plastic Waste Management

F. A. Uriarte, Jr.

Marine plastic pollution, www.google.com.ph




National Ocean Service, U.S. NOAA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Great Pacific Garbage Patch, www.google.com.ph

# The Issue of
# Paper Versus Plastic

Eco-Bilan, a division of PriceWaterhouseCoopers, carried out in 2004 a LCA on paper and plastic bags.

The results were definitive –
– plastic is environmentally superior to paper.

| | |
|---|---|
| Consumption of nonrenewable energy | Paper 2.2 times more than plastic |
| Consumption of water | Paper 4.7 times more than plastic |
| Emissions of greenhouse gases | Paper 3.1 times more than plastic |
| Emissions of acid gases | Paper 2.7 times more than plastic |
| Eutrophication | Paper 18 times more than plastic |

Scottish Government spent over two years analyzing the plastic bag issue and issued in 2005 a full EIA report,
The Scottish Report, comparing plastic and paper bags.

**Environmental Impact of Paper Relative to Plastic**

| Indicator of Environmental Impact | Paper bag |
|---|---|
| Consumption of nonrenewable primary energy | 1.1 |
| Consumption of water | 4.0 |
| Climate change (emission of greenhouse gases) | 3.3 |
| Acid rain (atmospheric acidification) | 1.9 |
| Air quality (ground level ozone formation) | 1.3 |
| Eutrophication of water bodies | 14 |
| Solid waste production | 2.7 |
| Risk of litter | 0.2 |

# Two main conclusions of the Scottish Report:

- environmental benefits will be achieved if consumers switch from lightweight plastic bags to reusable bags;
- in all circumstances, paper bags have a greater negative environmental impact than conventional plastic carrier bags.

# Additional conclusions of the Scottish Report:

- Paper bag manufacture is more resource-intensive than plastic bag manufacture
- Paper bags are more difficult to reuse because they tend to tear

- Paper bags contribute two to three times more weight to the waste stream compared to plastic bags
- Use of paper bags results in a threefold to fourfold increase in greenhouse gas emissions

North American Boustead Report (2007):
LCA of environmental impacts of plastic and paper bags.
Paper bags had 30% post-consumer content, and the recycling scenarios were 5.2% for plastic bags and 21% for paper bags.

Findings:

- **Consumption of energy, paper bags 3.4 times more than plastic.**
- **Consumption of water, paper 17.3 times more than plastic.**
- **Emission of greenhouse gases, paper 2 times more than plastic.**
- **MSW generation, paper bags 4.8 times more than plastic.**

# Environmental Impacts based on equalized carrying capacity of 1,000 paper bags

| Environmental Impacts | Plastic Bags | Paper Bags with 30% Recycled Content |
|---|---|---|
| Total energy use, megajoules | 763 | 2,622 |
| Fossil fuel use, kilograms | 14.9 | 23.2 |
| Municipal solid waste, kilograms | 7.0 | 33.9 |
| Greenhouse gas emissions, tonnes $CO_2e$ | 0.04 | 0.08 |
| Fresh water usage, liters | 220 | 3,800 |

North American Boustead Report (2007)

ULS Report (2008) updated four credible studies on environmental impacts of grocery bags to come up with their own conclusions and recommendations:

- Swiss Life Cycle Inventories for Packaging (1998)
- Eco-Bilan Life Cycle Analysis (2004)
- Eco-profiles of the European Plastics Industry (2005)
- LCA of Grocery Bags (2007)

# ULS Report Findings:

- Plastic bags generate 39% less GHG emissions (4,645 tons $CO_2e$ per 150 million bags) than uncomposted paper bags (7,621 tons) and 68% less GHG emissions than composted paper bags (14,558 tons per 100 million bags).
- Plastic bags (220 liters to produce 1,500 plastic bags) consume less than 6% of water needed to make paper bags (3,800 liters to produce 1000 paper bags).
- Plastic grocery bags consume 71% less energy during production than paper bags; 36% less than energy consumed during the lifecycle of paper bags; and 64% less than energy consumed by biodegradable plastic bags.
- Using paper sacks generates 5 times more solid waste than plastic bags.

# ULS Report Conclusions:

- **Legislation to reduce environmental impacts and litter by outlawing plastic grocery bags will not deliver the intended results.**
- **While some litter reduction may take place, it is outweighed by later disadvantages such as increased solid waste and greenhouse gas emissions.**
- **Reducing use of plastic bags will not reduce reliance on fossil fuels, as paper and biodegradable plastic bags consume at least as much energy during their lifecycle.**

U.K. Environment Agency (2011) conducted
LCA comparing environmental impacts of
conventional plastic grocery bags (HDPE), paper carry bags,
longer-life bags (cotton, non-woven polypropylene),
plastic bags-for-life (low density polyethylene),
and starch polyester blend bag.

# UKEA Findings:

- Conventional plastic shopping bag (HDPE) outperformed all alternatives on environmental performance.
- Conventional plastic bags have a much lower global warming potential.
- Environmental impact of carry bags is dominated by resource use and production stages.

# UKEA Findings:

- Heavier, sturdier bags have higher global warming potential, e.g., cotton bags, production of cotton needs heavy pesticide and water use.
- Whatever type of bag used, the key to reducing impacts is to reuse it as many times as possible.
- The reuse of HDPE bags for shopping and as bin liners is pivotal to their environmental performance; reuse of bags as kitchen catchers produces greater benefits than recycling.

# UKEA Conclusions:

- Paper bags would have to be used three times to lower their global warming potential to match that of a conventional HDPE plastic shopping bag used just once.
- LDPE bags (thicker polyethylene bags for life) would have to be used four times; non-woven polypropylene bags 11 times; and cotton bags 131 times to be as good environmentally as a plastic shopping bag used just once.
- Starch-polyester blend bags have higher global warming potential than conventional polymer bags due to increased weight of material and higher production impacts.

# Amount of Primary Use of Alternatives to Match the HDPE Conventional Bag Environmental Performance With or Without Secondary Reuse of the HDPE Bag

| Type of Carrier Bag | HDPE Bag (no secondary reuse) | HDPE Bag (40.3% reused as kitchen catchers) | HDPE Bag (100% reused as kitchen catchers) | HDPE Bag (reused 3 times) |
|---|---|---|---|---|
| Plastic Bag | 1 | 2 | 2 | 3 |
| Paper Bag | 3 | 4 | 7 | 9 |
| LDPE Bag | 4 | 5 | 9 | 12 |
| Non-woven PP Bag | 11 | 14 | 26 | 33 |
| Cotton Bag | 131 | 173 | 327 | 393 |

# Overall Conclusions:

- **Whatever type of bag is used, paper or plastic, the key to reducing its environmental impact is to reuse it as many times as possible.**
- **While there are differences in the results of various studies, the findings of numerous LCAs agree that plastic bags have a smaller environmental impact than paper bags.**
- **Manufacture of paper bags requires larger amounts of energy and water.**
- **Compared to plastic bags, paper bags tend to fail because they tear easily and are not waterproof.**
- **Plastic bags outperform paper since they can be reused as carry bags and as liners and kitchen catchers for garbage and organics.**

# Overall Conclusions:

- **Most significant impact of a switch from plastic shopping bags to paper grocery bags is the additional volume and weight that paper adds to the waste stream, which increases the amount of GHG emissions produced to transport it.**

- **Paper grocery bags (typically 55 grams) are heavier than plastic bags (6-8 grams), which leads to additional waste collection, transport and disposal costs.**

- **Although both paper and plastic bags can be recycled, paper bags tend to have higher recycling rates than plastic bags.**

- **With better information and education, it is possible to greatly enhance the level of plastic bag recycling and reuse.**

# The Issue of
# Glass Versus Plastic Bottles

## UK IHS Market (2018) conducted a comprehensive study on comparative use of glass or PET for food and beverage packaging.

## Findings:

- PET packaging is much lighter than glass, reducing cost of packaging and $CO_2$ footprint of transporting products.
- Raw material and production costs for PET are lower than glass.
- PET can be combined with other plastics in packaging materials to give different properties and lower the overall packaging weight.
- Glass has lower permeability to $O_2$ and $CO_2$ than plastic, which means alcohol can be stored longer, giving glass the advantage in alcoholic beverage packaging.

## UK IHS Market (2018) conducted a comprehensive study on comparative use of glass or PET for food and beverage packaging.

## Findings:

- Glass is more suitable for recycling than PET since glass can be recycled almost infinitely without loss of quality, and the use of one ton of cullet or recycled glass reduces $CO_2$ generation by 580 kg and saves 1.2 tons of virgin raw materials.

- Plastic food and beverage packaging provides better protection from product loss (less prone to breakage than glass), thus reducing overall cost of food and beverages to consumer and poses lesser risks from cuts from broken pieces.

**Macquarie University (2014) finds that a PET container weighing 20 g requires 9 kJ energy while equivalent glass container weighing 140 g requires 76 kJ energy to produce and transport.**

A comprehensive study in Spain of bottled water analyzed water for five types of phthalates (esters of phthalic acid), diethylhexyl adipate (DEHA), octylphenol, nonylphenol and bisphenol A (BPA) to determine whether there had been any migration.

Study concludes that in both plastic or glass packaging, bottled water is completely safe for health and comply with prevailing standards and legislation.

Guart and others 2014

The carbon footprint of PET bottles
is around 350 kg$CO_2$e/1,000 liters
while that of glass varies from
150 to 761 kg$CO_2$e/1,000 liters.

Gujba 2011

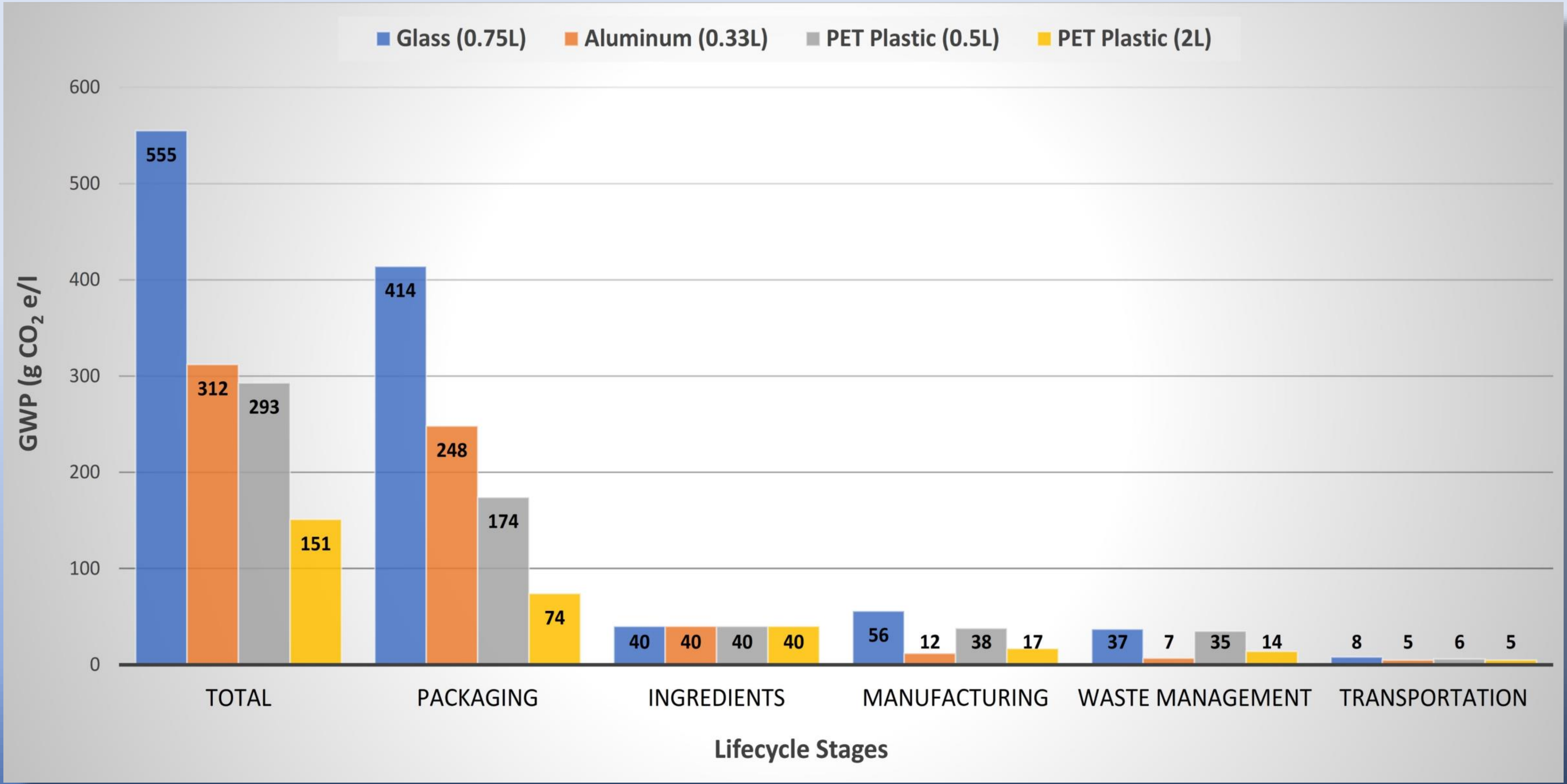
O-I Europe and AMR Research (2019) estimated carbon footprints for both glass and PET 355 ml carbonated beverage container in different parts of the world:

| Location | Carbon Footprint, $kgCO_2e$/container | |
|---|---|---|
| | Glass | PET |
| North America | 0.171 | 0.214 |
| Europe | 0.110 | 0.152 |
| South America | 0.117 | 0.124 |
| Asia-Pacific | 0.153 | 0.249 |

International Journal of Lifecycle Assessment (2013) published
the global warming potential of
beverage bottles made from glass,
aluminum, and PET (VFC 2015).

Glass has the highest global warming potential
at 555 $gCO_2e$/liter compared to PET with global warming
potential of 151-293 $gCO_2e$/liter.

# Global Warming Potential of Beverage Bottles




International Journal of Lifecycle Assessment, Jan 2013 Issue

# Overall Conclusions:

- **Comparative environmental impacts of glass bottles versus plastic bottles are not as clear and definitive as that of paper bags versus plastic bags.**
- **Glass bottles can be recycled in a closed loop into more glass without much loss of integrity.**
- **Plastic bottles are not recycled into plastic bottles but are turned into something different such as textile fiber and clothing, plastic lumber, or carpet padding.**
- **LCAs of glass versus plastic bottles and packaging are much more complex due to varying degrees of glass recovery and reuse.**
- **Studies often fail to capture the effect of full life cycle of the product on the environment, particularly what happens to packaging at the end of its life cycle.**

# Overall Conclusions:

- **PET is much lighter than glass thus reducing the cost of packaging and the carbon footprint of transporting products.**
- **Raw material and production costs for PET are lower than glass on a per unit basis (not taking into consideration the number of times glass is recycled).**
- **The choice between glass and plastic packaging is left to the consumers taking into consideration cost, convenience in use, and effectiveness in protecting the packaged product, bearing in mind the need to recover, recycle and reuse as much of the discarded glass or plastic material as possible.**

# The Issue of
# Use of Biodegradable Plastic

## Two classes of biodegradable plastics:

- Bioplastics, whose components are derived from renewable raw materials.

- Biodegradable fossil-based polymers, made from petrochemicals with biodegradable additives that enhance biodegradation.

Bioplastics can be made of two materials: biomass and polyesters derived from plants.

Biomass based bioplastics are made of starch and cellulose acetate from crop residues as well as wood from trees.

Two types of polyesters derived from plants are now produced in large quantities:

polylactide acid (PLA) and polyhydroxyalkanoate (PHA).

Biodegradable fossil-based polymers include polymers such as
polybutyrate adipate terephthalate (PBAT), polybutylene succinate (PBS), polycaprolactone (PCL) and
polyvinyl alcohol (PVA).

# Biodegradable synthetic polymers, their properties, popular brands and their applications

| Name | Properties | Can Substitute | Applications |
|---|---|---|---|
| Polybutyrate adipate terephthalate (PBAT) | PBAT is known for being flexible and tough which makes it ideal for combination with other biodegradable polymers that have high modulus and strength but are very brittle. | LDPE, HDPE | Garbage bags<br>Wrapping films<br>Disposable plastic products (lunch boxes, dishes, cups, etc.) |
| Polybutylene succinate (PBS) | Good oxygen barrier | Polypropylene | Films, bags, or boxes, for both food and cosmetic packagings. |
| Polycaprolactone (PCL) | Good water, oil, solvent and chlorine resistance | – | Manufacture of specialty polyurethanes |
| Polyvinyl alcohol (PVOH, PVA) | Water-solubility | – | Papermaking, textiles, and a variety of coatings |

# UNEP (2015) study concludes:

- Polymers most commonly used for general applications, with the required chemical and mechanical properties (e.g., PE, PP, PVC) are not readily biodegradable, especially in the marine environment.

- Polymers which will biodegrade in the terrestrial environment, under favorable conditions (e.g., PBS, PCL, PVA), also biodegrade in the marine environment, but much more slowly and their widespread use is likely to lead to continuing littering problems and undesirable impacts.

# UNEP (2015) study concludes:

- The inclusion of a pro-oxidant, such as manganese, in oxo-degradable polymers is claimed to promote fragmentation by UV irradiation and oxygen. The fate of these fragments (microplastics) is unclear, but it should be assumed that oxo-degradable polymers will add to the quantity of microplastics in the oceans.

- Oxo-degradable polymers do not fragment rapidly in the marine environment (i.e., persist > 2-5 years) and so manufactured items will continue to cause littering problems and lead to undesirable impacts.

# UNEP (2015) study concluses:

- **Some limited evidence suggests that public perceptions about whether an item is biodegradable can influence littering behaviour; if a bag is marked biodegradable it is more likely to be discarded inappropriately.**
- **On the balance of the available evidence, biodegradable plastics will not play a significant role in reducing marine litter.**

# Overall Conclusions:

- **Biodegradable plastics are energy intensive, expensive, and have the potential to make the problem of littering worse by encouraging people to think that it is okay to throw away.**
- **Even in ideal conditions, biodegradability does not resolve critical issues such as entanglement, or ingestion by marine animals.**
- **When some biodegradable plastics decompose in landfills, they produce methane gas, a greenhouse gas 23 times more potent than carbon dioxide.**

# Overall Conclusions:

- While biodegradability of bioplastics is an advantage, most need high temperature industrial composting facilities to break down.
- Bioplastics not discarded properly contaminate batches of recycled plastic and harm recycling infrastructure and entire lot is rejected.
- Bioplastics are expensive; PLA can be 20 to 50 percent more costly.
- Land required for bioplastics competes with food production.

Two general types of plastic:

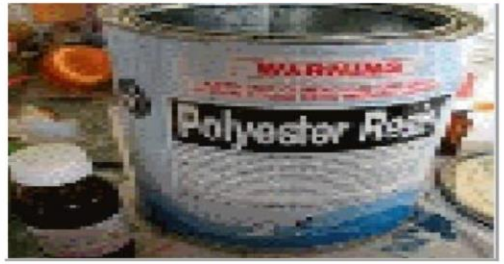
thermosetting plastics

thermoplastics

Thermosets make up about
20% of plastics produced.

They are hardened by curing
and cannot be re-melted or re-molded
and are therefore difficult to recycle.

# Some examples of thermosetting plastics

| Plastic Name | Products | | Properties |
|---|---|---|---|
| Epoxy resin |   | Casting and encapsulation, adhesives, bonding of other materials | Good electrical insulator, hard, brittle unless reinforced, resists chemicals well |
| Melamine formaldehyde |  | Laminates for work surfaces, electrical insulation, tableware | Stiff, hard, strong, resists some chemicals and stains |
| Polyester resin |  | Casting and encapsulation, bonding of other materials | Stiff, hard, brittle unless laminated, good electrical insulator, resists chemicals well |
| Urea formaldehyde |  | Electrical fittings, handles and control knobs, adhesives | Stiff, hard, strong, brittle, good electrical insulator |

Quora

In general, all thermoplastics
can be recycled or reused although some
are technically or logistically difficult
or too expensive to recycle.

The biggest challenge is and remains
the quality of the collected materials.

Plastic recycling faces a contradictory situation. The input quality is deteriorating, while the quality requirements for end products – especially for food products – are becoming more and more demanding.

The decline in quality is due to the
increasing complexity of the packaging.

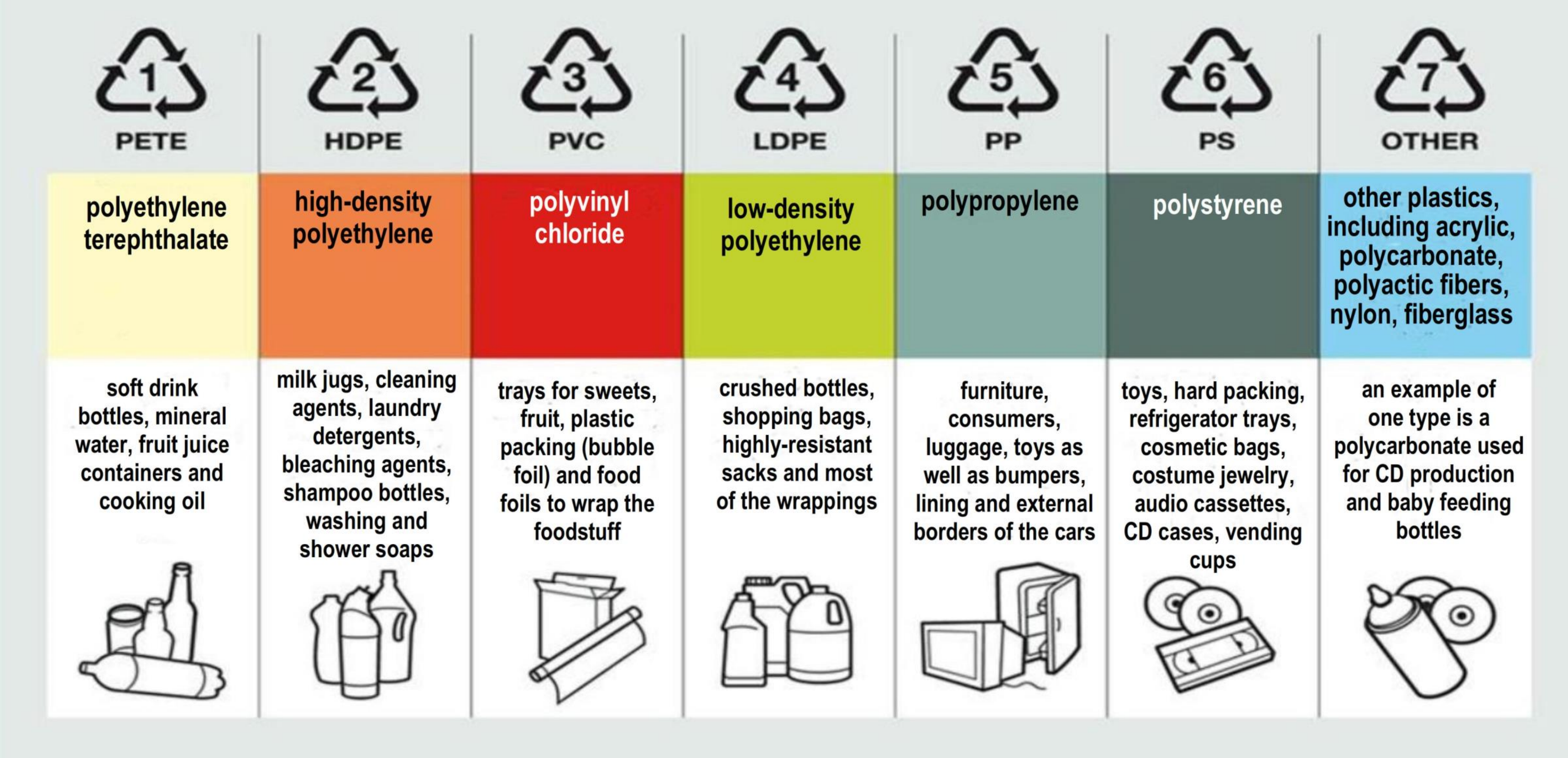
Manufacturers are adding more and more layers, barriers
and additives to their packaging.
This is good – and often necessary – for the preservation
and protection of the product. However, it is often a
nightmare
to recycle such packaging.

Other challenges in thermoplastics recycling are:

- Segregation: separating the desired plastic from the main waste stream from other types of plastic
- Collection of segregated materials
- Cleaning: removing dirt and impurities to prepare the plastic for further processing

Segregation is facilitated with the use of a Resin Identification Code (RIC), the number on the bottom of some rigid plastic packaging.

# Resin Identification Codes



# #1 - PET (Polyethylene Terephthalate)

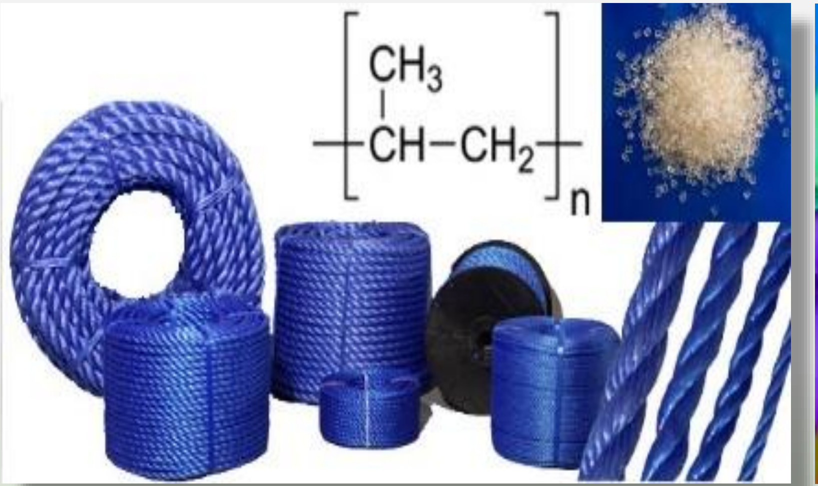
# #2 - HDPE (High-Density Polyethylene)

# #4 – LDPE (Low-Density Polyethylene)






# #5 – PP (Polypropylene)




# Plastic Bag RECYCLING in the Philippines

LDPE bags for sugar and rice

PP bags for tshirts, pants, etc.

HDPE garbage bags

HDPE grocery "sando" bags

## INDUSTRY PROFILE

- 300 companies – predominantly SMALL and MEDIUM INDUSTRIES
- Total number of employees – 176,922 direct employees in 2006 (down from 244,000 in 2004)

Undergoes
MECHANICAL RECYCLING
For Re-USE

Baled for storage or export


Mechanical Recycling for PLASTICS
Above: RECYCLED or PELLETIZED PLASTIC
SORTING
PELLETIZING
PROCESSING
Trash Bags,
among others
PPIA


Recycled Plastics
PLASTIC

Winder Recycling Company in Davao City manufactures school chairs and tables from waste plastics, converting 30 kgs of mixed soft plastic wastes
(10,000 candy wrappers, or 2,156 sando bags,
or 300 water bottles) into a 13-kg armchair.

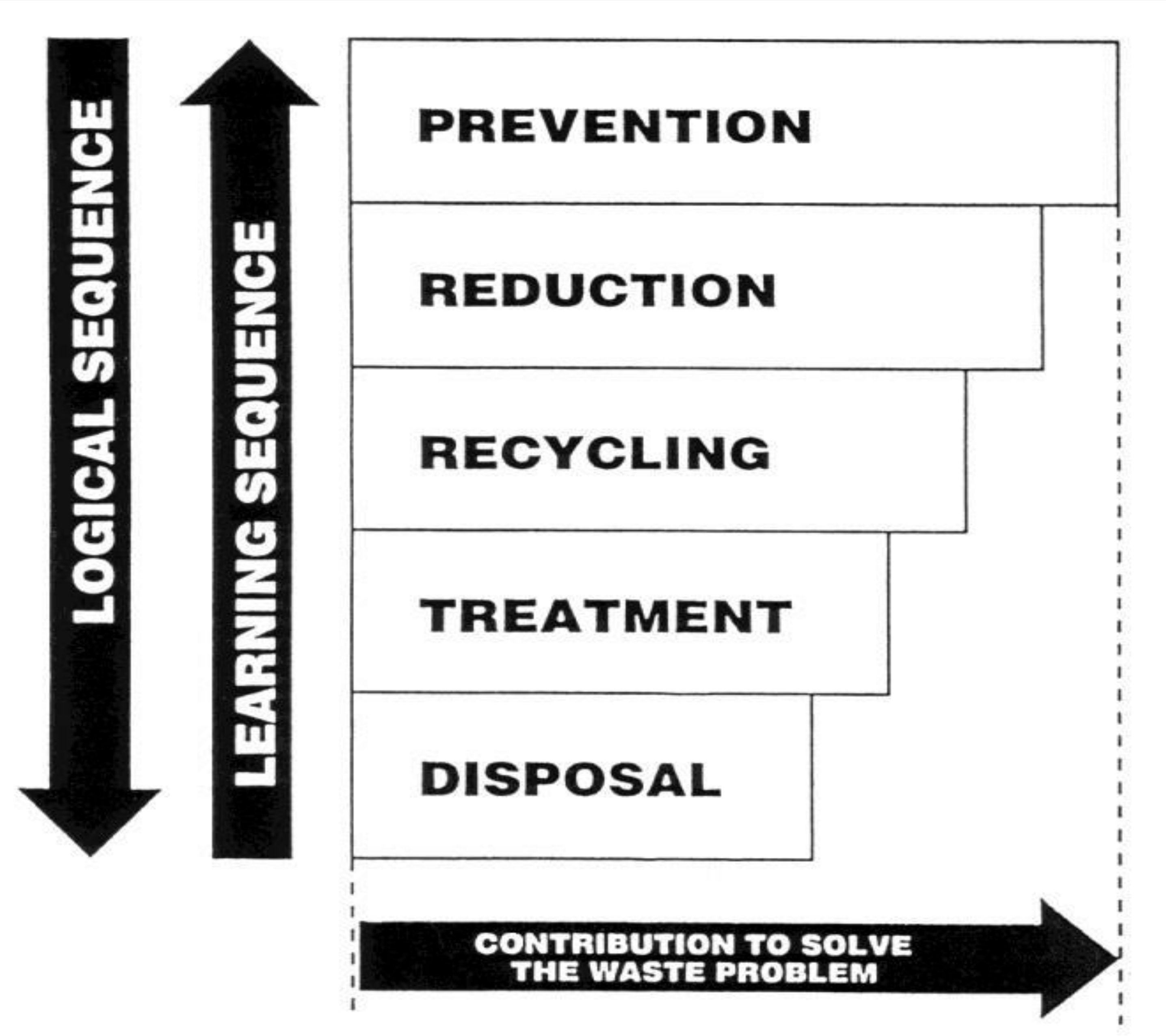

CGC


DECEMBER 05, 2017


Other Alternatives
Hollow block and Cement Fillers


Other Alternatives
Laminated "Zesto" Bags for Export to Europe


BAZURASHOP


LOGICAL SEQUENCE
LEARNING SEQUENCE
PREVENTION
REDUCTION
RECYCLING
TREATMENT
DISPOSAL
CONTRIBUTION TO SOLVE
THE WASTE PROBLEM