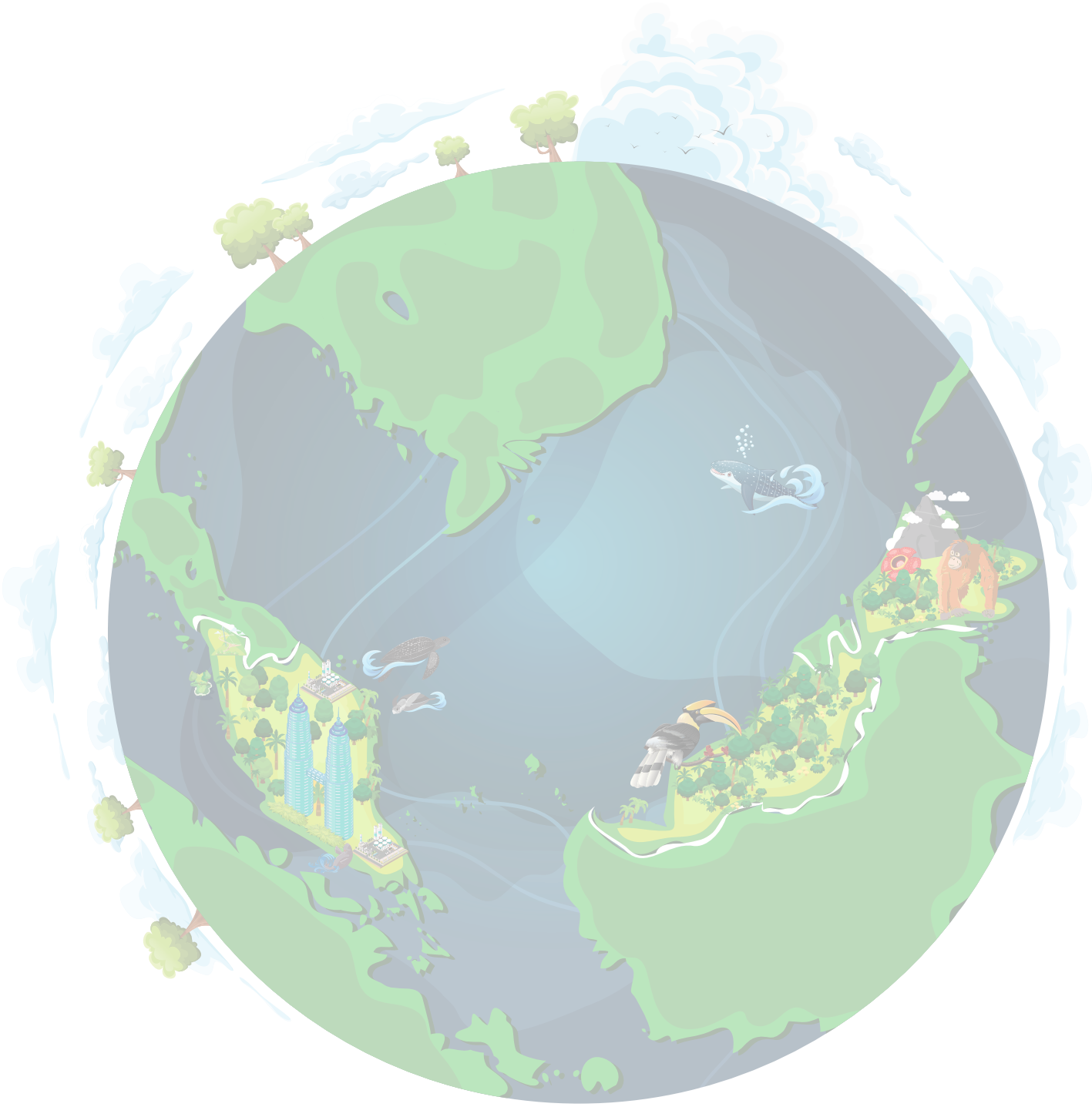
SUSTAINABILITY FOR TOMORROW

Module: Plastic, Sustainability & You
SECONDARY SCHOOL EDITION



Module: Plastic, Sustainability & You - Secondary School Edition

All information contained in this publication is correct as at September 2019.

MODULE INTRODUCTION

The way we live has deep and long-lasting consequences on the sustainability of our planet. Global warming and marine litter are two examples of how our actions are creating huge environmental issues. The current scenario is both urgent and serious. What is required to manage environmental issues is an understanding of the underlying causes and consequences of these issues, a change in mindset towards the environment and taking responsibility of the environment.

Plastic is widely used today in many applications because of its affordability and properties such as lightweight, strength, flexible, thermal insulation and inert. Plastics are replacing conventional materials in diverse areas due to advancements in technology. However, like all products, when disposed irresponsibly, plastic will have an impact on the environment. **Plastic, Sustainability & You** module was put together to equip teachers with the right information for dissemination on plastics, proper waste management and what students can do to play a role to address issues such as global warming and marine litter.

The information contained can be used in relation to subjects such as Science, Additional Science, Chemistry, Geography and Sustainability. This module serves to inspire students to think about the choices and decisions that they can make to care for our environment. While the topics can stand on their own, teachers are advised to use the module in totality and to engage the students with the videos and interactive content that have also been developed to make learning more fun and interesting. This module is to be used in PdP (classroom teaching) and extra co-curriculum as well as schools' environmental club activities. It will also serve as an important resource to help schools that currently do not run any environmental activities to start introducing them.

CONTENTS

1.0 | SUSTAINABILITY: EVERYONE'S RESPONSIBILITY

Key Messages:

1. United Nations (UN) has issued a set of 17 Sustainable Development Goals (SDGs) to rally governments, corporations, non-governmental organisations (NGOs) and individuals to act towards creating a sustainable world.
2. Everyone has a role to play in reducing global warming and marine litter which negatively impact environmental sustainability.

LEARNING STANDARD

At the end of this chapter, each student is able to:
- Understand the importance of sustainability.
- Explain the impact of global warming and marine litter on the environment.

What is sustainability?

Sustainability is about efforts to preserve the social, economic and environmental well-being of the current generation without compromising the ability of future generations to meet their own needs.*

Why is it important?

It is important because the world is a fragile ecosystem with only a limited amount of resources, such as oil, gas and water. If we do not use our resources carefully and responsibly, we will affect the resources available to future generations. We will also cause irreparable damage to the environment, affecting the health and well-being of people today and in the long term.

Figure 1: Diminishing sources of clean water

Figure 2: Increasing drought worldwide

**Source: Brundtland Commission Report 1987 as adopted by the UN*

1.1 | WHAT HAVE WE DONE TO OUR WORLD?

Large areas on land have been deforested

Between 1990 and 2016, the world lost 1.3 million km^2 of forests. That is about four times the area of Malaysia. Forests still cover about 30% of the world's land area, but are disappearing fast. Since humans started cutting down forests, 46% of the world's forests have been felled.

Source: National Geographic

Figure 3: Deforestation

Marine litter

Every minute, the equivalent of one garbage truck full of waste enters our oceans. This rubbish is carried into the sea as a result of littering by individuals on land and sea, and poor waste management. By the year 2050, there will be more litter in our oceans than marine life by mass.

Source: Earthday.org

Figure 4: Littering is the main source of marine litter

Increase in GHGs

The global surface temperature is rising because of an increase in generation of greenhouse gases (GHGs). GHGs are emitted by various human activities including waste generation. Organic solid waste that goes to landfills emits carbon dioxide (CO_2) and methane (CH_4), both GHGs. Global carbon emissions stood at about 15 billion tonnes in 1970 and hit 37.1 billion tonnes in 2018. In the same time span, the average global temperature has increased at the fastest rate in recorded history.

Source: Global Carbon Project, University of East Anglia; NASA

Figure 5: Overflowing landfills cause an increase in GHGs

These environmental issues are urgent because they affect everyone. What is more, they are caused by people and we have a responsibility to address them.

Did you know?

"*Water vapour (H_2O) is the most abundant GHG in the atmosphere.*"

Source: National Centers for Environmental Information

1.2 | SUSTAINABLE DEVELOPMENT GOALS

Environmental sustainability has been identified by the UN as a key focus area that needs the world's attention. Of 17 Sustainable Development Goals (SDGs) that it has outlined, three are directly related to critical environmental issues such as global warming and marine litter.

	The Sustainable Development Goals	How It Relates To The Environment	Malaysia's Actions
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Responsible Consumption & Production	The more we consume, the more our carbon emissions from production and the more waste we generate.	• Sustainable consumption and production (SCP) was introduced in the 11th Malaysia Plan to achieve green growth.* • SCP has been included in the national education curriculum.* • The government has set the target of increasing the national recycling rate to 22% from 17.5% in 2016.*
13 CLIMATE ACTION	Climate Action	This SDG seeks to address the issue of global warming.	• Malaysia has pledged to reduce the country's GHG emissions intensity by 35% from the 2005 baseline, and by a further 10% with assistance from developed countries.**
14 LIFE BELOW WATER	Life Below Water	One component of ensuring healthy oceans is to manage marine litter.	• Malaysia has introduced the National Coastal Zone Physical Plan (NPP-CZ) and the Coral Triangle Initiative Malaysia National Plan of Action (CTI-NPOA) to manage coastal and marine areas.* • As of 2016, Malaysia has established 63 marine protected areas covering 16,492.92 km^2, or 3.36% of the country's coastal and marine areas.* • Monitoring stations have been established to monitor the quality of marine water and the health of coral reefs.*

Waste management is critical to achieve the three SDGs above. Overflowing landfills emit GHGs while littering is a direct cause of marine litter.

**Source: Malaysia Sustainable Goals Voluntary National Review 2017*
***Source: Intended Nationally Determined Contribution (INDC) under the UN Framework Convention of Climate Change 2017*

What can we do?

We can help our country achieve its goals by reducing our energy consumption as well as reducing solid waste. This booklet has been produced to help us create the kind of world we would like to live in.

1.3 | GLOBAL WARMING

Global warming is the increase in our planet's temperature. It is caused by GHGs – mainly CO_2 and CH_4 – in our atmosphere. As more GHGs accumulate in the atmosphere, less heat is able to escape, and the hotter our planet gets.

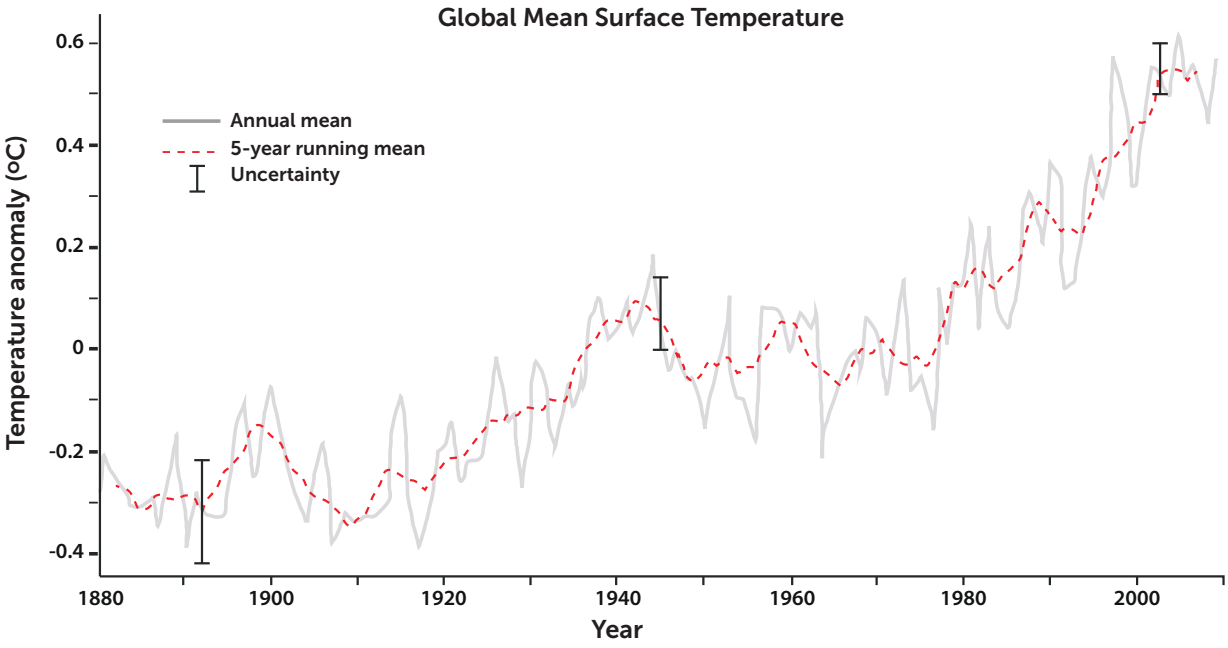


Figure 6: Global mean surface temperature 1880 - 2000

The average global surface temperature has been rising. At the beginning of the 21st century, the Earth's temperature was roughly 0.5°C above the long-term (1951 - 1980) average.

Source: NASA figures adapted from Goddard Institute for Space Studies Surface Temperature Analysis

CASE STUDY

Disappearing Coral

Coral reefs are killed by seawater temperature rising by 2°C over a sustained period of 6-10 weeks.

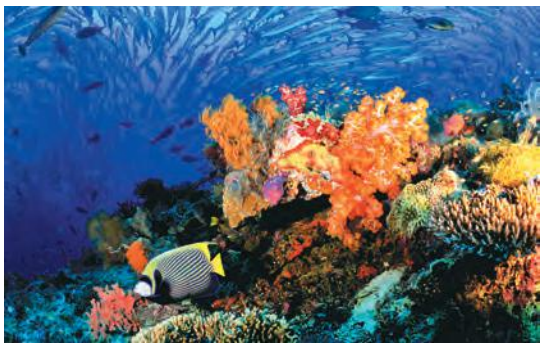


Figure 7: Healthy coral reef in Sipadan Island, Sabah

Figure 8: Dead coral reef in Sipadan Island, Sabah

Why is global warming serious?

Global warming is serious because it causes ice caps and glaciers to melt, increasing sea levels. It also causes changes in weather patterns, such as hurricanes, droughts and increased rainfall leading to floods. These, in turn, can cause crop devastations and mass migrations of animal species.

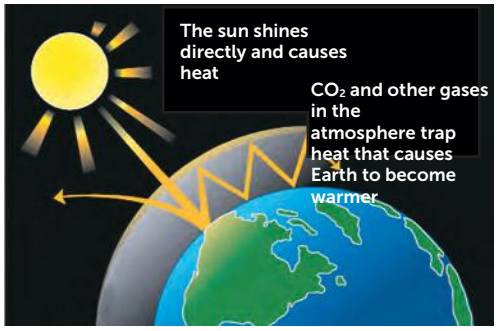


Figure 9: The greenhouse effect

Figure 10: Melting glaciers

Effects of global warming:

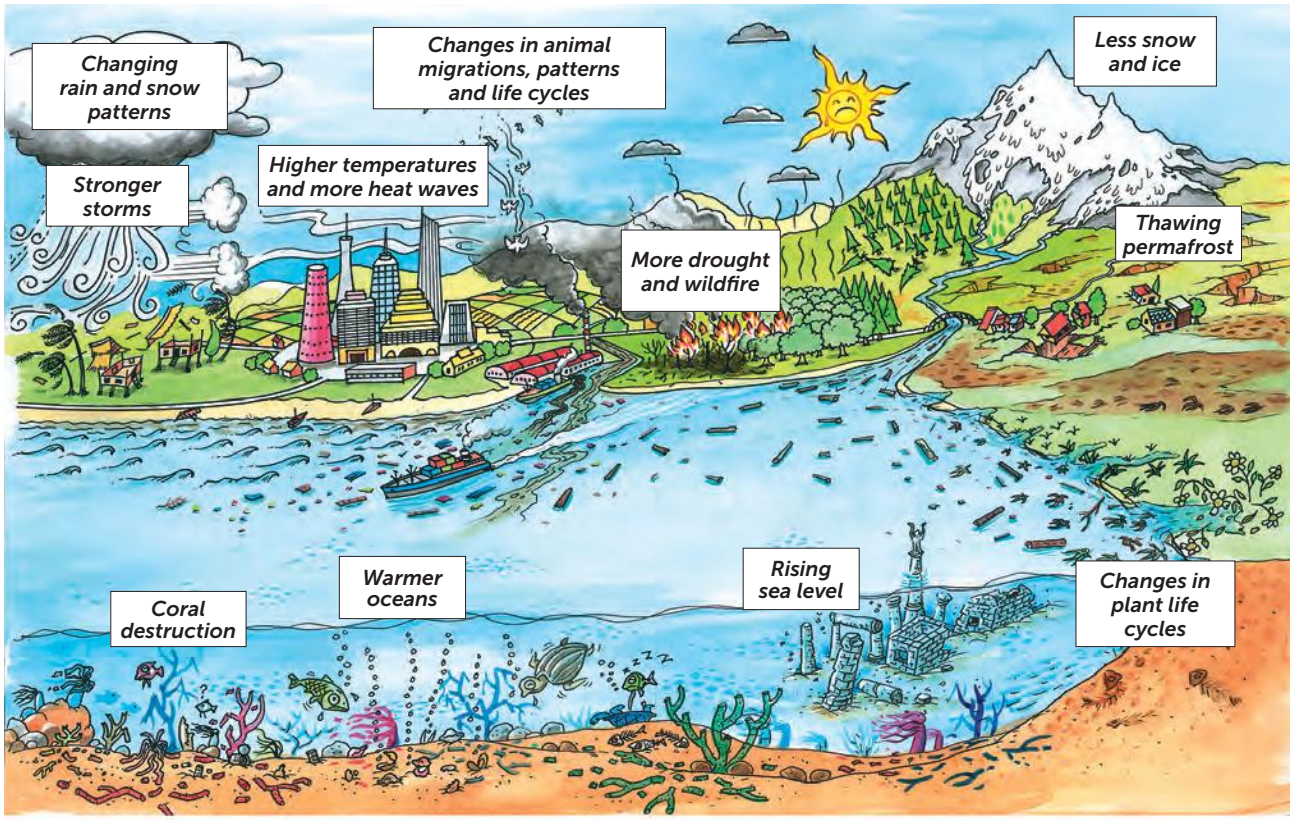


Figure 11: The wide-ranging effects of global warming

If the situation in Figure 11 is left unchecked, we can expect the following:

- Sea levels rising between 10-32 inches or more by the end of the century, resulting in many smaller islands sinking including popular tourist destinations such as the Maldives.
- Stronger hurricanes and storms as well as more pronounced droughts (megadroughts).
- Less availability of freshwater as glaciers store about 3/4 of the world's freshwater.
- More outbreaks of mosquito-borne diseases such as malaria, dengue fever and the Zika virus because some mosquitoes thrive in warmer climates.

What can we do to reduce global warming?

Each of us is responsible for global warming because of our daily actions and behaviours. Most of the energy we use comes from fossil fuels (crude oil, natural gas and coal) which contain carbon and hydrogen.

When these are burned, carbon from the fossil fuels combines with oxygen to form CO_2. The solid waste that we produce also emits GHGs.

Table 1: Actions that we can take to reduce global warming

Our actions	How they contribute to global warming	How we can reduce global warming
Using electricity, e.g. lights, fans, air conditioners, water heaters, laptops, mobile phones, fridges	***Electricity generated by fossils fuels emits GHGs***	• *Switch off fans and lights, and remove the plugs of electrical appliances when these are not in use* • *Turn off our computers/ laptops when not in use rather than leave them on sleep mode* • *Use energy-efficient appliances, such as LED lights instead of conventional lights* • *Use high-energy appliances such as air conditioners and water heaters sparingly*
Using cars and motorbikes	***Burning fuel to power engines releases CO_2***	• *Use public transport like buses and trains (LRT/MRT)* • *Walk whenever possible* • *Car pool with others* • *Plan our errands so that they can be accomplished in one trip rather than many separate trips*
Producing solid waste	***Organic solid waste in landfills decompose and emit GHGs***	• *Reduce our solid waste to landfills by reducing our consumption* • *Practise the 3Rs*

1.4 | MARINE LITTER

Figure 12: The Great Pacific Garbage Patch, located between Hawaii and California, is the largest accumulation of ocean litter in the world. It covers an area of 1.6 million km², about five times the size of Malaysia.

Marine litter is the accumulation of solid waste in the oceans and coastal areas, 80% of which comes from land. Things that we litter are washed into drains and rivers, then get channelled into the sea. Solid waste can be found at every level in the ocean, from the seabed to the surface, posing a grave danger to fish and other marine life.

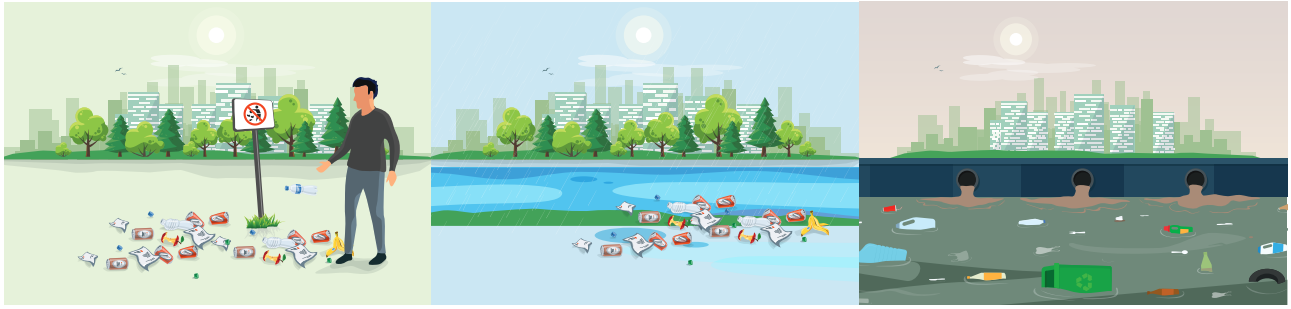


Figure 13: Marine litter starts from land

How marine litter affects sustainability

- When marine animals eat marine litter, they can develop severe problems in their digestive systems.
- Marine animals also get caught in nets discarded in the sea.
- Litter that covers coral prevents algae living in the coral's polyps from making food which also serves to nourish the coral.
- Any change in the biodiversity of marine life affects the overall marine ecosystem, causing a chain reaction affecting coastal and other ecosystems.

Microplastics

Oxo-degradable plastics break down into microplastic particles up to 5mm in diameter when they are exposed to ultraviolet (UV) radiation. Microplastics are a major by-product of plastic debris in the ocean.

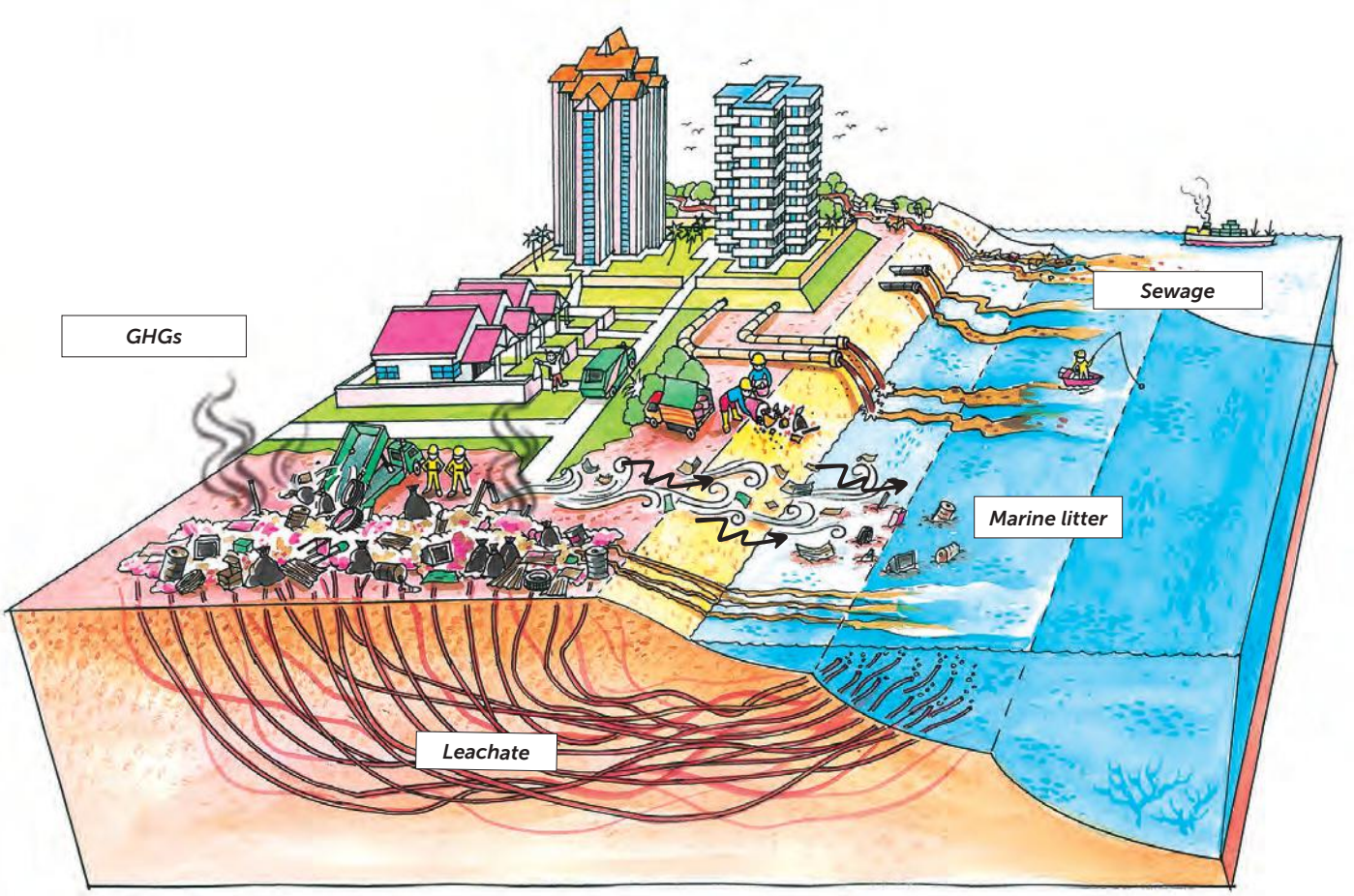


Figure 14: Process of pollution

How waste contributes to global warming and marine litter

- Organic solid waste such as food and garden waste will decompose in landfills and emit GHGs that contribute to global warming.
- Other forms of litter will get into drains and rivers, eventually entering the sea where they add to marine litter.

Therefore waste management is critical to prevent global warming and marine litter.

Did you know?

“Irresponsible people at sea contribute to marine litter by throwing away damaged nets, tins, bottles and food packaging into the sea.”

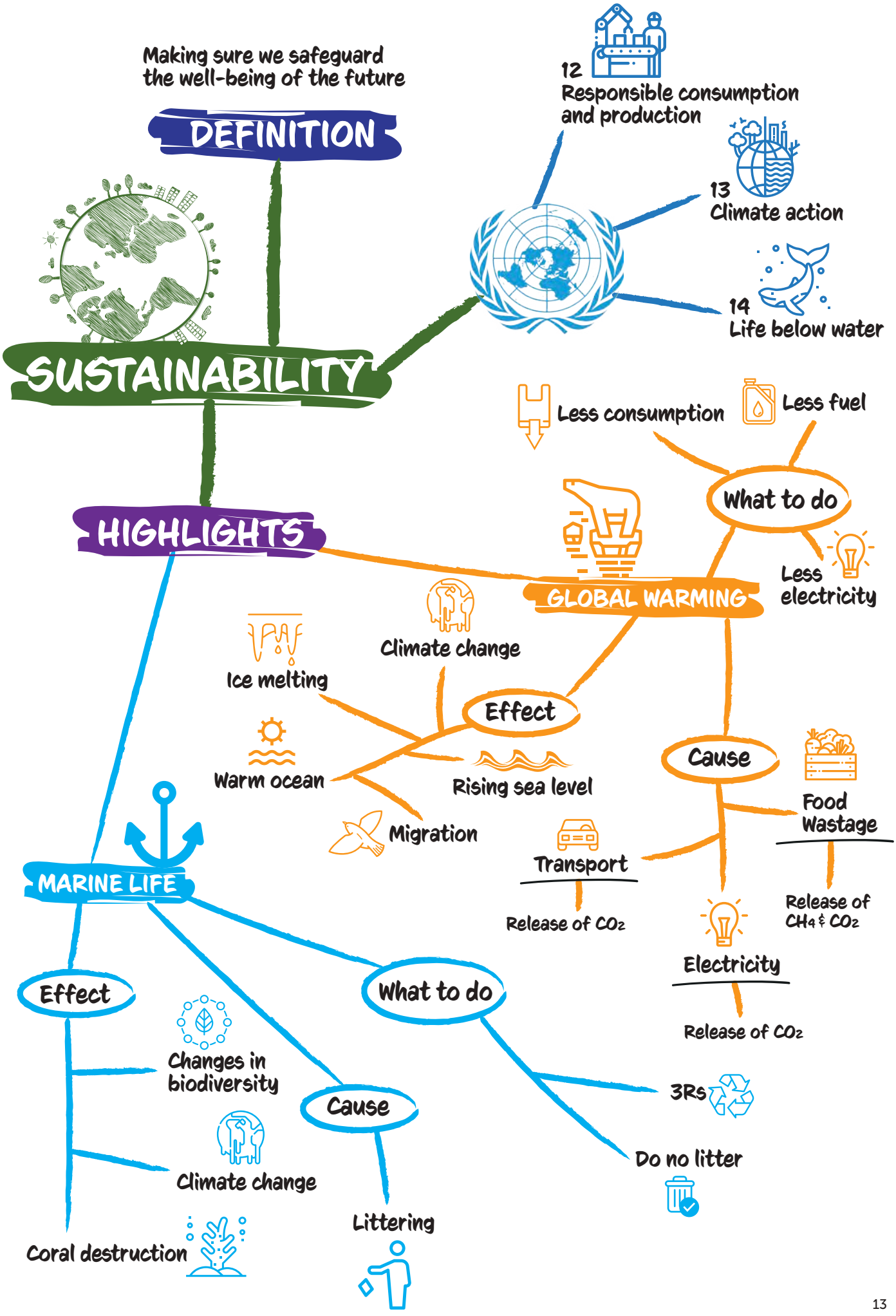
Myth:#1

Marine litter is all plastic.

Fact:

All sorts of waste enters the sea – from paper to tins, bottles, rubber tyres, metal parts, wood, etc.

However, a lot of the non-plastic items sink, leaving plastic on the surface, visible to the human eye. People therefore see a lot of plastic in the oceans and think all marine litter is plastic.


Making sure we safeguard the well-being of the future
DEFINITION
SUSTAINABILITY
12 Responsible consumption and production
13 Climate action
14 Life below water
HIGHLIGHTS
GLOBAL WARMING
Less consumption
Less fuel
What to do
Less electricity
Climate change
Ice melting
Effect
Warm ocean
Rising sea level
Migration
Cause
Food Wastage
Release of CH4 & CO2
Transport
Release of CO2
Electricity
Release of CO2
MARINE LIFE
Effect
Changes in biodiversity
Climate change
Coral destruction
Cause
Littering
What to do
3Rs
Do no litter

WORKSHEET

ACTIVITY

Share the video "Be The Judge: Plastics or Humans?" with your class, then discuss the cause and effects of marine litter.

Note : Retrieve the video from "VIDEO" folder located in the USB flash drive.

Questions

1. Why is sustainability important?

   i. To ensure current development does not impact the well-being of future generations
   ii. To ensure we do not deplete the world's natural resources such as water and hydrocarbon-based fuels
   iii. To ensure everyone enjoys greater wealth by creating greater demand for products, hence improving the economy

   A. i and ii **B.** ii and iii **C.** i and iii **D.** All of the above

2. Which of the following is the odd one out in respect to global warming?

   A. Open burning
   B. Felling of trees
   C. Melting ice caps
   D. Overconsumption and excessive waste entering landfills

3. 80% of marine litter originates from land. How does waste from land end up in the ocean?

   i. Illegal dumping of waste into rivers
   ii. People using beaches for recreation or shore fishing
   iii. Litter washed by rain or blown by wind into drains, which eventually flows into rivers and then oceans

   A. i and ii **B.** ii and iii **C.** i and iii **D.** All of the above

4. Which of the items below can be found in marine litter?

   i. Tyres
   ii. Fishing nets
   iii. Drink bottles
   iv. Food wrappers/containers

   A. i, ii and iii **B.** ii, iii and iv **C.** i, iii and iv **D.** All of the above

5. Which of the following action(s) would help to reduce both global warming and marine litter?

   i. Practise the 3Rs
   ii. Save on electricity
   iii. Reduce consumption

   A. i and ii **B.** ii and iii **C.** i and iii **D.** i, ii and iii

6. Which of the following are the most harmful greenhouse gases?

   A. CH_4 and O_2 **B.** CO_2 and O_2 **C.** CH_4 and CO **D.** CH_4 and CO_2

7. Global warming has many effects on the world around us, including...

   i. Increased incidence of floods
   ii. Increased incidence of dengue
   iii. Increased incidence of droughts
   iv. Increased incidence of tsunamis and earthquakes

   A. i, ii and iii **B.** ii, iii and iv **C.** i, ii and iv **D.** i, iii and iv

8. Animals are also affected by global warming. Some of the signs we are already seeing include...
   i. Fewer corals worldwide
   ii. Decreasing number of penguins in the Antarctic
   iii. Polar bears losing the Arctic sea ice on which they depend to hunt for food

   A. i and ii **B.** ii and iii **C.** i and iii **D.** All of the above

9. Based on your knowledge, which of the following statements describe microplastics?
   i. Microplastics can be formed from plant matter in the sea
   ii. Microplastics are pieces of plastic that are less than 5mm in size
   iii. Microplastics can come from scrubs used in some cosmetic products
   iv. Microplastics can be formed by fragmentation of plastic products in UV light

   A. i, ii and iii **B.** ii and iv **C.** i and iv **D.** ii, iii and iv

10. Which of the following contributes to global warming?
   i. Marine litter
   ii. Deforestation
   iii. Solid waste in landfills
   iv. Use of electrical items

   A. i, ii and iii **B.** ii, iii and iv **C.** i, ii and iv **D.** i, iii and iv

ANSWER SCHEME

ACTIVITY

The video will show how litter from land enters the sea, contributing to marine litter. It will also show how marine litter is harmful to marine life. Before watching the video, ask your students some questions to gauge their understanding of marine litter such as:

a. Where does marine litter come from?
b. Who is responsible for marine litter?
c. Propose one solution to solve the problem of marine litter.
d. Organise a campaign and Gallery Walk on how to reduce marine litter.

After the video, ask them what we can all do to reduce marine litter. Make sure they understand that marine litter is caused by human action (littering), and that they have a role in reducing marine litter; by not littering.

Objectives:

a. For students to understand the causes and effects of marine litter.
b. For students to realise that humans cause marine litter by littering and that each one of us has a role to play in reducing marine litter.

Question 1 – A
Sustainability is about ensuring we are able to meet our current needs without affecting the ability of future generations to meet their needs

Question 2 – C
In this question, (A), (B) and (D) are to do with man's actions and are causes of environmental issues, whereas (C) is an effect of our actions, i.e. global warming.

Question 3 – D
People on beaches for recreational reasons could litter, and if they did litter would almost certainly end up in the sea. Litter from drains/rivers that empties out into the sea is one of the most common sources of marine litter. Illegal dumping is another source of marine litter.

Question 4 – D
All sorts of waste are found in the sea, among the most common being fishing nets and food wrappers/ containers.

Question 5 – C
The most important way we can reduce both our personal carbon footprint and marine litter is to consume less as all purchased products carry a carbon footprint; and the more we buy, the more likely we are to litter.

Question 6 – D
Carbon dioxide (CO_2) and methane (CH_4) are among the most common harmful GHGs. Carbon monoxide (CO) is a very weak GHG, while oxygen (O_2) is not a GHG.

Question 7 – A
Global warming causes increased rainfall and therefore floods; climate change causes droughts and warmer weather where certain mosquitoes such as aedes can thrive in, hence increasing the incidence of dengue. Earthquakes and tsunamis, on the other hand, are caused by movements of plates in the Earth's crust.

Question 8 – D

With global warming, sea temperatures are rising causing polar ice caps to melt. This rise in sea temperature is also causing a depletion of fish and plankton, both primary food source for the polar bears and penguins. Warmer weather on land is decreasing the quality of birds breeding grounds whilst coral reefs are disappearing as they are sensitive to the rise in sea temperatures.

Question 9 – D

In 2016, NGO Greenpeace found that the tiny beads in face and body scrubs were made of microplastics. Since then, there has been a ban of microplastics in such products. However, it is possible that some products may still contain them.

Question 10 – B

Solid waste in landfills comprise primarily food and other organic solid waste which decompose, releasing CO_2 and CH_4. As a result of deforestation, we lose trees that would otherwise help to absorb CO_2 for use in photosynthesis. To generate electricity, fossil fuels are burnt, releasing CO_2.

2.0 | SUSTAINABILITY & THE WAY WE LIVE

Key Messages:

1. Our lifestyle of consuming products and disposal of solid waste generated is damaging to the environment.
2. Littering is a key challenge in managing solid waste.
3. We can reduce our negative impact on environmental sustainability by managing solid waste responsibly.

LEARNING STANDARD

At the end of this chapter, each student is able to:
- Practise proper waste disposal behaviours.
- Reason out the importance of consuming products wisely.

2.1 | PRODUCTS IN OUR LIVES

A typical day in our lives

From the time we get up till we go to sleep, we use many products – so many that if we were asked to list them all, we probably would miss out a lot of the products.

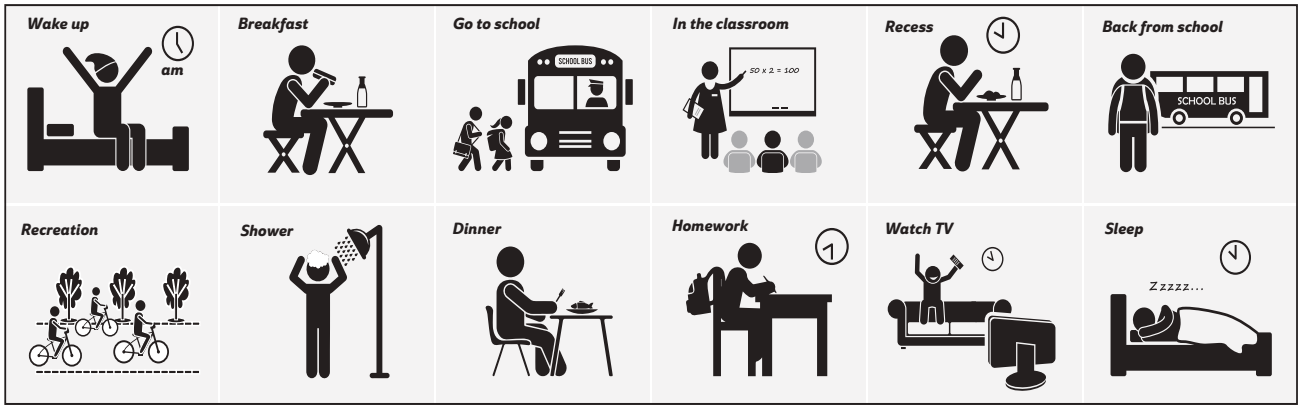
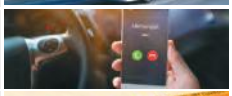


Figure 1: Daily activity

Here's a quick look at some products we use daily:

Table 1: Products in our daily lives

Type	Product example	
Personal hygiene products	Toothpaste & toothbrush, soap, shampoo & conditioner	
Personal grooming products	Hair gel, brush/comb, hair dryer, deodorant/powder	
Clothes and shoes	T-shirt, shirt, jacket, trousers, skirt, dress, sarong, sports outfits, slippers, sandals, covered shoes	
Food and drinks	Coffee, tea, milk, cereal, rice, bread, meat, vegetables, fruit, soft drinks	
Appliances	Kettle, fan, air conditioner, water heater, washing machine, dishwasher, vacuum cleaner, mop, broom	
Transportation	Car, bicycle, bus, motorbike	
Communication and entertainment devices	Mobile phone, television, computer/laptop	
School items	Book, pen, pencil, bag	

- Products have been developed to make our lives more convenient and comfortable.
- The materials used to make each product, such as paper, plastic and aluminium, are carefully chosen to suit their functions and applications.
- The convenience provided by product is invaluable, however excessive consumption has its consequences.

2.2 | A PRODUCT'S LIFESPAN

There are two broad categories of products – products that have a long lifespan and those with short lifespans.

Table 2: Products based on lifespan

Long Lifespan	Books, computers, televisions, cars, machines, equipment and others				
Short Lifespan	Personal hygiene and grooming products, food, drinks, stationeries and others				

- We tend to buy more items with short lifespans because these run out quickly and need to be replaced.
- Therefore, most of our waste comprise such products. In general, the more we buy, the more waste we generate.
- All products that we use will end up as solid waste. We need to manage the waste to ensure environmental sustainability.

PRODUCT USAGE FLOW

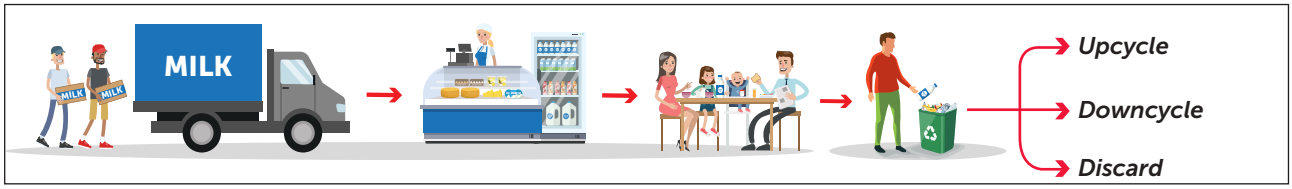


Figure 2: Product usage flow

Figure 2 illustrates the usage flow of milk products from distribution to retailer, consumer and disposal. It is important to use a bin for disposal to avoid littering and protect the environment.

2.3 | LITTERING

One of the challenges in managing solid waste is human behaviour, particularly littering and excessive wastage.

What is littering?

Littering is waste disposed of irresponsibly.

How it affects the environment?

Littering has many negative effects on the environment:

- It attracts pests such as rats, cockroaches and flies which spread many types of diseases.
- It blocks drains and rivers, causing floods.
- Litter can end up in drains and rivers, eventually flowing into the sea where it adds to marine litter.

Tips to manage your waste

- When outdoors and there are no trash cans around, store your trash and dispose of it when convenient.
- For long trips, keep a spare garbage bag in your car. Discard the garbage at your destination.

2.4 | EXCESSIVE WASTAGE

What is excessive waste?

- Excessive wastage results from excessive consumption.
- This entails buying things we want rather than need.

How it affects the environment?

- The more products we use, the more waste we generate.
- Our landfills have finite capacity; they cannot accommodate limitless quantities of waste.
- Also, decomposing waste in landfills emit GHGs.

Tips to reduce consumption

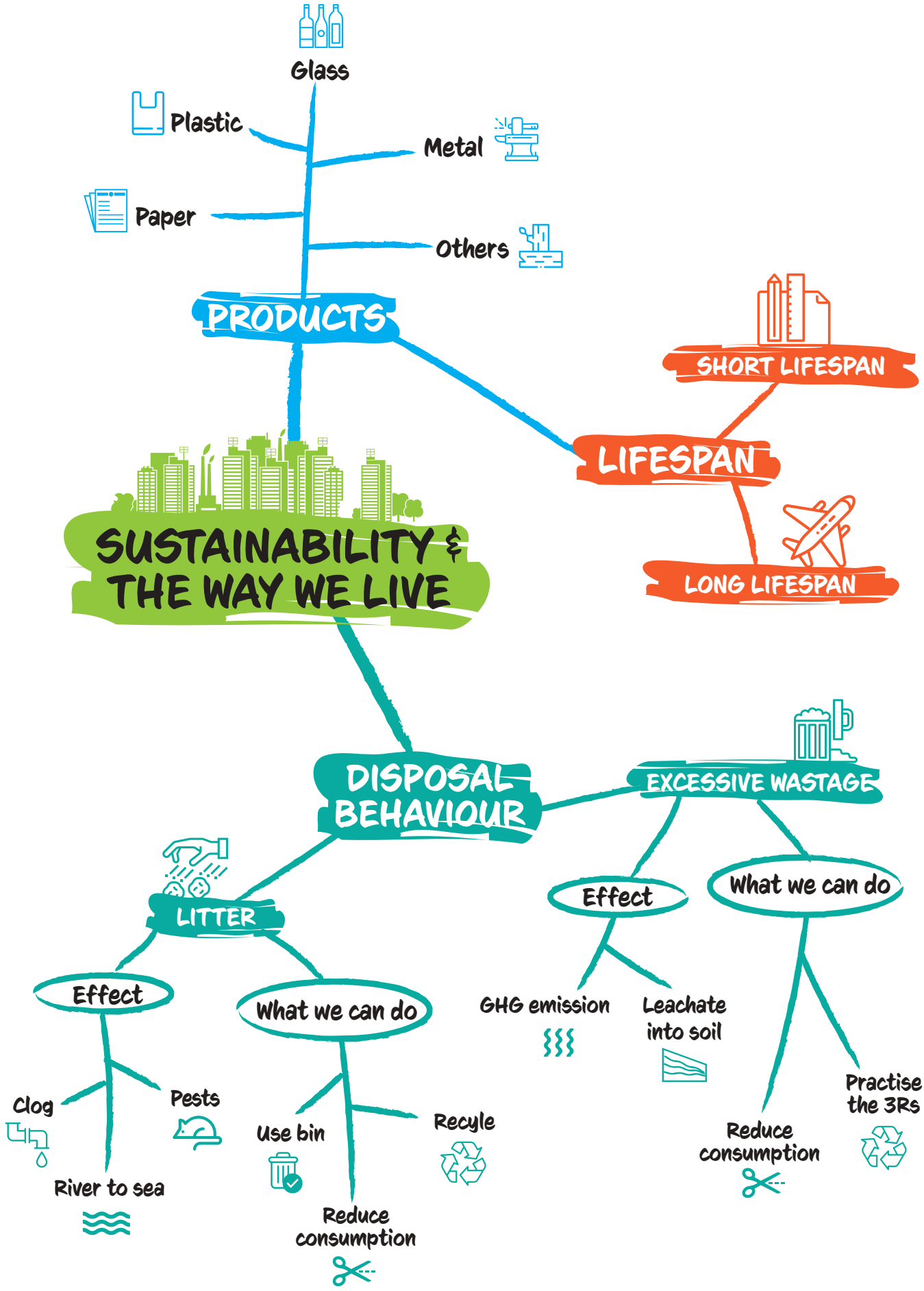
- Only buy products that you really need.
- Look after your belongings wisely so that they last, and don't need to be replaced sooner than necessary.
- Do not be influenced by the latest trends and make unnecessary purchases.

Myth:#2

Plastic bottles can cause cancer.

Fact:

Plastic packaging used in food contact applications are safe and have been approved by the Malaysian Food Act 1983, Malaysian Food Regulation 1985 and the US Food and Drug Administration (FDA).


Glass
Plastic
Metal
Paper
Others
PRODUCTS
SHORT LIFESPAN
LIFESPAN
LONG LIFESPAN
SUSTAINABILITY & THE WAY WE LIVE
DISPOSAL BEHAVIOUR
EXCESSIVE WASTAGE
LITTER
Effect
What we can do
Clog
Pests
River to sea
Use bin
Recyle
Reduce consumption
Effect
What we can do
GHG emission
Leachate into soil
Reduce consumption
Practise the 3Rs

WORKSHEET

ACTIVITY

Ask each student to write down a statement starting with "If I ......" to describe something he/she can do which has a positive effect on the environment.

Example: "If I turn off the tap when I brush teeth, I will save a lot of water." Put all their statements in a box and teacher reads out the statements randomly. Teacher discusses each point with students to decide which of the statements help reduce global warming and marine litter.

Note: Teacher should encourage the students to classify the different statements, based on global warming and marine litter. Together, the class should decide on what actions can be taken to reduce the impact of global warming and marine litter.

Questions

1a. There are so many products out there, and what we choose to buy makes a difference to the ..... environment. Which of the following should guide your purchasing behaviour?

i. Choose products with long lifespans over short lifespans

ii. Only choose expensive products because they are better, and will last longer

iii. Always choose the cheapest products because they are the most economical

iv. Buy locally-made products (especially food) as much as possible because they have lower carbon footprints

A. i and iii **B.** ii and iii **C.** i and iv **D.** i, ii and iii

1b. When you are out shopping, you buy only what you need.
Explain your action.

Figure 1

2a. Referring to Figure 1, when you go on a picnic and see someone litter, what can you say to convince the person to pick up the litter and throw it away in a bin?

i. Littering can add to marine litter

ii. Littering adds to carbon emissions

iii. Littering can deplete the ozone layer

iv. Littering can cause the spread of diseases

A. i and ii **B.** ii, iii and iv **C.** i, ii and iv **D.** i, ii and iii

2b. When you're spending the day at the seaside or waterfall, what should you do to ensure you do not litter?

i. Take along a plastic bag or bin liners for your rubbish
ii. Separate and throw away your rubbish in different bags if possible
iii. Leave the rubbish at the site for the local authorities to collect and dispose of
iv. Take the rubbish home with you and dispose of appropriately, in recycling and non-recycling bins

A. i and ii **B.** i, ii and iii **C.** i, ii and iv **D.** All of the above

3. Most of us are guilty of overconsumption. This can result in .....

i. Increase in GHGs
ii. Increase in marine litter
iii. Decrease in food wastage
iv. The need for more landfills

A. i and iv **B.** iii and iv **C.** i and iii **D.** i, ii and iv

4. To protect the environment, we can try to reduce the amount of waste we produce by .....

i. Only buying what we need
ii. Reusing or recycling products
iii. Looking after our belongings properly
iv. Throwing away our rubbish into proper bins

A. i and ii **B.** ii and iii **C.** i and iii **D.** i, ii and iii

ANSWER SCHEME

ACTIVITY

This activity will get students to think about how they can contribute to a healthier environment. By categorising their actions into two columns – one that will help marine litter; another that will help global warming – you are also helping them to have a better grasp of the causes of these two key environmental issues.

Objectives:

a. ***To create awareness of simple daily actions that will have a positive impact on the environment.***
b. ***To create awareness of human behaviours that cause marine litter and global warming.***

Question 1a – C

The price of a product does not always correlate with quality or how long it will last. Choosing products that will last means buying less over a period of time. And choosing local products is good because these will have smaller carbon footprints compared to imported products which have to be transported to Malaysia by plane or ship.

Question 2a – C

Litter attracts pests such as rats, flies and cockroaches which spread many different types of diseases. It can also add to carbon emissions, because food waste will emit CO_2 as it decomposes. We have seen how litter gets into drains and rivers and then enters the sea.

Question 2b – C

The most responsible way to handle your rubbish when there is no rubbish bin is to take it away with you so you can dispose of it properly at home or anywhere else in proper bins. Everyone is responsible for your own waste and should not depend on the local authorities, therefore any rubbish left at such sites will just stay there and pollute the environment.

Question 3 – D

The more we buy, the more we have to throw away. Our waste will either enter landfills (causing them to overflow eventually), or end up as litter. If we buy too much food, this will also end up as waste (i.e. food waste). Food waste and other organic waste in landfills contribute to GHGs.

Question 4 – D

Throwing away rubbish adds to waste.

3.0 | WHAT IS PLASTIC

Key Messages:

1. Plastic is an organic compound derived from crude oil and/or natural gas.
2. There are many different types of plastic with different properties, making plastics versatile for use in various applications.

LEARNING STANDARD

At the end of this chapter, each student is able to:

- Elaborate on the raw materials used and explain the process of making plastic.
- Explain with examples about the different types of plastic which are suitable for different products.

Did you know?

"Plastic is the term commonly used to describe polymers."

Plastic comes mainly from crude oil and natural gas, but it can also come from plants, e.g. cellulose acetate from cotton and wood pulp, and polylactic acid from corn. There are many different plastics, depending on the type of monomers and their structural arrangement. Examples of monomers include ethylene, styrene, propylene, vinyl chloride and others.

Figure 1: Plastic compounds and products made from plastic

3.1 | HOW POLYMERS ARE MADE FROM CRUDE OIL AND NATURAL GAS IN MALAYSIA

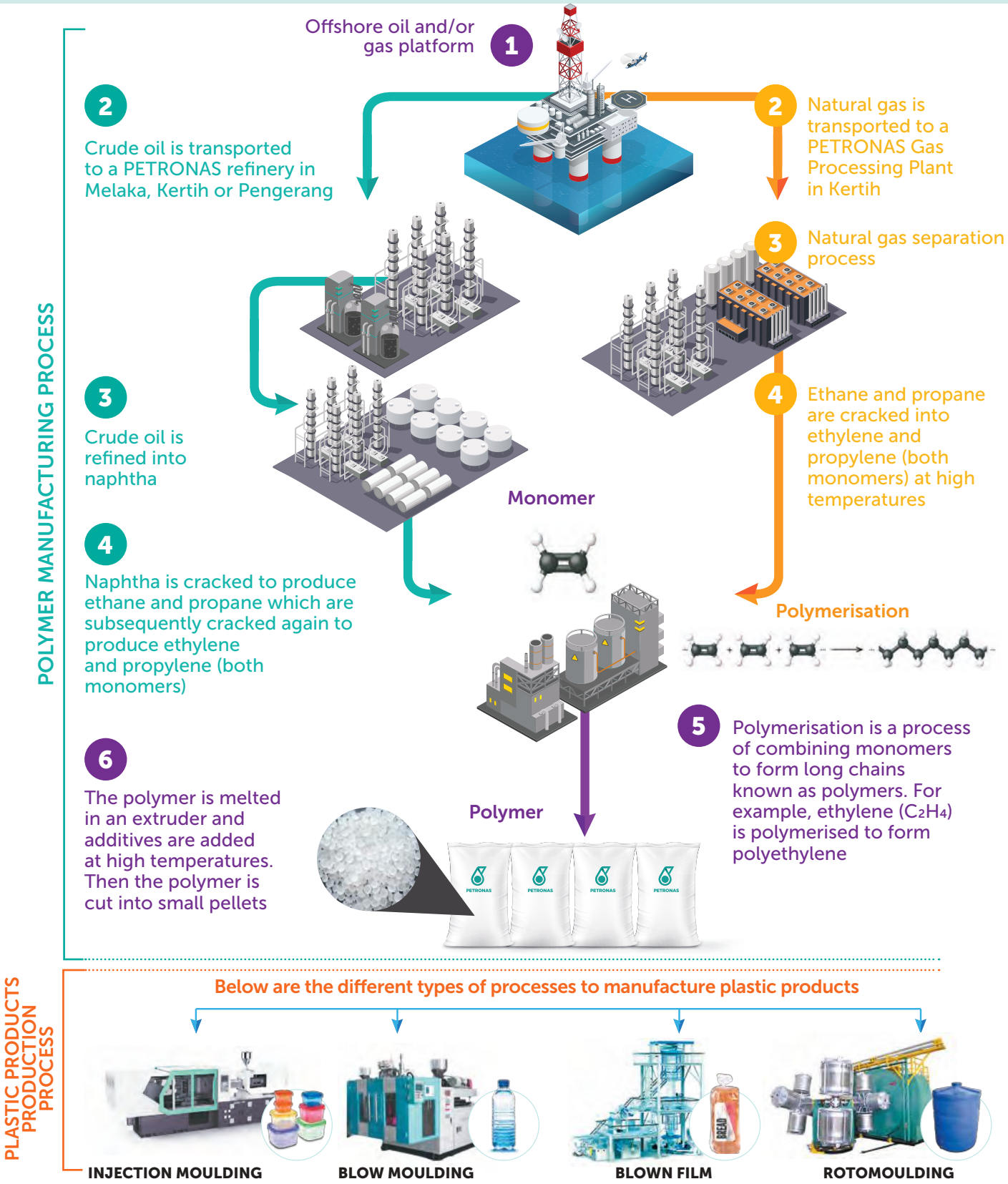


Figure 2: Process flow of plastic products made from crude oil and natural gas

MELT INDEX (MI)

Melt index (MI) is a measure of the ease of flow of polymers. Water flows more easily than sauce, so the MI of water is higher than that of sauce. The same goes for polymers. Each polymer has a different MI value, based on its molecular structure morphology.

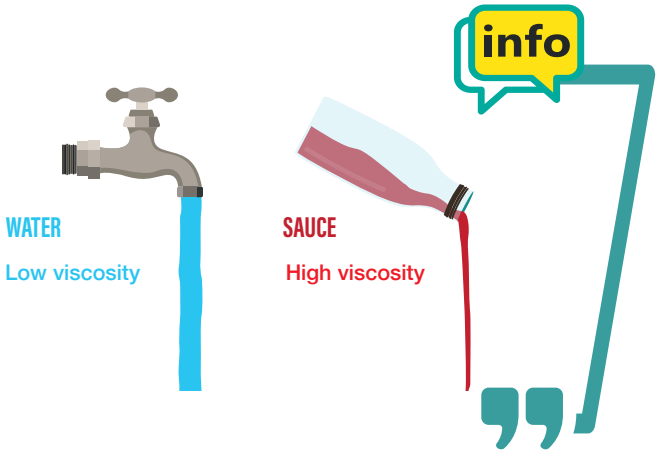
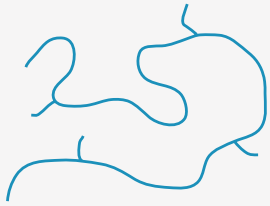


Figure 3: Simple MI analogy

3.2 | DIFFERENT POLYMERS AND THEIR PROPERTIES

There are different forms of polyethylene with different densities and applications

Table 1: Types of polyethylene based on density and application

Properties	Low Density Polyethylene (LDPE)	Linear Low Density Polyethylene (LLDPE)	High Density Polyethylene (HDPE)
Molecular structure morphology			
Density (g/cm³)	0.917 - 0.925	0.917 - 0.939	>0.940
Applications	Food packaging, insulation, bags, laminations, coatings, stretch film	Food packaging, insulation, heavy duty bags, sheets, stretch films, toys, bank notes, food containers	Shopping bags, trash bags, ducting, insulation, bottles

There are different forms of polyethylene with different stiffness and toughness

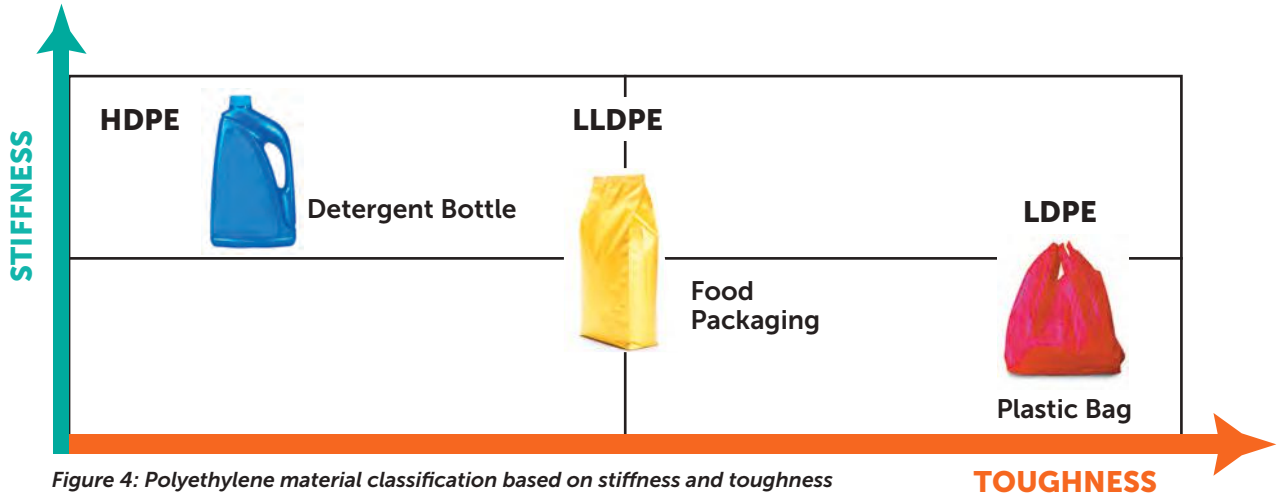


Figure 4: Polyethylene material classification based on stiffness and toughness

There are different types of polypropylene with different characteristics and applications

Table 2: Types of polypropylene based on characteristic and application

Type of polypropylene	Characteristic	Main application	End product
Homopolymer	High rigidity Excellent chemical resistance	Films, cups	
Random Copolymer	High flexiblity Good optical clarity Medium rigidity	Food containers, caps and closures	
Impact Copolymer	High impact strength Opaque	Automotive parts	

There are different types of polypropylene with different stiffness and toughness

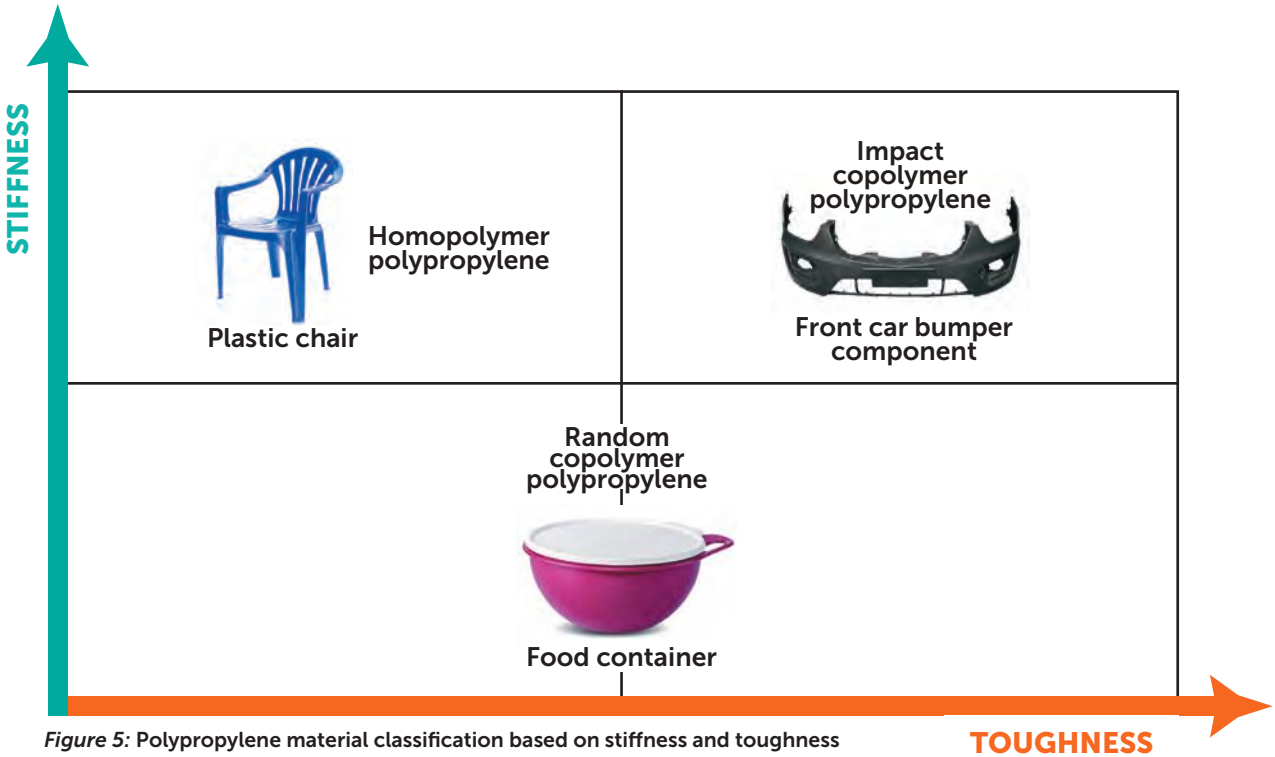
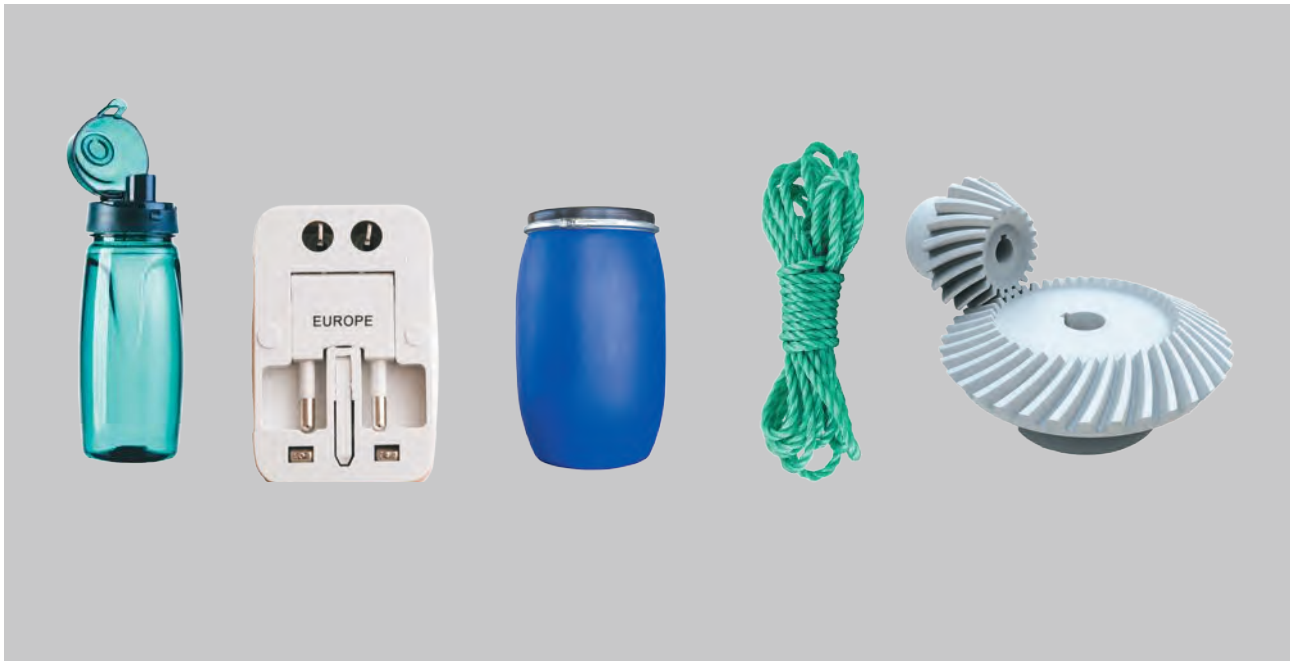


Figure 5: Polypropylene material classification based on stiffness and toughness

3.3 | POLYMER CLASSIFICATION



There are two different types of polymer: Thermoplastic and thermoset

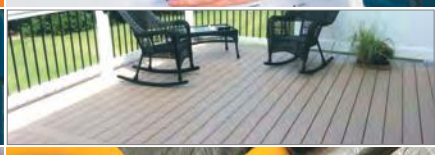
Table 3: Thermoplastic and thermoset

	Thermoplastic	Thermoset
Characteristics	• Will soften when heated • Can be reshaped	• Will not soften when heated • Cannot be reshaped
Examples	• Polyethylene (PE) • Polypropylene (PP) • Polyvinyl chloride (PVC) • Polystyrene (PS) • Polyethylene terephthalate (PET)	• Epoxy resins • Polyurethane • Phenol formaldehyde • Melamine/Urea formaldehyde • Bakelite

Types of thermoplastics

There are seven main categories of thermoplastics. Products made from thermoplastics carry the triangle recycling logo with a number code indicating the polymer they are made of. This code is to make the recycling process easier. Only plastics with the same code can be mixed together before being recycled. When you see the recycling logo on a plastic item, make sure you recycle it rather than bin it.

Table 4: Types of thermoplastics

Type of plastic	Code	Uses	Can be recycled into...
Polyethylene Terephthalate (PET/PETE)	1 PETE		
High Density Polyethylene (HDPE)	2 HDPE		
Polyvinyl Chloride (PVC/V)	3 PVC		
Low Density Polyethylene (LDPE)	4 LDPE		
Polypropylene (PP)	5 PP		
Polystyrene (PS)	6 PS		
Others – acrylics, polycarbonates, polylactic fibres, nylon, etc.	7 OTHER		

Types of thermosets

Thermosets possess linear and cross-linked chains that make their molecule bonding even stronger. These cross-linked bonds between molecules prevent them from sliding resulting in structures that are strong and hard to melt.

Table 5: Types of thermosets

Thermoset	Uses	
Melamine/Urea formaldehyde	Plates, glue	
Phenol formaldehyde	Brake pads and brake shoes (for cars), clutches	
Polyurethane	Foam for cushions	
Epoxy resin	Furniture coating	

Thermoset and thermoplastic share common charateristics such as being lightweight, flexible and having good thermal and chemical resistance.

info

WHAT IS BIOPLASTIC?

A plastic material is defined as a bioplastic if it is biobased.

- ***'Biobased'*** means the material or product is at least partly derived from plants, such as corn and sugarcane.
- Bioplastics can be either biodegradable or non-biodegradable.
- For biodegradable plastic to degrade, it must be exposed to specific control conditions, involving ***oxygen, bacteria and temperature.***
- Non-biodegradable plastic has to be sent for recycling.
- No matter which plastic you use, you need to manage it properly. Do not litter.

	Biobased	Fossil-based
Non-Biodegradable	*Non-Biodegradable and Biobased* e.g. Biobased PE, PET, PA, PTT	*Conventional plastics* e.g. PE, PP, PET
Biogradable	*Biodegradable and Biobased* e.g. PLA, PHA, PBS, Starch blends	*Biodegradable and fossil-based* e.g. PBAT, PCL

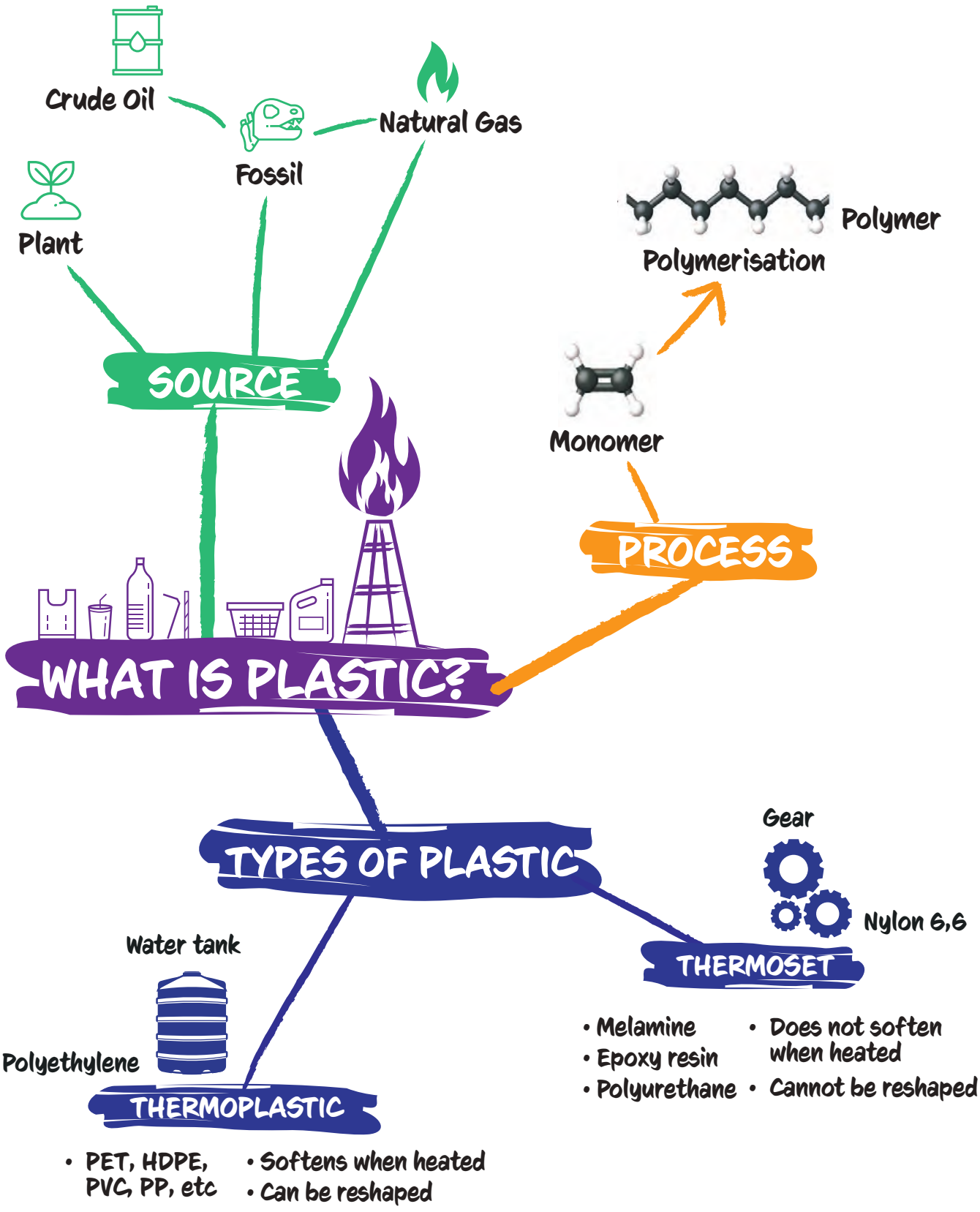
Myth:#3

Biodegradable plastic is environmentally friendly because it can decompose.

Fact:

Biodegradable plastics require the presence of bacteria, oxygen and high temperature to degrade. These conditions are only made available in industrial composting sites. Unfortunately, degradation does not happen in landfills.

Watch video at ' MENU > RESOURCES > REFERENCES ' in the interactive module to learn more about the degradation process and its effect on global warming.


Crude Oil
Natural Gas
Fossil
Plant
SOURCE
Polymer
Polymerisation
Monomer
PROCESS
WHAT IS PLASTIC?
TYPES OF PLASTIC
Gear
Nylon 6,6
THERMOSET
• Melamine
• Epoxy resin
• Polyurethane
• Does not soften when heated
• Cannot be reshaped
Water tank
Polyethylene
THERMOPLASTIC
• PET, HDPE, PVC, PP, etc
• Softens when heated
• Can be reshaped

WORKSHEET

ACTIVITY

Share the video "Plastic & You" and show the process flow of how plastic products are made. Then discuss and ask students to draw the process flow.

Note : Retrieve the video from "VIDEO" folder located in the USB flash drive.

Questions

1. What is plastic?
   i. Plastics are inorganic compounds
   ii. Plastics can be made from plant sources
   iii. Plastics are made from crude oil and natural gas
   iv. Plastics are strong, durable and can be moulded into any shape

   A. i, ii and iv
   B. i, ii and iii
   C. ii, iii and iv
   D. All of the above

2. Nowadays, bioplastic can be easily obtained. Bioplastic is a type of plastic, which is .....

   A. Environmentally friendly
   B. Made entirely from plant sources
   C. Derived at least in part from plants
   D. Will decompose under normal conditions

Figure 1

3. Figure 1 shows a carrier bag made of polyethylene and classified as thermoplastic. Superglue is made from urea formaldehyde, and is classified as a thermoset.

   What do you understand about the differences between products made from thermoplastics and those made from thermosets?
   i. Thermoplastic products are softer than those made of thermosets
   ii. Thermoplastic products can be reshaped; those made of thermosets cannot
   iii. Thermoplastic products will soften when heated; those made of thermosets will not

   A. i and ii
   B. i and iii
   C. ii and iii
   D. All of the above

4. Which of the following statements indicates the properties of thermoset?

   A. Thermosets can be recycled
   B. Thermosets are not reversible
   C. Thermosets will melt when heated
   D. Thermoset will blow up when in contact with water

Figure 2

5. Polymers are made from repeated monomers. Grocery bags are made from polyethylene. What do you understand about polymers?

   i. A polymer can be made from different types of monomers
   ii. The density and molecular structure of polymers determine their properties
   iii. Monomers combine to form polymers under specific temperatures and pressure

   A. i and ii
   B. i and iii
   C. ii and iii
   D. i, ii and iii

6. Which of the following statements describes Figure 3?

   i. The higher the density of a polymer, the higher its MI
   ii. The melt index (MI) measures how easily melted plastics flow
   iii. The more branching there is in the molecular structure of a polymer, the less dense it is

   A. i
   B. i and ii
   C. i and iii
   D. ii and iii

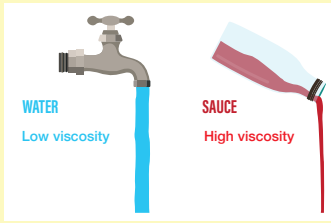


Figure 3

7. **Figure 4 shows several logos.**

Figure 4

What is the significance of the number that you can find on plastic products?

i. It indicates the polymer the plastic is made of.
ii. Only plastic of the same number can be recycled together.
iii. The higher the number, the better the quality of the plastic.
iv. It indicates the number of times that the product can be recycled.

A. i and ii
B. i, ii and iii
C. i, iii and iv
D. ii, iii and iv

8. Figure 5 shows a landfill full of biodegradable plastic. Which of the following are true regarding biodegradable plastic in landfills?

   i. Biodegradable plastic will react similarly to conventional plastic

   ii. Biodegradable plastic will not decompose before the end of the landfill's lifespan

   iii. Biodegradable plastic are environmentally friendly and will decompose in the landfill

   A. i

   B. i and ii

   C. i and iii

   D. ii and iii

Figure 5

9. Table 1 shows several types of polymers and their characteristics. Fill in the third column with an appropriate product.

Polymer	Characteristic	Product
High-density polyethylene; HDPE	Very rigid and recyclable	
Low-density polyethylene; LDPE	Very stiff and recyclable	
Linear low-density polyethylene; LLDPE	Medium stiffness and recyclable	
Polyethylene terephthalate; PET	Very flexible and recyclable	

Table 1

10. Put in the correct order according to the process of producing plastic.

    i. Cracker

    ii. Refinery

    iii. Oil Platform

    iv. Polymer plant

    A. iii, i, ii, and iv

    B. iii, ii, iv and i

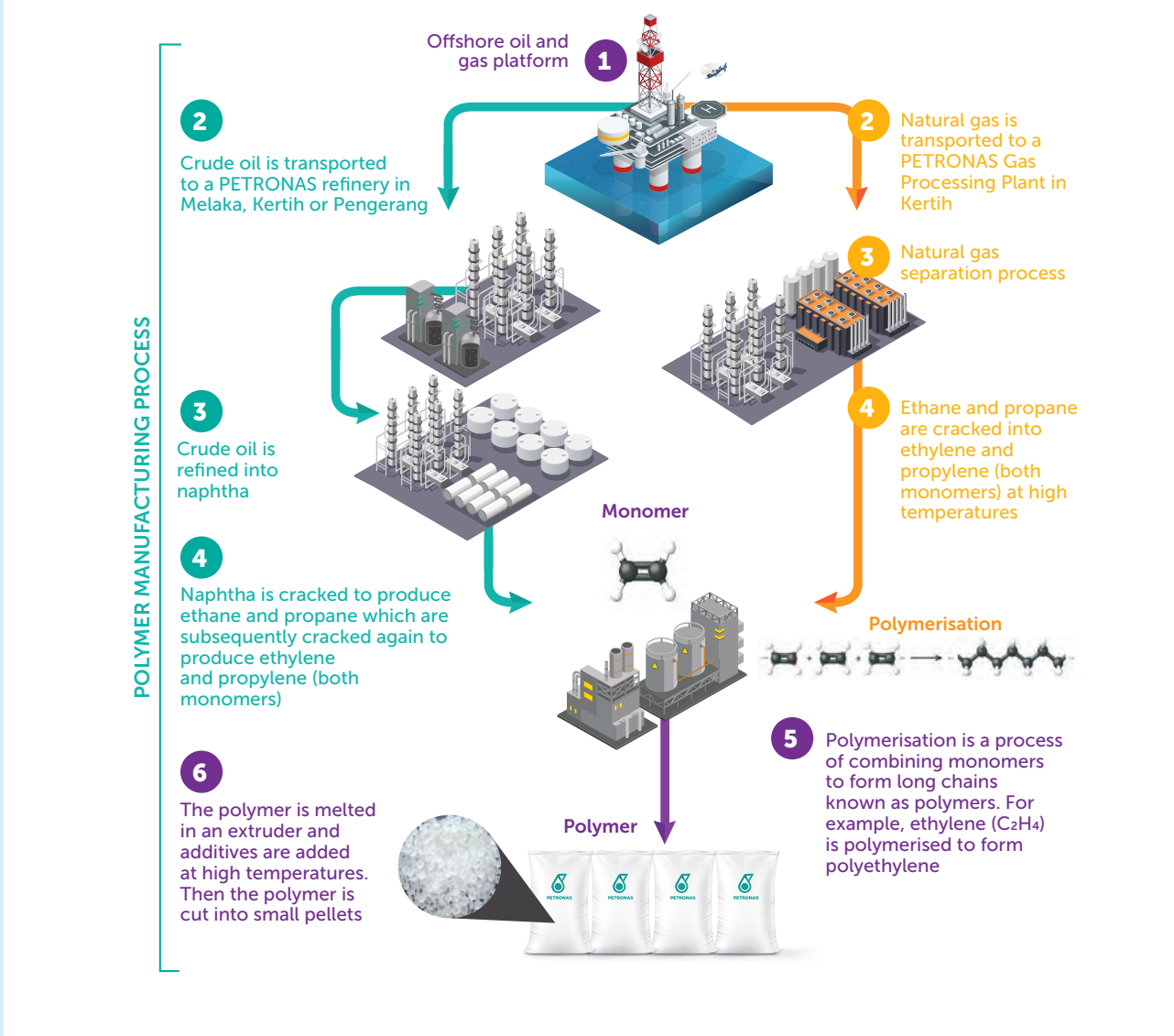
    C. iii, ii, i and iv

    D. iii, iv, i and ii

ANSWER SCHEME

ACTIVITY

This activity will help students understand the process of making plastic from crude oil and natural gas. Ask several questions to gauge the students' understanding of how plastic is made. For example; what are the natural resources used to make plastic?



Process flow of plastic products made from crude oil and natural gas

Objective:
To provide student with a clear understanding of what is plastic and how it is made.

Question 1 - C

Plastic is an organic compound because it is made from organic raw materials, i.e. crude oil, natural gas, coal and plant components. It is also commonly used in different applications because it is strong, durable and can be moulded into almost any shape. Therefore, only statement (i) is not true.

Question 2 - C

Bioplastics are made at least in part (not necessarily entirely) from plants. They are biodegradable, but only in the presence of O_2 and microbes at high temperatures, i.e. they will not decompose under normal conditions.

Question 3 - C

Some thermoset products – such as superglue – can be soft. However, once set, a thermoset will not soften at normal fire temperatures; they will only soften once their inter-molecular bonds are broken at very high temperatures. Because their physical structure changes when they soften (at very high temperatures), they cannot be reshaped.

Question 4 - B

When a thermoset is heated it will not return to its original form due to the presence of cross-linked chains.

Question 5 - C

Question 6 - D

The more dense a polymer, the more viscous it is and the lower its MI.

Question 7 - A

The number code on a plastic product indicates the polymer it is made from. And only plastics made of the same polymer (bearing the same code number) can be recycled together. The code number has nothing to do with the quality of plastic or the number of times it can be recycled.

Question 8 - B

Biodegradable plastics can decompose, but only in the presence of O_2 and microbes at high temperatures. They will not, therefore, decompose in landfills under normal conditions; and behave like conventional plastics in landfills.

Question 9

Polymer	Characteristic	Product
High-density polyethylene; HDPE	Very rigid and recyclable	***Detergent bottle***
Low-density polyethylene; LDPE	Very stiff and recyclable	***Plastic bag***
Linear low-density polyethylene; LLDPE	Medium stiffness and recyclable	***Instant noodle wrapper***
Polyethylene terephthalate; PET	Very flexible and recyclable	***Drinking bottle***

Question 10 - C

The correct order is platform (where crude oil is drilled), refinery (where it is refined into naphtha), cracker (where the naphtha is cracked into ethylene and propylene) and polymer plant (where the ethylene and propylene is polymerised and then cut into pellets, ready to be used by plastic manufacturers).

4.0 | PLASTIC IN OUR DAILY LIVES

Key Messages:

1. Food packaging is used widely in our daily lives.
2. Its applications range from simple films to high-tech food packaging and high-precision engineering components.
3. One-third of all plastics are used in food packaging, which is environmentally friendly for everyday use.

LEARNING STANDARD

At the end of this chapter, each student is able to:

- Justify the use of plastic in different product applications.
- Reason out why plastic packaging e.g. plastic bags are actually more environmentally friendly than packaging made out of paper or cloth.

In the 1950s, more and more plastics began to be produced after World War II. Very quickly, plastic replaced traditional materials such as paper, glass, wood and metal in almost every area of our everyday life.

THE HISTORY OF PLASTIC INVENTIONS

1860

Developed cellulose known as celluloid to replace ivory in billiard balls

1872

Polyvinyl chloride (PVC) invented

1907

Bakelite invented from coal tar

1920

Gun powder led to the development of rayon which eventually led to the development of nylon

1930

Polystyrene was accidentally discovered from the natural resin of a Turkish Sweetgum

1938

PTFE, scientifically known as polytetrafluoroethylene, is used in cooking pans

1940

PVC is created and used in the production of toys

1941

Polyethyelene (PE) is invented

1950

First PE bag is commercially used in supermarkets

1965

Kevlar is invented in 1965 and commercialised for the sports industry in 1970. Later, used as bullet proof vest

1973

Polyethylene terephthalate (PET) is commercially used for water bottles

1980

First LDPE is invented, mainly for food packaging industry

1983

Polyether ether ketone (PEEK), a high performance polymer mainly used in medical applications e.g. prosthetics, dental, spinal cage & automotive industry e.g. gears

2000

First metallocene LLDPE (mLLDPE) is invented for food packaging industry

2001

Most commercial airplanes have been built using polymeric material for fuel efficiency

UNTIL NOW...

2009

First self-healing polymer is invented. Mainly used in engines, fuselage, aerostructures and coating

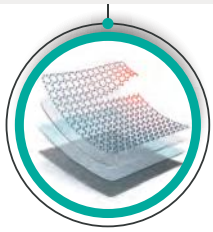


Figure 1: Evolution of plastic

4.1 | WHY WE USE PLASTIC

Lighter

Metals used previously in cars made them heavier than cars that use plastic components today. The lighter a car, the less fuel it consumes, making it more cost efficient and environment-friendly.

Barrier Properties

You will find plastic packaging on almost all fresh produce in supermarkets. This is because the barrier properties of plastic help to keep food fresh for longer periods, thus significantly reducing food waste.

Durable

Plastic tumblers last longer, and do not crack or break easily.

Thermal Insulation

Plastic ice boxes are more efficient than steel boxes. Plastic has better insulation properties to maintain food temperatures for longer storage.

Chemical Resistance

Plastic is chemically inert, corrosion-resistant and does not rust.

Flexible

A key property of plastic is its flexibility, meaning it can be moulded into any shape while maintaining its strength, making it ideal for manufacturers to produce complex shapes.

Figure 2: Products made from conventional materials and replaced by plastic

4.2 | APPLICATIONS THAT RELY ON PLASTIC

Plastic is used in seven main sectors.

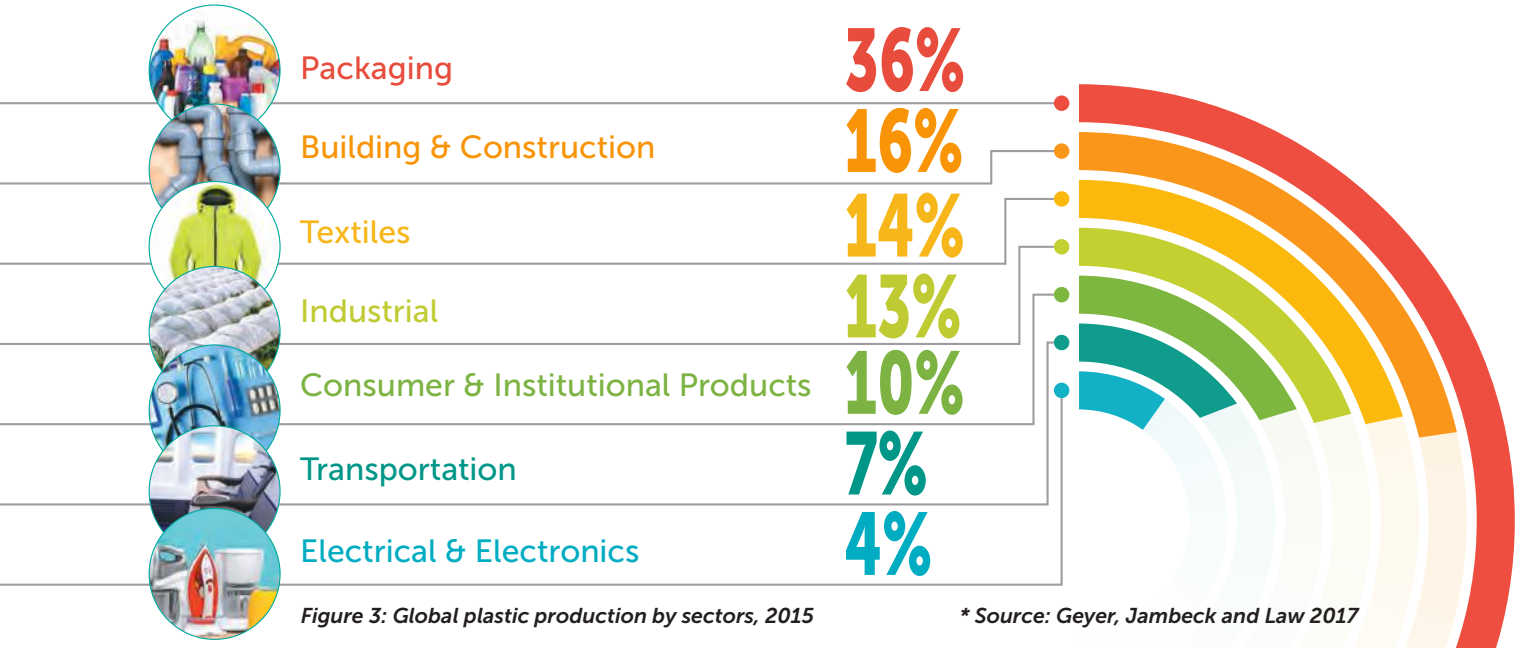


Figure 3: Global plastic production by sectors, 2015 ** Source: Geyer, Jambeck and Law 2017*

Figure 4: The various uses of plastic in daily life

Table 1: Plastic usage in various sectors

Sector	Benefits	
Packaging	- Plastic packaging helps to preserve food, keeping food fresh hence reducing waste - Food waste is a major issue in Malaysia, accounting for 44.5% of total solid waste generated in the country	
Building and Construction	- Plastic helps to maximise energy efficiency, durability and performance in buildings - All new buildings benefit from plastic damp-proof membranes. Cabling, piping and plastic insulation; fire-resistant doors, windows, cladding and drainage; and main water supply pipes are made from plastic	
Textiles	- Plastic is used to make various textiles because of its unique characteristics: flexible, durable, strong and waterproof	
Industrial	- Plastic is widely used in industries because of its strength and durability in natural surroundings	
Consumer and Institutional Products	- Plastic is used in syringes, blood bags and heart valves because it is inert, flexible and biocompatible	
Transportation	- Plastics have contributed to innovations in safety, performance and fuel efficiency in cars - In the last 15 years, lightweight plastic components in cars have increased from 3% to 11% leading to a 14% decrease in petrol consumption - Plastic is also used in other modes of transport such as trains, motorcycles, yachts and aircrafts because it is lighter than conventional materials	
Electrical and Electronics	- The low thermal conductivity and good electrical insulation properties of plastic makes it ideal for microwave ovens, computers, mobile phones, televisions and many other electrical products	

Did you know?

The use of just 1.5g of plastic film for wrapping a cucumber can extend its shelf life to 14 days, while selling grapes in plastic bags or trays has reduced in-store wastage of grapes by 20%.

**** Source: Advisory Committee on Packaging, UK***

Multi-layered packaging

- Most food and medical packaging today come in anything from 1 to 17 layers. This provides the packaging with excellent moisture/oxygen barrier properties while improving resistance to tears and punctures.
- Preventing the permeability of O_2, CO_2 and moisture in packaging is key to preserving the freshness of food for longer periods.

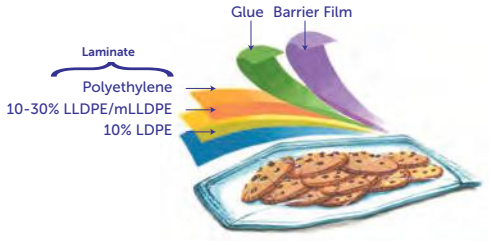


Figure 5: Food packaging has multiple layers to keep out oxygen and moisture

Did you know?

Because plastic packaging is light, it reduces the load on lorries needed to transport products, thus decreasing carbon emissions. Without plastic packaging, overall packaging weight would increase by 291% while the energy required for manufacturing would increase by 108%

****Source: Benefits of Plastics In Our Daily Life***

Other environmental benefits of food packaging

- Ten times more resources are used to distribute food than to make the packaging that protects it.
- Every time food is wasted, all the natural resources that went into producing it is wasted as well.

Did you know?

All the football jerseys used in the 2018 FIFA World Cup were made from recycled plastic. Each jersey comprised seven recycled 1.5L PET bottles

Source: NIKE

CASE STUDY

Plastic components used in aviation

One of the first applications of plastic components in aerospace was as a lining for fuel tanks during World War II. Since 1970, plastic usage in aerospace has quadrupled. Interior components like overhead compartments, components for navigational and propulsion functions, and structural elements can all be made out of plastic. Military aircraft also benefit from the use of plastics. They make the aircraft lighter, which extends flight range.

Advantages of plastic in aircraft

- *Plastic components can be as much as 10 times lighter than metal parts. For each kilogram of mass reduced, about USD1,000 is saved in fuel over the life of an airplane.*
- *Plastic components are generally more cost-effective to make.*
- *Plastic does not corrode as it is chemically inert.*

Source: http://www.craftechind.com/why-the-aerospace-industry-loves-plastic-materials/

4.3 | LIFE CYCLE ASSESSMENT (LCA)

Life Cycle Assessment (LCA) is a technique to assess the environmental impact associated with a product's life cycle from cradle to grave. Below are the LCAs of plastic bags and paper bags.

Figure 6: LCA process for paper bags

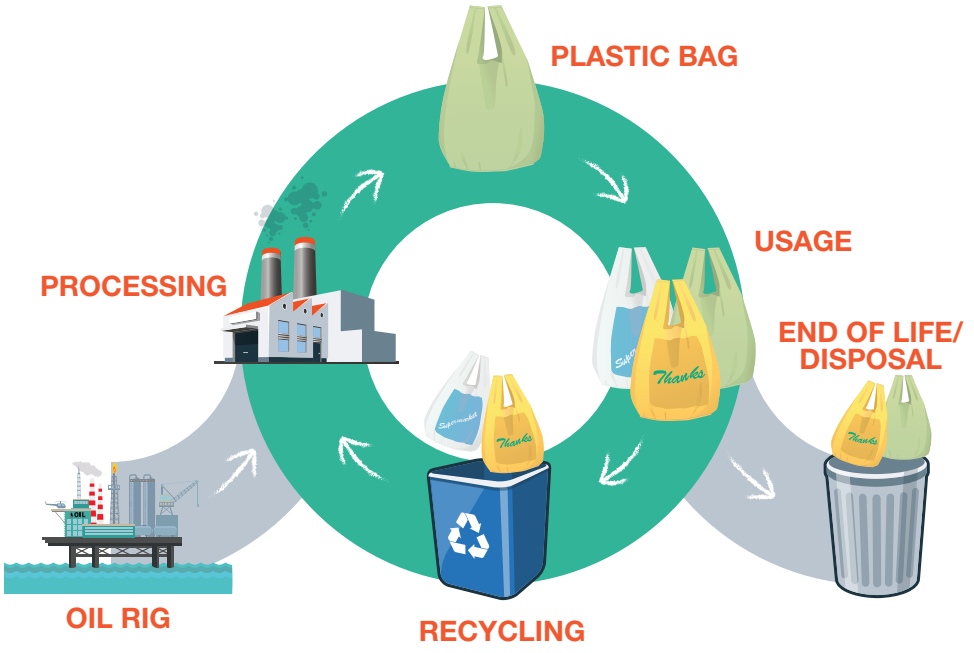


Figure 7: LCA process for plastic bags

LCA encompasses all processes and environmental releases beginning with the extraction of raw materials and the production of energy used to create the product through the use and final disposal of the end product.

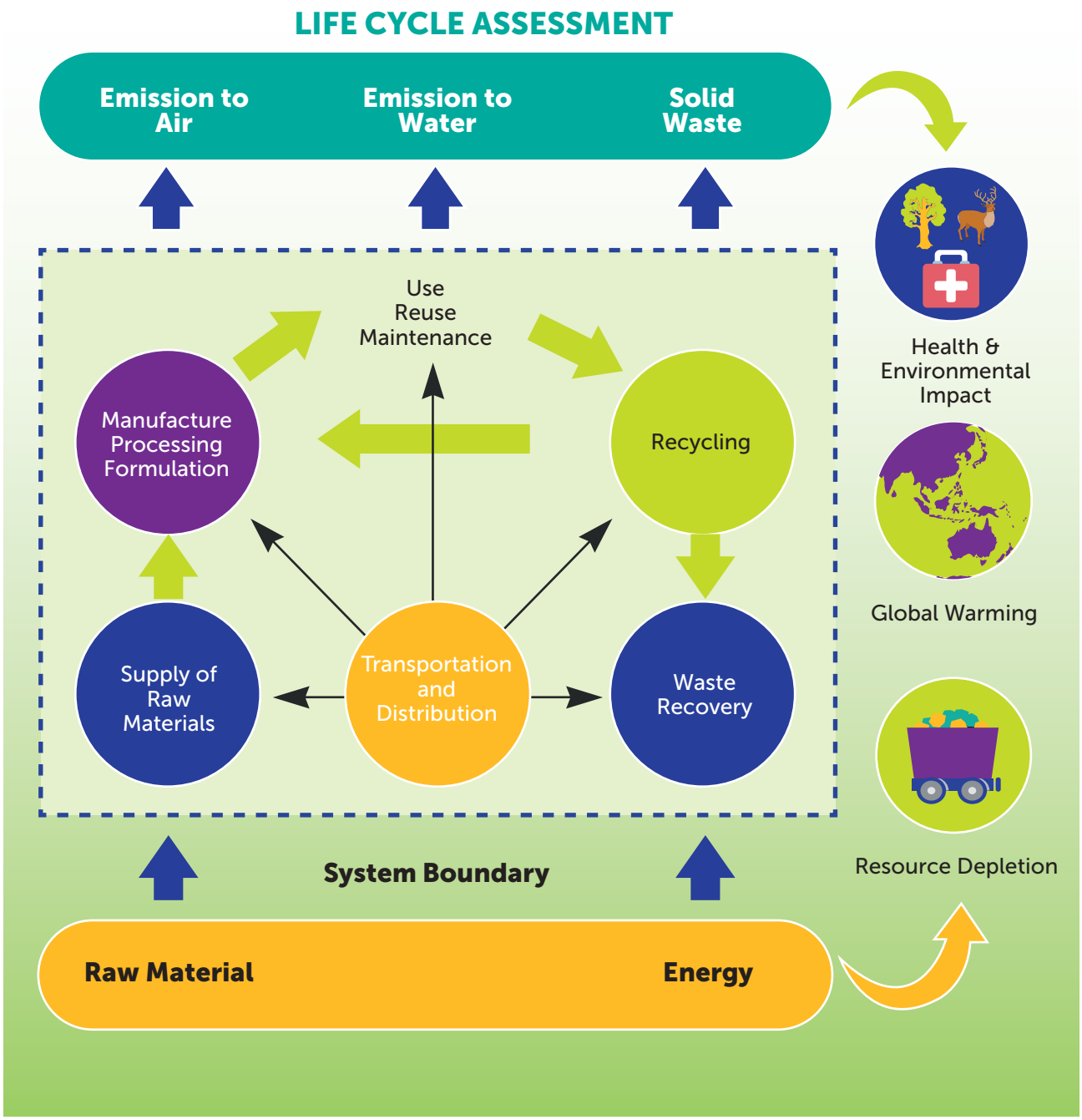


Figure 8: Life cycle assesment

Source: A Science-Based Decision Making: Using life cycle assesment and other scientific data to optimise packaging performance

The goal of LCA is to compare the full range of environmental effects assignable to products and services in order to improve processes, support policy and provide a sound basis for informed decisions.

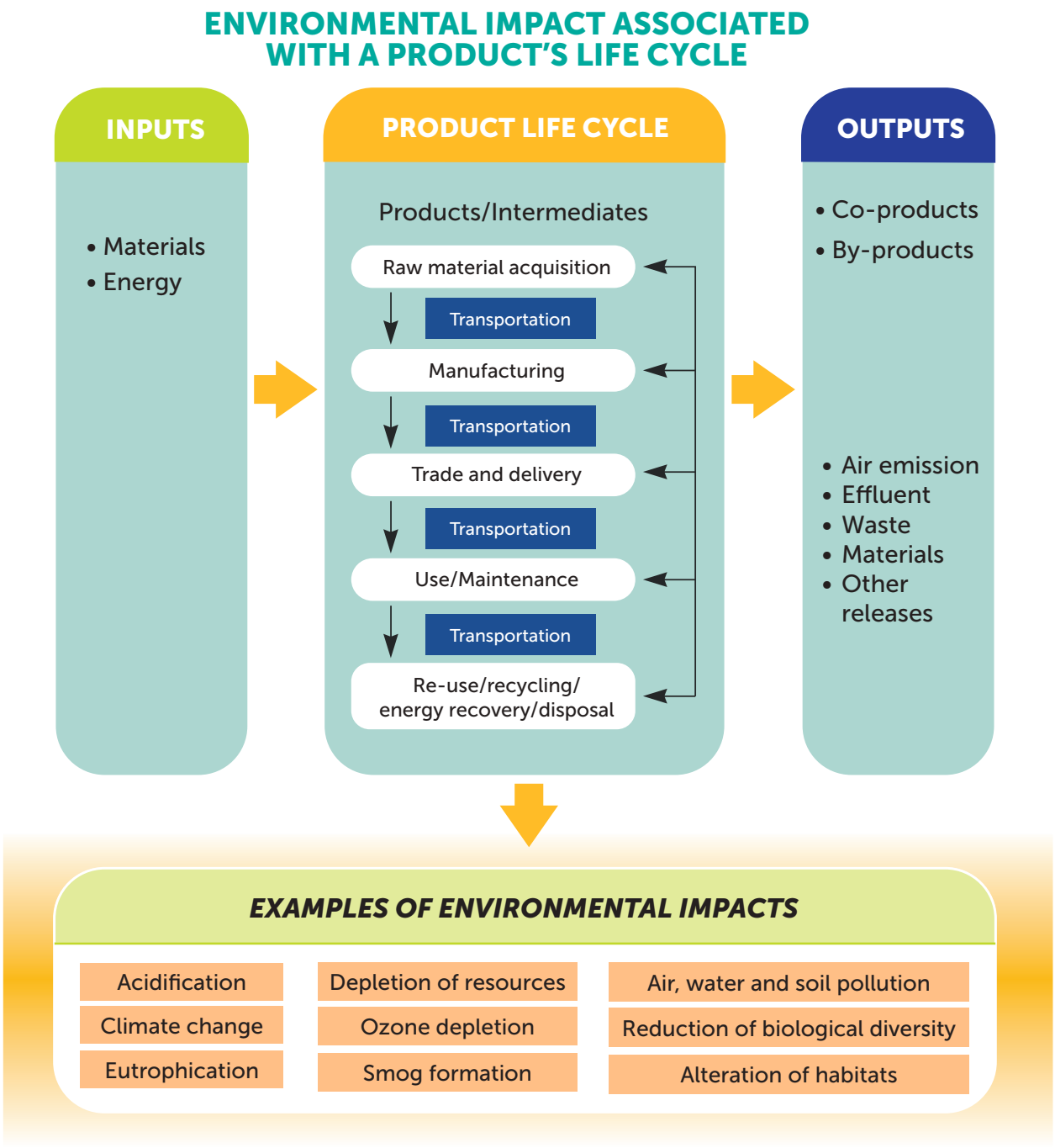


Figure 9: Product life cycle and environmental impacts *Source: ISO 14062*

The LCA of bags

Extensive comparisons have been made between plastic bags and bags made from other materials such as paper, cotton and jute, in terms of their carbon emissions. The uniformity of CO_2 is used to compare CO_2 emissions of various products.

Table 2: Comparison of CO_2 emissions for various types of bags

Bag Type		Average Bag Weight (g)	CO_2 Equivalent per 1kg of Bag	CO_2 Equivalent per Bag (kg)
HDPE Vest Carrier grocery bag		8.12	1.578	0.0128
Oxo-Degradable Vest Carrier		8.27	1.750	0.0145
Starch Based Biodegradable Vest		16.49	4.184	0.0690
Paper Bag		55.2	5.525	0.305
LDPE 'Bag for Life'		34.94	6.924	0.242
Non Woven PP Bag		115.83	21.510	2.491
Woven PP Bag		120	23.088	2.770
Cotton Bag		183.11	271.533	49.720
Jute Bag		190	273.111	51.891

Source: Life cycle assesment of supermarket carrier bag report SC030148, Environment Agency, UK

Based on a comparison of mass, HDPE grocery bags have 3.5 times less carbon emission than paper bags, and 172 times less than cotton bags. This means HDPE bags have the lowest carbon footprint.

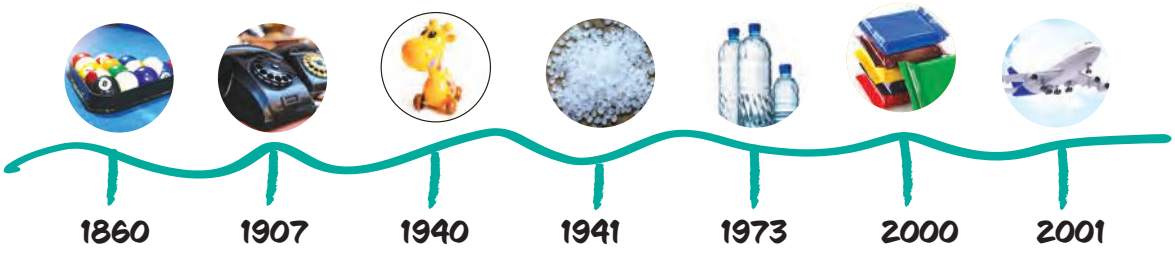
Myth:#4

1. The numbers 1-7 in plastic bottles ***represent the number of times the bottles can be used.***

2. The numbers 1-7 indicate the quality of the plastic, ***with 1 being the worst and 7 the best.***

Fact:

The numbers indicate the polymer type from which the plastic is made, and has no correlation with how many times the product can be recycled. The numbers are important because only plastics made of the same polymer and carry the same code number can be recycled together.



HISTORY

PLASTIC TODAY

SECTORS

Packaging

Sports

Medical

Textiles

Transport

Building & construction

Electrical & electronics

Agriculture

CO_2 CH_4

Lower GHG emissions

LCA

ENVIRONMENT

BENEFIT

PRODUCT PROPERTIES

Lightweight

Durable

Barrier properties

Flexible

Good thermal insulation

Chemically inert

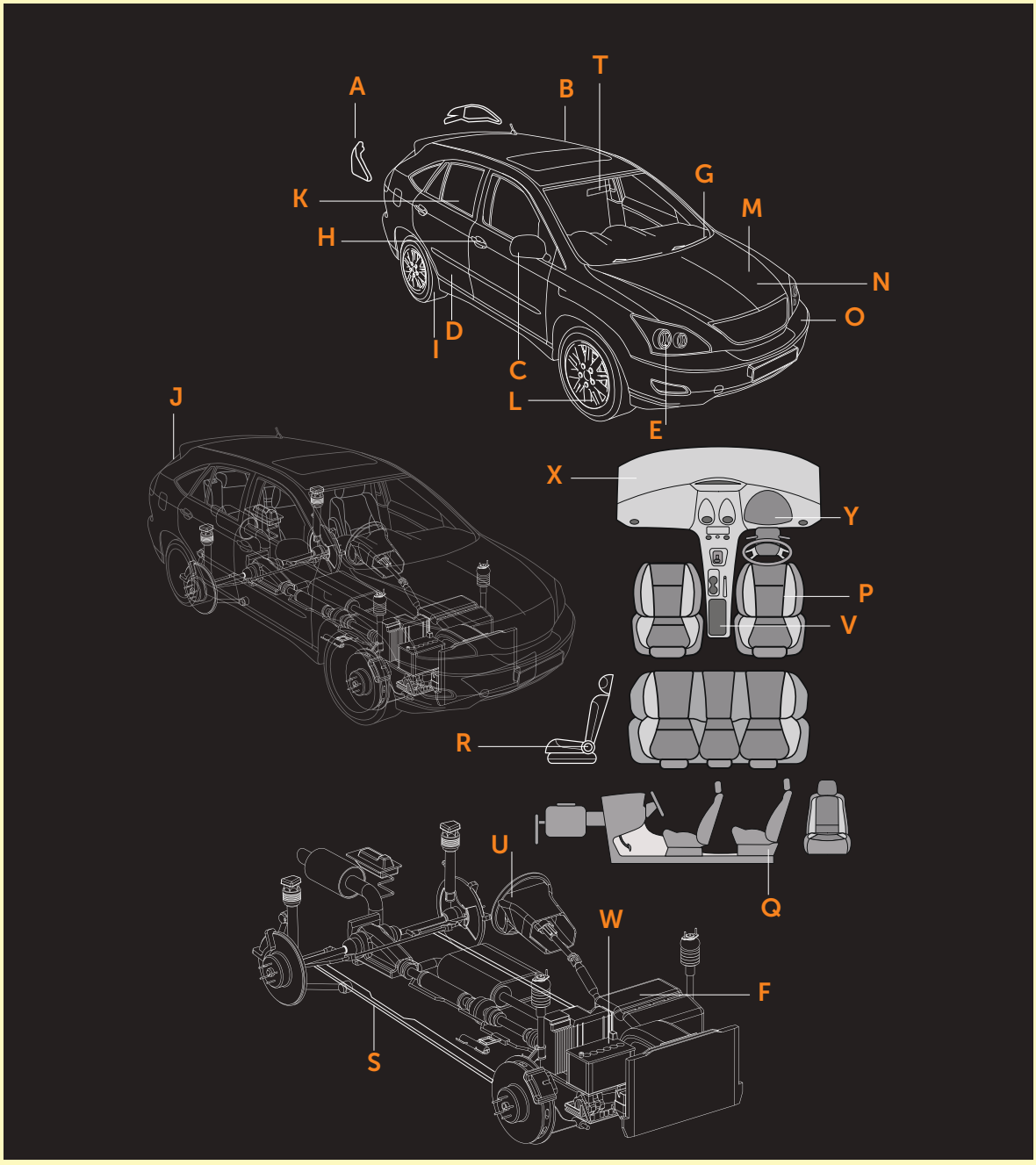
WORKSHEET

ACTIVITY 1

Teacher get students to list plastic products that can be found in class and discuss the various uses of plastic for different types of products.

ACTIVITY 2

Teacher takes students to a car and show them the internal and external components of the car. Students are to be instructed to list components made of plastic and discuss the advantages of plastic when compared with other conventional materials (steel, aluminium etc.).



The above diagram shows how plastic is used in many different components in a car

Questions

1. Khairul : We need to keep this fruit fresh until Friday this week.
   Amar : We should wrap the fruit to preserve it better.
   Khairul : Let's wrap it with .....

   A. Newspaper
   B. Tracing paper
   C. Aluminium foil
   D. Plastic cling wrap

2. Among the following, pick the most suitable material to make an ice-cream container to ensure it will not melt rapidly.

   A. Wood **B.** Glass **C.** Plastic **D.** Aluminium

3. Figure 1 shows a few balls made from different materials.

Figure 1

They are of the same size and volume. Which ball would travel the furthest distance when it is rolled using equal force and air resistance?

A. Wooden ball **B.** Plastic ball **C.** Metal ball **D.** Rubber ball

Questions 4 & 5 refer to Figure 2

Figure 2

4. Lewis Hamilton races in Formula 1 for Mercedes-AMG PETRONAS Team. Different materials were used to manufacture the racing car. Material X was chosen and used for the structural body of the car. What is material X?

   A. Polystyrene **B.** Polypropylene **C.** Polytene terephthalate **D.** Fibre Reinforced Polymer (FRP)

5. Pick the correct pair that explains why material X was used.

	Characteristic	Explanation
A	Anti-corrosive	So the car's part will not degrade in the rain
B	Stiff	Material X is light, hence it would allow for a smooth launch
C	Light	Material X is light, it would allow the car to run longer since it saves energy
D	Hard	Material X is hard, hence it will not stick when it is exposed to high temperature

Table 1

6. All the following items have plastic components. Which of the stated components are correct?

No	Items	Component	Picture
i	Car	Car fuel tank	
ii	Aeroplane	Interior parts	
iii	Non-Stick Frying Pan	The outer sides of the pan	
iv	Bicycle Helmet	Helmet shell	

Table 2

A. iii and iv **B.** i, ii and iii **C.** ii, iii and iv **D.** i, ii and iv

7. Figure 3 shows a girl walking in the rain.
What are the characteristics of polymer in a bag that make it suitable to be used in a situation as depicted?

i. Lightweight
ii. Fire retardant
iii. Water resistant
iv. High cost and good quality

A. i and iii **B.** ii and iv **C.** iii and iv **D.** ii, iii and iv

Figure 3

8. Figure 4 shows a few products that come in contact with food.

Figure 4

Malaysia Food Act 1983 and Malaysia Food Regulation 1985 were created to ensure that food-contact plastic products can be safely used in Malaysia. In your opinion, why do you think these regulations must be obeyed in the production of food-contact products?

A. To ensure the food containers are affordable
B. To ensure that the container is resistant to heat when microwaved
C. To ensure that it was made from polyethylene without any other composite material
D. To ensure that the container is safe, non-toxic and free from any hazardous substances such as phthalate to be used for food contact.

9. In Malaysia, plastic is widely used in various industries. Pick the characteristics that make plastic suitable for the given industries.

	Industries	Characteristic
i	Transportation	It is light, hence it will save fuel
ii	Sports	It is durable, hence optimal for sports equipment
iii	Medical	It is not bio-compatible, hence it is used in blood tubes
iv	Food packaging	It has weak barrier properties, hence can increase the shelf life of food and reduce food wastage

Table 3

A. i and ii **B.** i, ii and iii **C.** iii and iv **D.** All of the above

10. Figure 5 shows a few logos on a container.

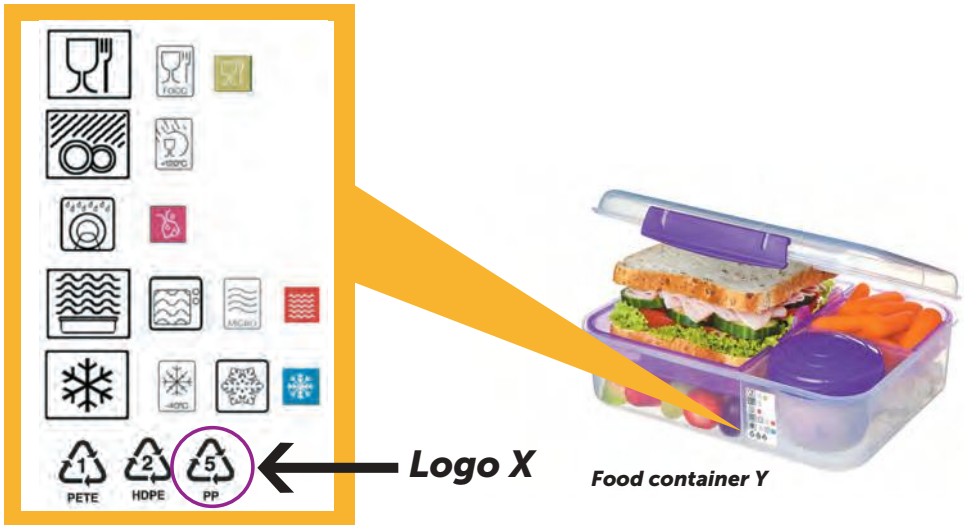


Figure 5

Adam is eating at a café. He notices multiple logos on container Y. Based on your understanding, what does logo X identify and how it can be used?

	Identification	Usage
A	The time needed for it to be recycled	To allow the consumer to buy high quality plastic
B	The hardness of the plastic	To know whether the plastic is durable or not
C	Resistance to heat	To know whether the container will melt if it is microwaved
D	Type of plastic used	To allow the product to be separated in accordance to its own type

ANSWER SCHEME

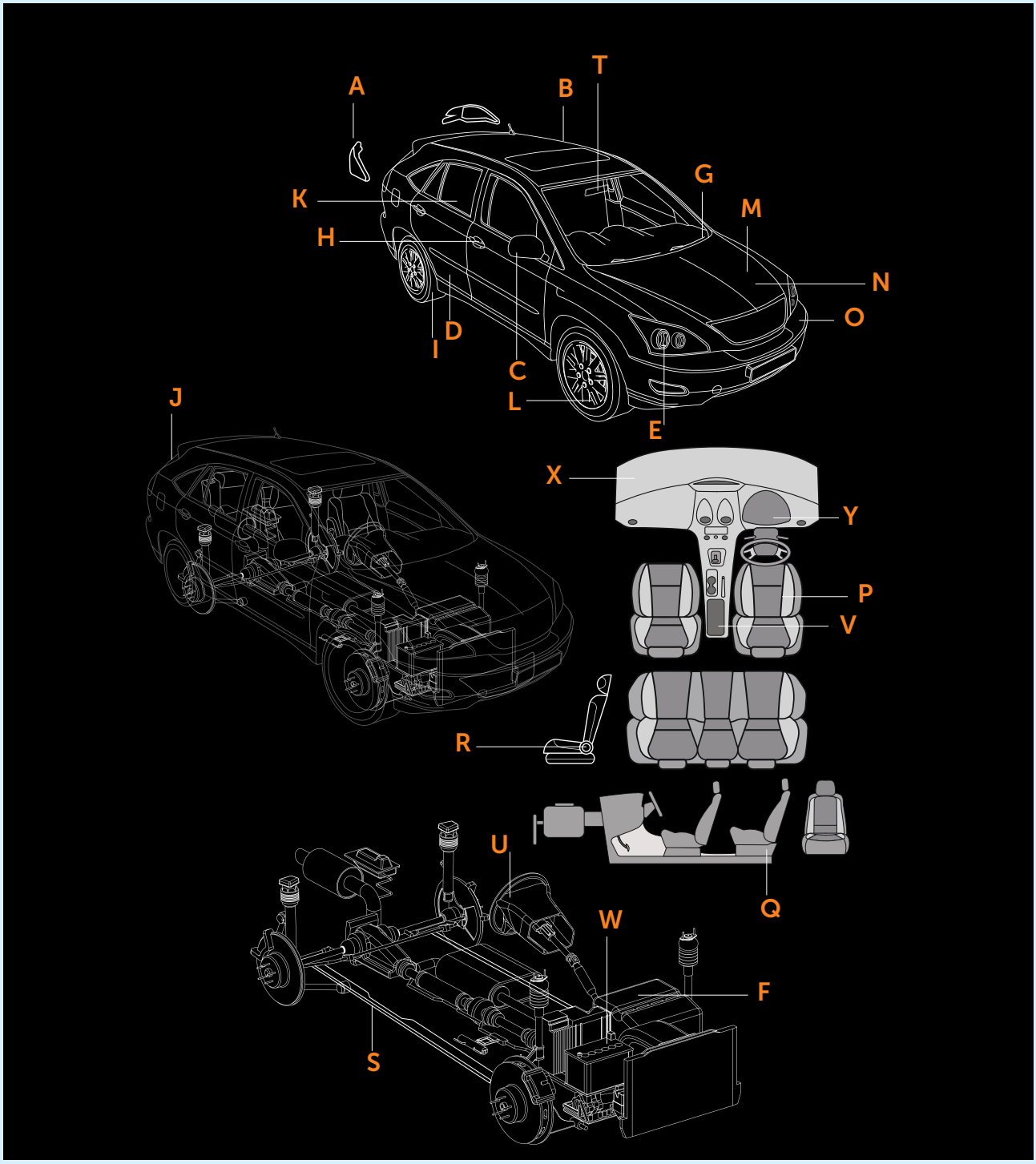
ACTIVITY 1

Teacher should prompt students to check what they have in their pockets as well as in their desks and bags. Give them three minutes to write down all the plastic products they can identify, then ask: how many students have found more than five products; etc.

Objectives:

a. ***To increase awareness of how prevalent plastic is in the products that we use***
b. ***To increase awareness of the benefits of plastic***

ACTIVITY 2



A Tail light
B Frame structure
C Side mirror
D Door
E Headlight
F Air intake
G Windshield wiper
H Door handle
I Tyre
J Rear windshield
K Side window
L Hub cap
M Front hood
N Paint
O Bumper
P Seat
Q Seat frame
R Handle
S Inner frame
T Rear view mirror
U Steering
V Compartment
W Battery
X Dashboard
Y Display panel

After the students have identified all the different plastic components, engage them in a discussion on why plastic is used (because it is light, yet also strong, and can be moulded into irregular shapes) and what its benefits are. The benefits include lower fuel consumption, which helps to reduce global warming.

Objectives:

a. ***To increase awareness of how many different components in a car are made of plastic.***
b. ***To understand why plastic is used – because it is light, strong and can be moulded into any shape (bumpers, for example, are not a regular shape – hard to be made from other materials).***
c. ***To understand how technology can be used to make products that are currently not environmentally friendly, into more environmentally friendly ones.***

To make the activity more interesting, teachers can share the following information with students:

- ***Steel is still the most prominent material in cars, but is gradually being replaced by lighter alternatives such as aluminium and plastic.***
- ***In Europe, plastic makes up 11% of the total weight of a car. This percentage has been increasing over the years.***
- ***The Smart car uses all-plastic body panels, meaning it is lighter and consumes less fuel than other cars.***

Question 1 - D
Plastic cling wrap has good barrier properties that will keep food fresh.

Question 2 - C
Plastic is a good heat insulator and will keep ice-cream cool for longer.

Question 3 - B
Plastic ball.

Question 4 - D
Fibre Reinforced Polymer (FRP) is a plastic composite which has high strength, stiffness, fatigue, energy absorption and resistance to corrosion and fire.

Question 5 - C
FRP is light, leading to the car consuming less energy and being able to travel for longer distances before having to be refuelled.

Question 6 - D

Question 7 - A

Question 8 – D
Malaysia Food Act 1983 & Malaysia Food Regulation 1985 both highlight the requirements for products that are used in contact with food. This is to ensure products containing food such as food containers and water bottles are not hazardous to human health.

Question 9 – A

Question 10 – D
The logos shown are used to identify the type of plastic used to make the product. Consumers will be able to separate them in accordance to their type to allow for easier mechanical recycling.

5.0 | WHAT A WASTE!

Key Messages:

1. The biggest contributor to Malaysia's solid waste composition is food waste.
2. Landfills are sources of GHGs.
3. Proper waste management is crucial to reducing the impact of solid waste to landfill.

LEARNING STANDARD

At the end of this chapter, each student is able to:

- Explain the solid waste management system in Malaysia.
- Explain the importance of reducing our waste to landfills.
- Elaborate on the effects of solid waste in landfills.
- Evaluate the importance of separation at source so as to change the direction of the current waste management hierarchy.

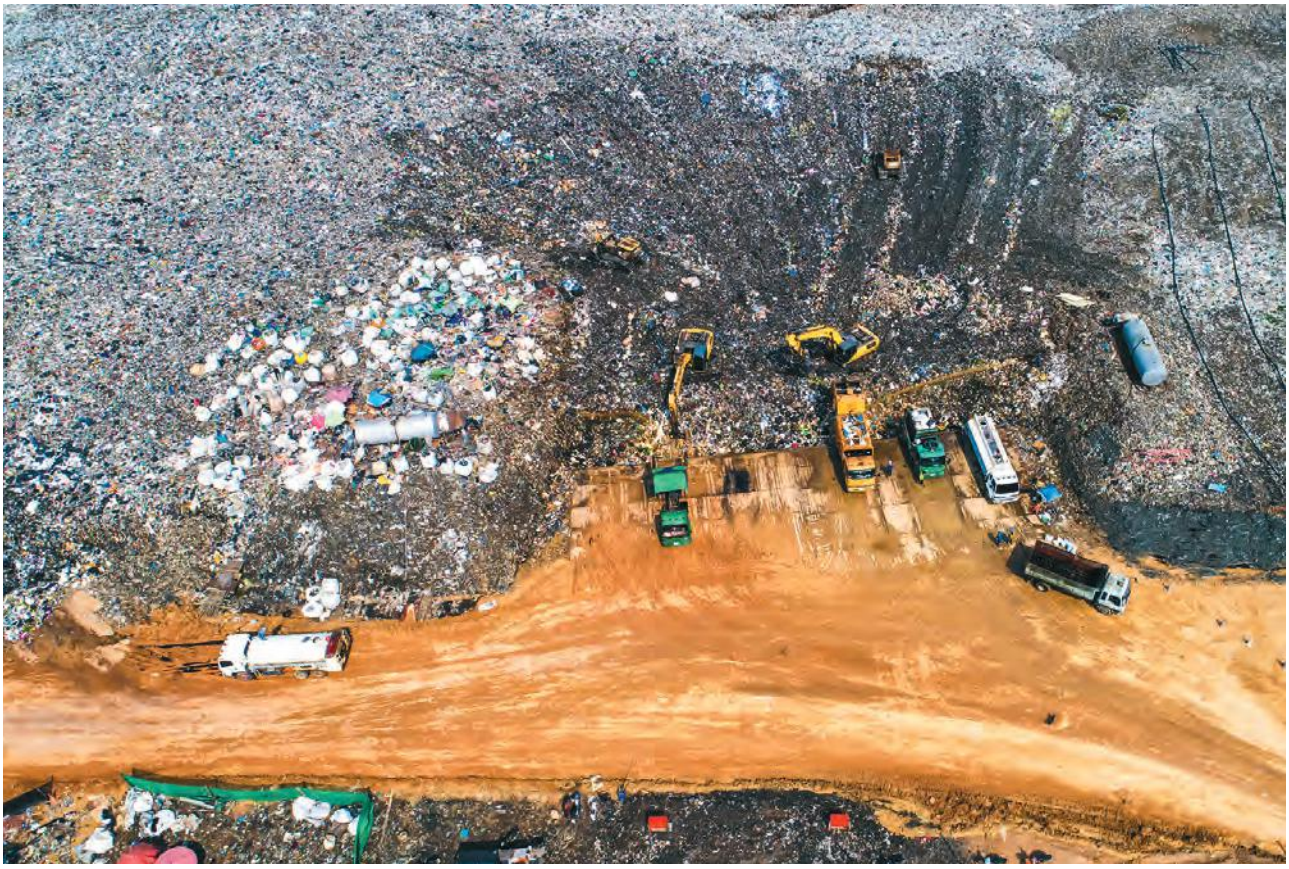
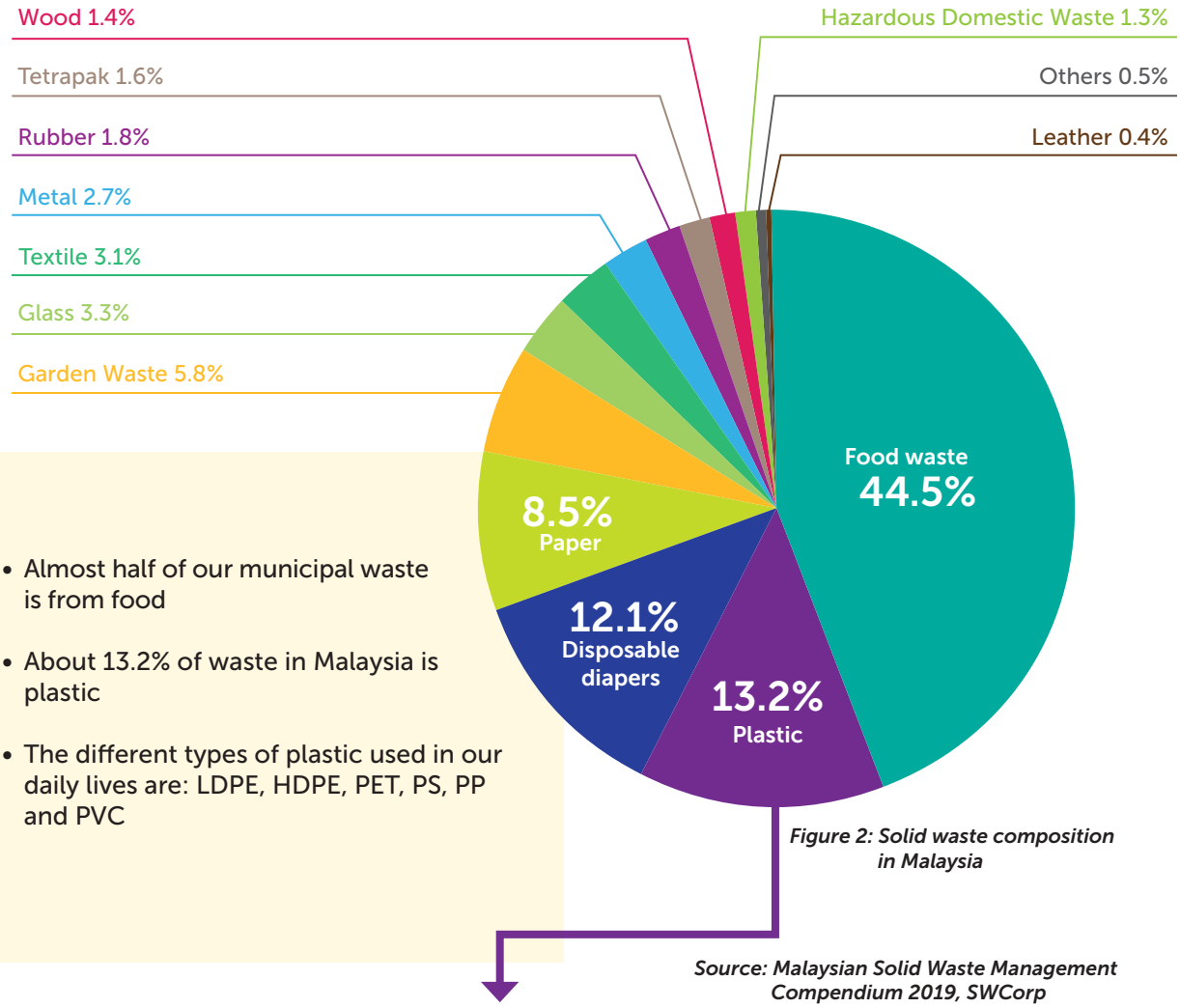


Figure 1: Landfill

Solid waste is waste materials generated by human activities, be it at home, in schools, commercial areas (offices, hotels, malls, etc.) or factories.



- Almost half of our municipal waste is from food
- About 13.2% of waste in Malaysia is plastic
- The different types of plastic used in our daily lives are: LDPE, HDPE, PET, PS, PP and PVC

Figure 2: Solid waste composition in Malaysia

Source: Malaysian Solid Waste Management Compendium 2019, SWCorp

Table 1: Plastic waste composition

Plastic Type		Applications
3.8%	Low-density polyethylene (LDPE)	Plastic bags, bread bags, toys and buckets
3.6%	High-density polyethylene (HDPE)	Detergent and shampoo bottles, water pipes and dustbins
2.5%	Polyethylene Terephthalate (PET)	Water bottles, thermal insulation, tapes, conveyor belts and seat belts
1.4%	Polystyrene (PS)	Disposable plates and cutlery, compact disc (CD) cases
1.3%	Polypropylene (PP)	Ice-cream tubs, straws, ropes and car parts
0.5%	Polyvinyl chloride (PVC)	Cosmetic containers, containers for cleaning products, piping and electric insulation
0.1%	Others	-

Source: Dr. Theng Lee Chong, Environment and Waste Management Specialist

5.1 | RECYCLABLE AND NON-RECYCLABLE WASTE

In general, solid waste can be categorised into recyclable and non-recyclable waste. Recyclables will be sent to a recycling centre and non-recyclables will be sent to the landfills. Therefore, it is important to manage your waste by practising waste separation at source to increase recycling rates and to reduce waste at the landfills.

Let's Comply & Intervene

- Everyone should take responsibility for the way we manage solid waste.
- 'Let's Comply & Intervene' is a concept to urge everyone not to litter and to use a bin when disposing of litter.

A man eats a banana and simply discards the skin.

A lady sees his irresponsible action. She intervenes and tells him not to litter.

The man picks up the skin and throws it into the rubbish bin.

Figure 3: Let's Comply & Intervene

Why separation at source?

- Separation at source means separating our recyclables such as plastic, paper and others from non-recyclables like organic/food waste.

Tip: Ensure the recyclables are clean before separation

- This simple act of waste separation at source helps to reduce the amount of solid waste going to landfills thus contributing to a reduction in GHG emissions.

Figure 4: Solid waste separation at source

CASE STUDY

The Jeram Sanitary Landfill commenced operations in 2007 and was designed to manage a daily solid waste intake of 1,250 tonnes/day for 20 years. However, the landfill's current daily solid waste intake is 3,000 tonnes/day, thus shortening the lifespan of the landfill. This necessitates the setup of new landfills to manage the increase in solid waste.

Landfills and GHG emissions

- Although landfills are necessary for solid waste management, they are not without problems.
- In Malaysia, and the rest of the world, landfills are overflowing and there is not enough land to create new landfills.
- The lifespan of landfills are continually reduced due to the ever-increasing volume of solid waste.
- Decomposing waste in landfills emit CH_4 and CO_2.
- The most effective way to reduce GHG emissions from landfills is to reduce the amount of solid waste thrown away.

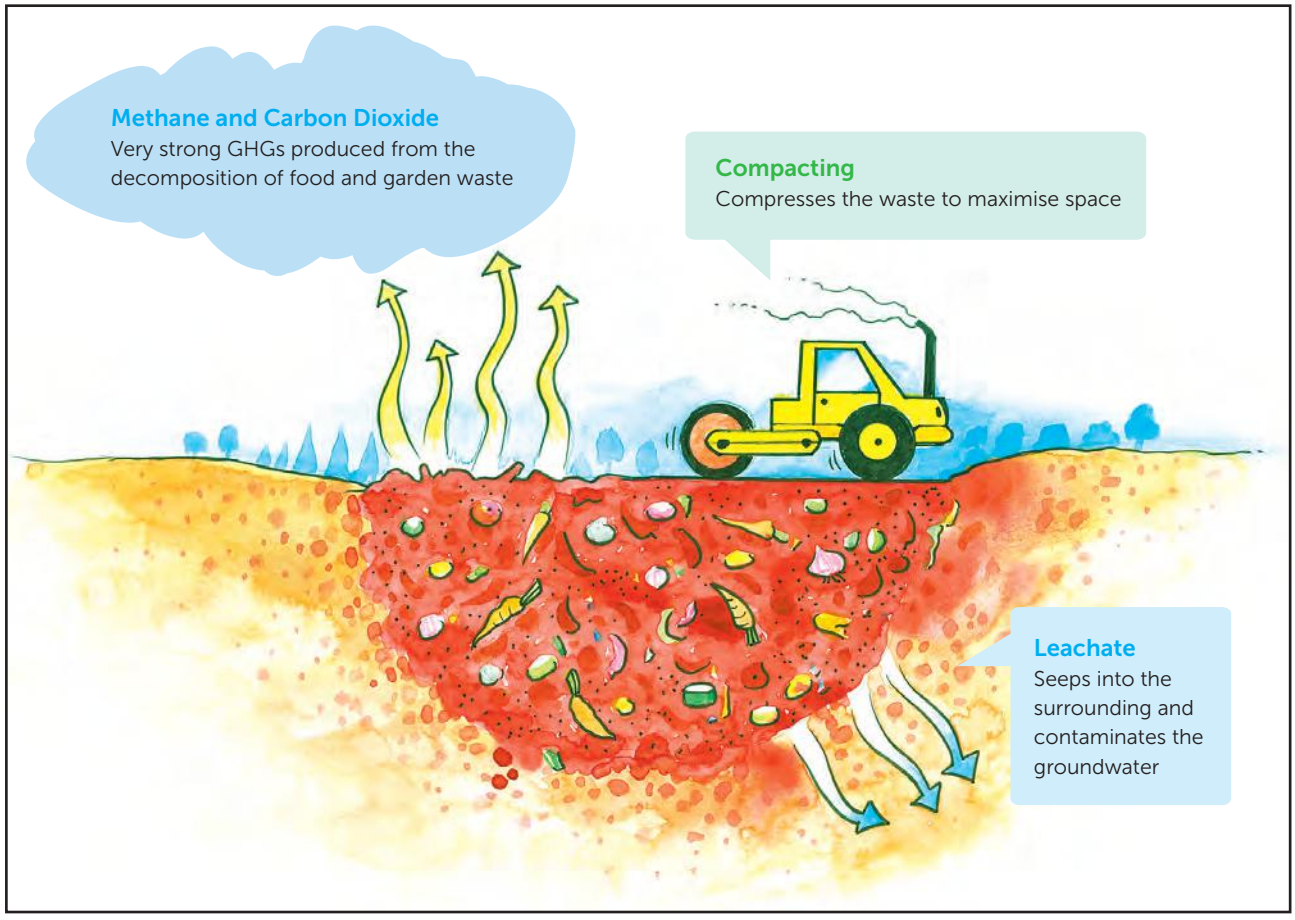


Figure 5: GHG emissions and leachate in a landfill

Did you know?

"*Landfill gas contains 40%-60% methane, which is a GHG.*"

Source: US Energy Information Administration

5.2 | MUNICIPAL SOLID WASTE MANAGEMENT

Let's see what happens to municipal solid waste in Malaysia.

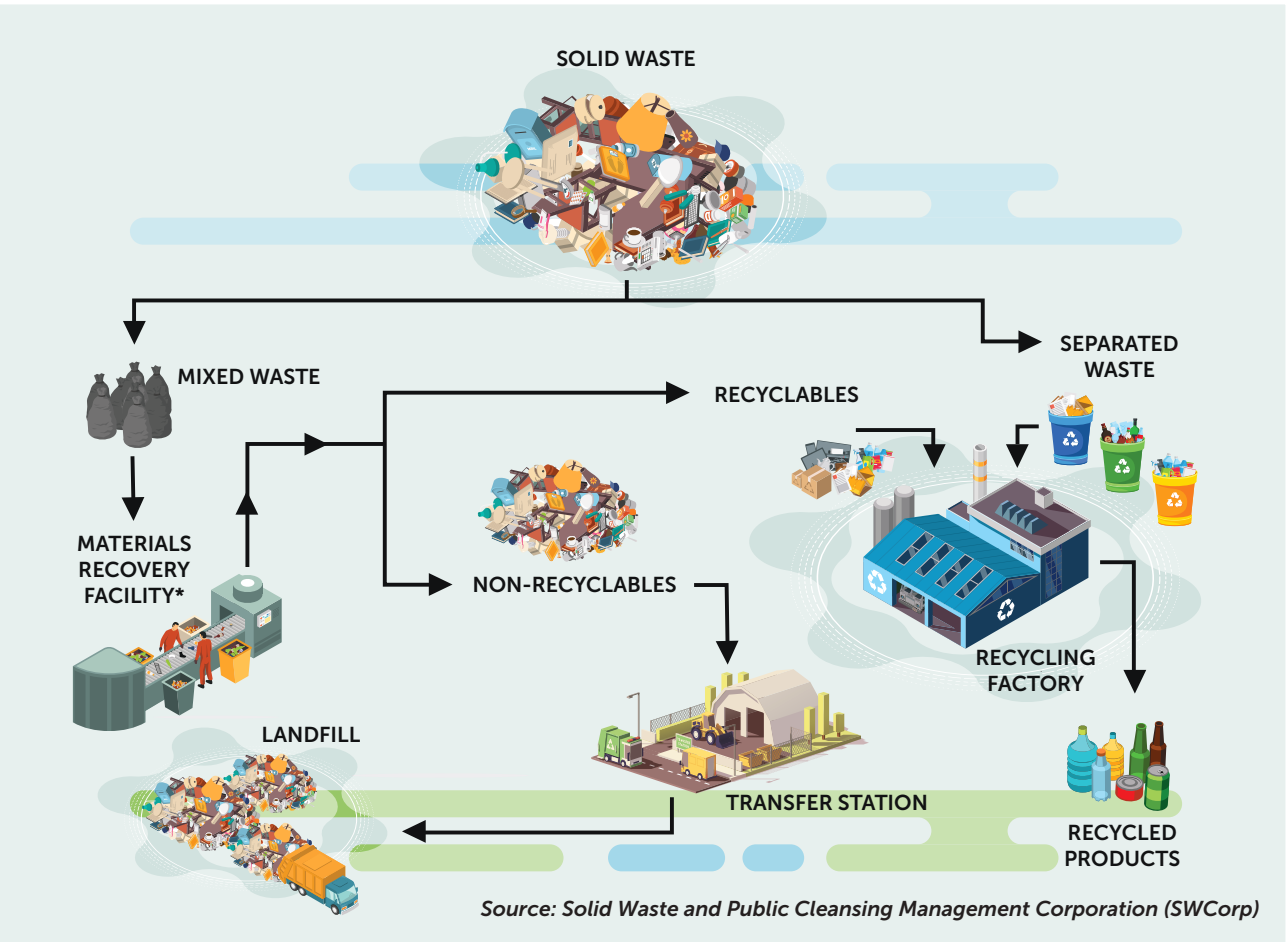


Figure 6: Municipal solid waste management in Malaysia

* Collected solid waste is still mixed waste due to low level of awareness on waste separation of recyclables and non-recyclables. Therefore, recyclable waste will be recovered from the mixed waste at the Materials Recovery Facility before the waste is disposed of at landfills.

In Malaysia, an average of 30% of waste is recycled and the remaining 70% ends up in landfills.

Did you know?

"There are only 10 sanitary landfills in Malaysia. A sanitary landfill is engineered to be equipped with various solid waste treatment facilities and pollution prevention measures to contain and reduce its environmental impact to the surrounding area."

5.3 | CURRENT VS FUTURE SOLID WASTE MANAGEMENT HIERARCHIES

- The practice of solid waste separation has yet to become part of our culture in Malaysia resulting in lots of resources being used for treatment and disposal.
- Our goal is to shift our mindset and create a culture of solid waste reduction via the practice of the 3Rs.

SOLID WASTE MANAGEMENT HIERARCHY

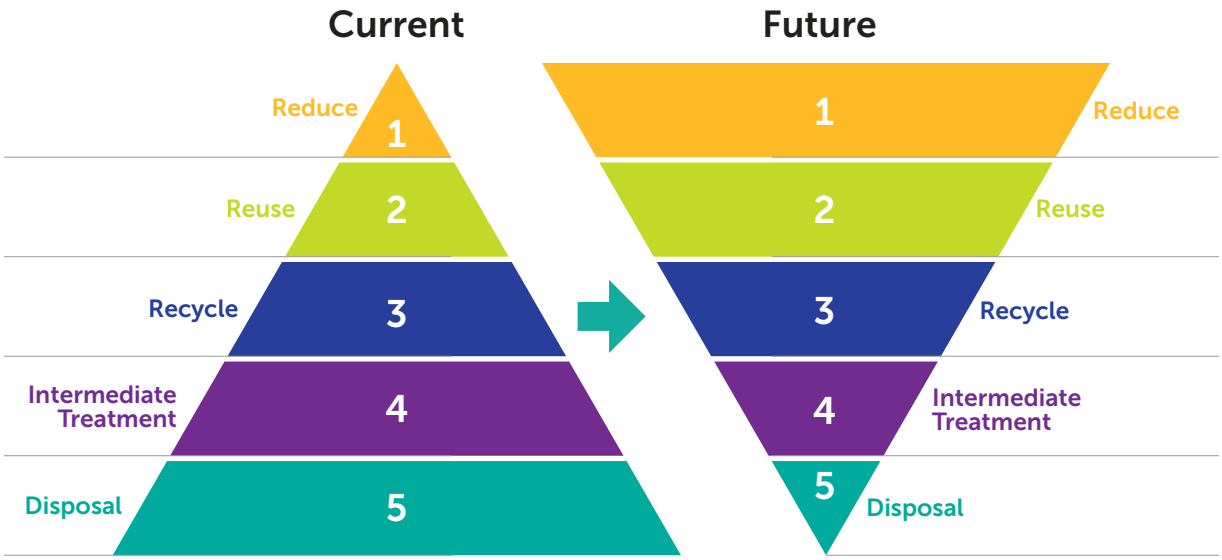


Figure 7: Current vs future solid waste management hierarchies

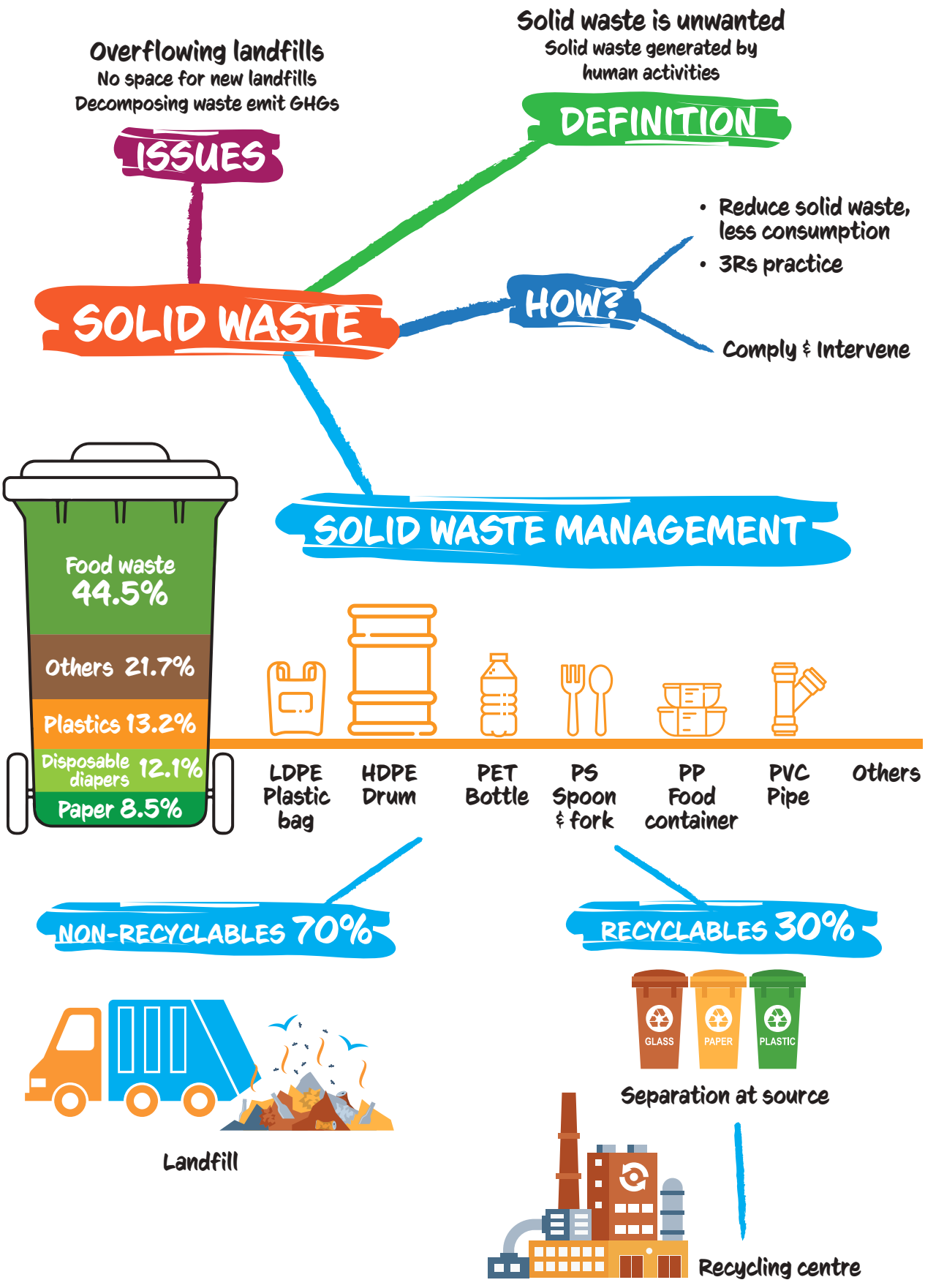
Source: Ministry of Housing and Local Government (KPKT)

Myth:#5

We throw away more plastic than anything else.

Fact:

Plastic comprises only about 13% of our waste, as compared to food waste which makes up 45%. What's more, plastic packaging helps to prolong food's freshness, thus reducing food waste.


Overflowing landfills
No space for new landfills
Decomposing waste emit GHGs
ISSUES
Solid waste is unwanted
Solid waste generated by human activities
DEFINITION
SOLID WASTE
HOW?
• Reduce solid waste, less consumption
• 3Rs practice
Comply & Intervene
SOLID WASTE MANAGEMENT
Food waste 44.5%
Others 21.7%
Plastics 13.2%
Disposable diapers 12.1%
Paper 8.5%
LDPE Plastic bag
HDPE Drum
PET Bottle
PS Spoon & fork
PP Food container
PVC Pipe
Others
NON-RECYCLABLES 70%
RECYCLABLES 30%
GLASS
PAPER
PLASTIC
Separation at source
Landfill
Recycling centre

WORKSHEET

ACTIVITY

Students to collect their waste, do a personal audit at the end of the day and formulate a plan to reduce waste.

Questions

1. Figure 1 shows an example of excessive food waste. This is detrimental to our environment. In your opinion, how can we reduce food waste?

   i. Use less plastic
   ii. Stop using plastic straws
   iii. Buy only the food you need
   iv. Log your food wastage and try to reduce it

   A. i and ii **B.** ii and iv **C.** iii and iv **D.** i, iii, and iv

Figure 1

Questions 2 - 3 refer to Figure 2

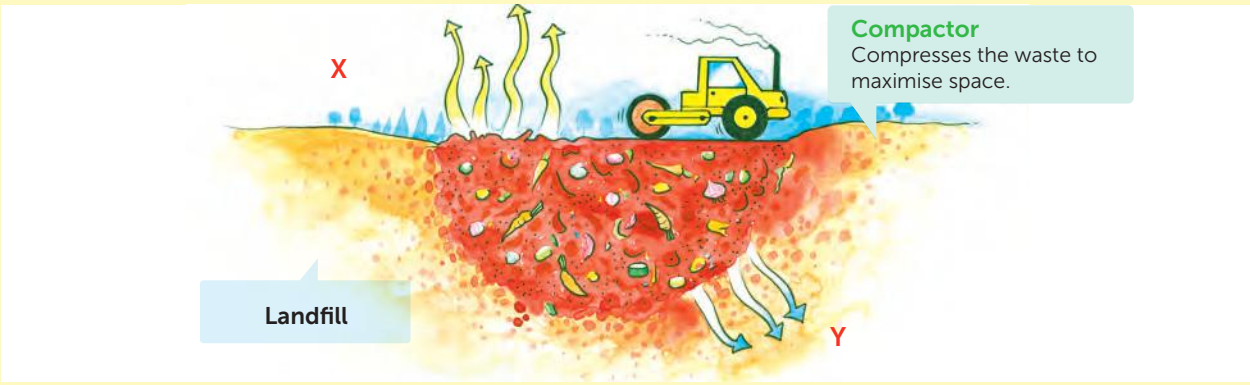


Figure 2

2. X is a harmful greenhouse gas produced due to the compressed environment of the landfill in the absence of oxygen. What is X?

   A. Oxygen
   B. Methane
   C. Carbon monoxide
   D. Chlorofluorocarbon

3. Based on your observation of Y, pick the best explanation on why it would contaminate groundwater?

   A. The methane gas will flow to the river and infuse with it
   B. Leachate from the landfill contaminates the groundwater
   C. The landfills attract animals that come to pollute the groundwater
   D. The leachate pushes the soil surrounding the landfill towards the groundwater

Figure 3

4. What can you relate from the two pictures in Figure 3?

	Human Behaviour	Environmental Impact
A	Excessive emission of CO_2	Increase in solar radiation melts the ice caps
B	Usage of CFC gas	Thinning of ozone layer causes migration of animals to the North Pole
C	Excessive dumping of solid waste materials in landfills	Accumulation of GHGs from landfills causes global warming and melting polar ice caps
D	Littering of trash into the ocean	Massively increases the density of the ocean hence causes the iceberg to float higher leading to higher exposure to the sun.

Questions 5 - 6 refer to Figure 4

5. Figure 4 shows the composition of solid waste in Malaysia. What is X?

   A. Paper
   B. Plastic
   C. Metals
   D. Food waste

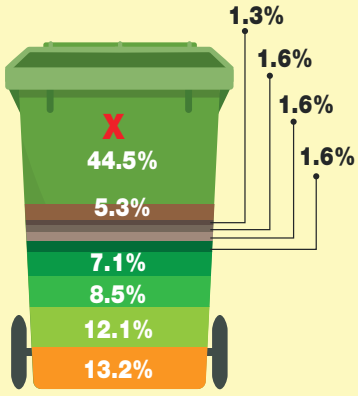


Figure 4

6. Why is X abundant in Malaysia's landfills?

   A. Excessive crop production by farmers
   B. Usage of plastic cling wrap to wrap food
   C. Food being wasted when bought in excess and thrown away
   D. Many foods produced are not suitable to be consumed, hence they are thrown away

7. One of the most effective methods in conserving our natural resources is recycling.
Pick the correct pair of recycling method and type of waste.

No	Type of Waste	Recycling	
i	Metal Spoon		Incinerate the metal spoon to produce energy
ii	Food Waste		Process food waste into compost fertiliser to grow crops
iii	(PET) Plastic Bottle		Mechanically recycle the material into reusable plastic
iv	Glass Bottle		Smelt the glass bottle and reuse the material to manufacture new products

A. i and iii
B. i and iv
C. ii and iii
D. ii, iii and iv

8. ..... is a concept to urge everyone not to litter and to use a bin when disposing of litter.

A. Let's Comply & Follow
B. Let's Follow & Comply
C. Let's Intervene & Comply
D. Let's Comply & Intervene

9. Figure 5 shows the current solid waste management hierarchy and future waste management hierarchy. Based on your understanding and knowledge, why is it vital for us to move from the current waste management hierarchy to the future waste management hierarchy?

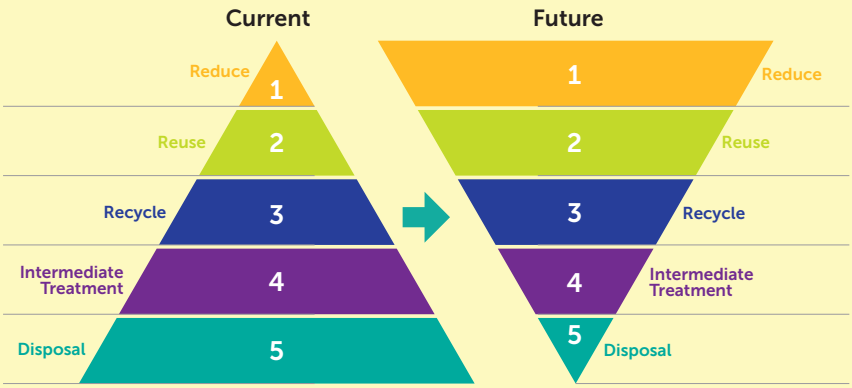


Figure 5

i. Increase the quality of recycled products
ii. Decrease the amount of resources used for treatment and disposal of waste
iii. Increase the possibility of waste materials being recycled by practising separation at source
iv. Decrease the generation of methane gas from the reduction of waste materials ending up in landfills

A. i and iv **B.** ii and iii **C.** i, ii and iii **D.** ii, iii and iv

Figure 6

10. Figure 6 shows a poster regarding separation at source. Based on your understanding, what is separation at source?

A. Separation of raw materials during early manufacturing
B. Sourcing different materials for the manufacture of products
C. Separation of different types of waste materials in recycling factories
D. Separating waste materials in accordance to their type at your home

11. How does plastic help to reduce food wastage?

A. Diffusion of microplastic in food will slow down its rate of spoilage

B. Plastic usage in farms will attract bees to better pollinate the plants

C. The sugar level of fruits wrapped in plastic will increase, hence increasing its quality

D. Plastic can be used to wrap food to slow down its rate of spoilage due to its barrier properties

ANSWER SCHEME

ACTIVITY

Objectives:

a. ***For students to realise how much waste and the type of waste they throw away everyday.***
b. ***For students to share practical and effective ideas on how they can reduce waste.***

Question 1 - C

Question 2 - B
Methane is a harmful GHG, produced in anaerobic conditions present in compressed landfills

Question 3 - B
Leachate from landfills will spread into the groundwater through the soil

Question 4 - C
GHGs such as methane is produced from landfills and will result in the increase of global temperature

Question 5 - D
Based on SWCorp statistics, food waste makes up the biggest portion of solid waste in Malaysia

Question 6 - C
Food waste is the major contributor to Malaysia's landfills as excess food is not consumed and thrown away

Question 7 - D

Question 8 - D

Question 9 - D

Question 10 - D
Separation of waste by type at home

Question 11 - D
The barrier properties of plastic will prevent infiltration of O_2, CO_2 and moisture hence prolonging food's freshness and lifespan, thus helping to reduce food waste

6.0 | 3Rs: REDUCE, REUSE, RECYCLE!

Key Messages:

1. The 3Rs (Reduce, Reuse and Recycle) are important as they help to minimise the volume of solid waste going to landfills.
2. New technologies are being developed to help recycle plastics that previously were thought to be non-recyclable.

LEARNING STANDARD

At the end of this chapter, each student is able to:

- Explain the concept of 3Rs.
- Practise the 3Rs to reduce solid waste to landfills.
- Communicate the new technologies available for plastic recycling.

Each Malaysian produces an average of 1.17kg of waste a day amounting to an average total of about 38,000 tonnes a day nationwide. An average of one-third of our waste is recycled, the rest goes to landfills.

6.1 | SOLID WASTE GENERATION IN MALAYSIA

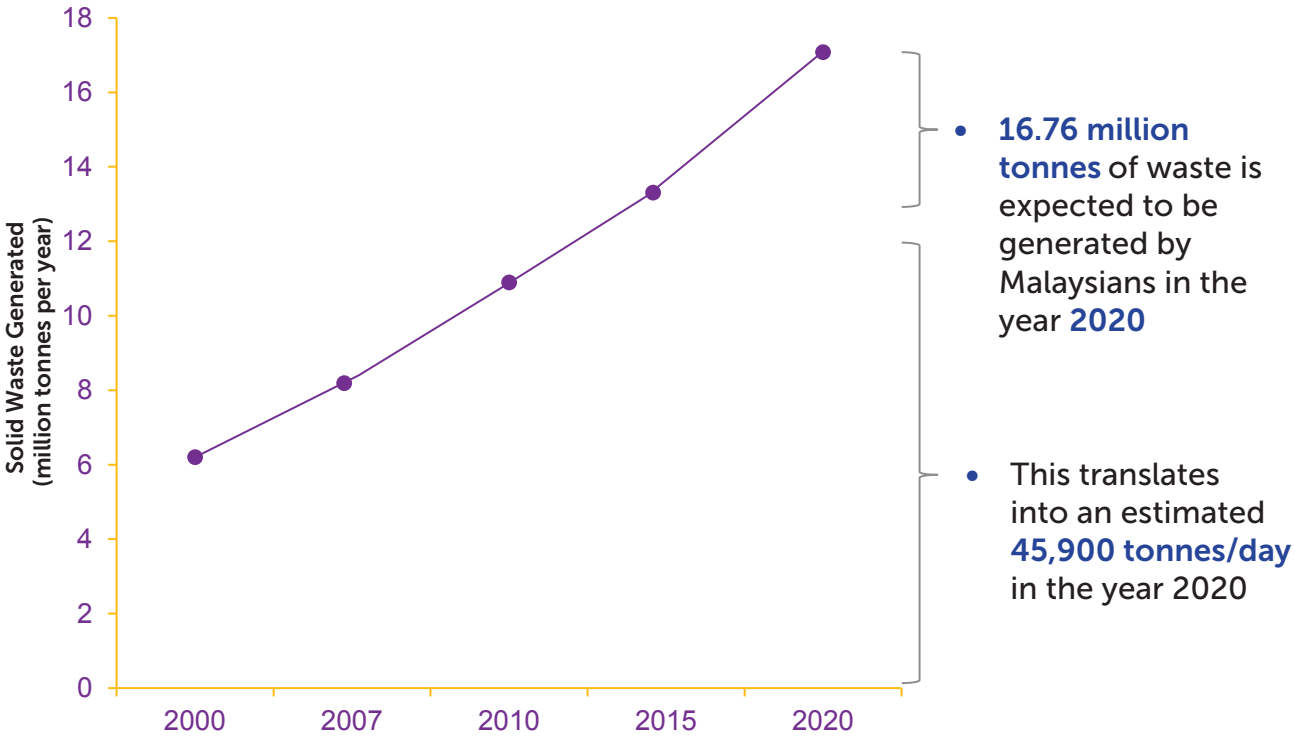


Figure 1: Solid waste generation (2000 - 2020)

Source: SWCorp

In the last 19 years, the amount of waste generated by Malaysians has increased every year. This trend will continue unless we control our consumption.

We need to reduce the amount of solid waste sent to landfills as they are fast reaching their limits. Landfills emit GHGs and release leachate into the soil which contaminates our water. There are three ways to reduce solid waste going to landfills: reduce, reuse and recycle, also known as the 3Rs.

Figure 2: Creative reuse of a water bottle

Table 1: Summary of the 3Rs concept

Reduce means reducing consumption	Reuse is about reusing products or materials which can be used again	Recycle involves recycling products into new materials
		
REDUCE	**REUSE**	**RECYCLE**
• Take action to reduce solid waste generation before and during product usage. • Buy only what is needed so as to avoid wastage and optimise product usage. Indirectly, this will reduce solid waste to landfills.	• Reuse a product or its parts so as to avoid waste. • Reusing a product will extend its lifespan and reduce solid waste generation. • Conventional method: use the item for the same or similar purpose as its original function. • Creative method: use an item for a new purpose. This is also known as upcycling and downcycling. • Refurbishing	• Recycling involves separating solid waste at source, for example at home, so that recyclables can be sent to the recycling centres. • The government made it mandatory for Malaysians to segregate our solid waste under the Solid Waste and Public Cleansing Management Act 2007 (Act 672) which came into effect on 1 September 2015 to increase Malaysia's recycling rate. • All households must separate organic/food waste from plastic waste, paper waste and other recyclable wastes.

Benefits of the 3Rs

- Reduces the use of raw materials to make new products
- Reduces GHG emissions from the decomposition of solid waste in landfills
- Reduces water pollution from leachate produced at landfills

Of the 3Rs, 'reduce' is the most effective in reducing solid waste generation

In the previous chapter, you learned that plastics contribute about 13% of our solid waste and most of it can be recycled. Separating at source (SAS) is important as it separates recyclables from non-recyclables. Practising the 3Rs ensures that most plastics do not end up in landfills.

6.2 | THE 3Rs AND PLASTIC

Applying the 3Rs to plastic:

- We can reduce our plastic usage by reducing our consumption and reusing items such as food containers and cutlery whenever possible.
- We can reuse various plastic items such as plastic bags and bottles.
- We can recycle plastic by practising waste separation at source. Keep your plastics clean.
- We should not only practise 3Rs at home but also in public places.

Can all plastic be recycled?

- All plastics can be recycled, as long as they are the same type and carry the same plastic code.
- Some plastic products contain a mix of different types of polymers e.g. multilayered film packaging. There are technologies to manage such complex plastic products.

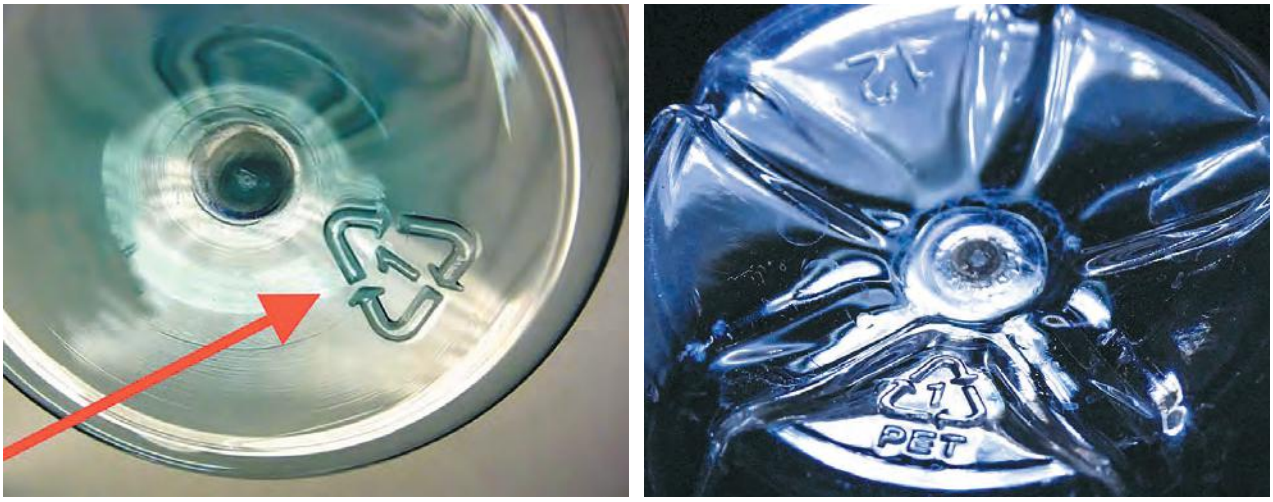


Figure 3: Recycling code

Did you know?

A single recycled plastic bottle saves enough energy to run a light for six hours!

Source: Bureau of International Recycling

Recycling Plastic

Plastic is chemically inert, therefore it does not degrade easily in landfills. However, plastic is recyclable. It needs to be separated from other solid waste going to landfills so that it can be sent for recycling.

6.3 | RECYCLING TECHNOLOGIES

Plastics can be recycled either through mechanical, energy or chemical processes.

TYPICAL TECHNOLOGY

MECHANICAL RECYCLING

Mechanical recycling is the most conventional method of plastic recycling and has been used for decades.

Figure 4: Manual sorting

- The recycled plastic can be used to make new packaging, garbage bags, flooring, hoses and car parts.
- Most widely used for PET and PE.

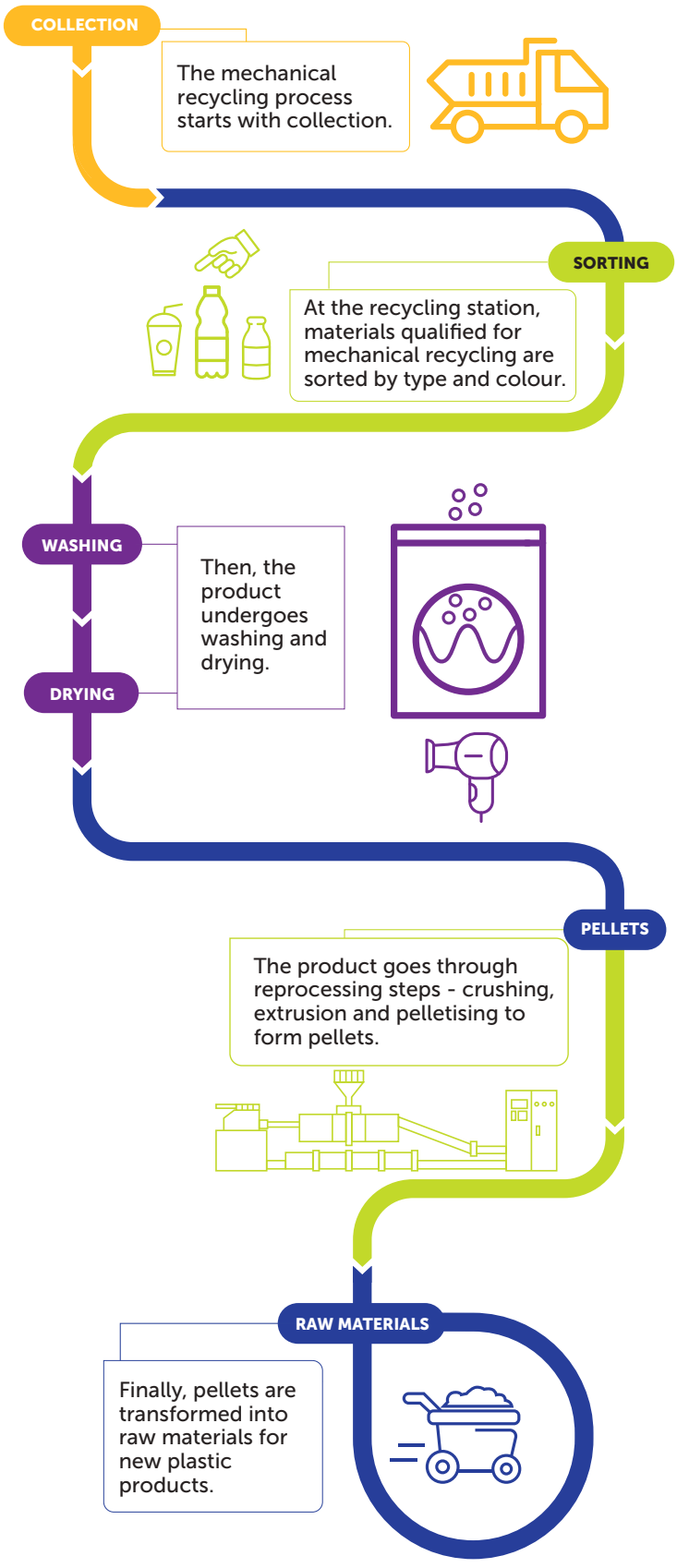


Figure 5: Mechanical recycling process

ADVANCED RECYCLING TECHNOLOGY

Energy and chemical recycling are newer forms of recycling.

1. WASTE TO ENERGY (WTE)

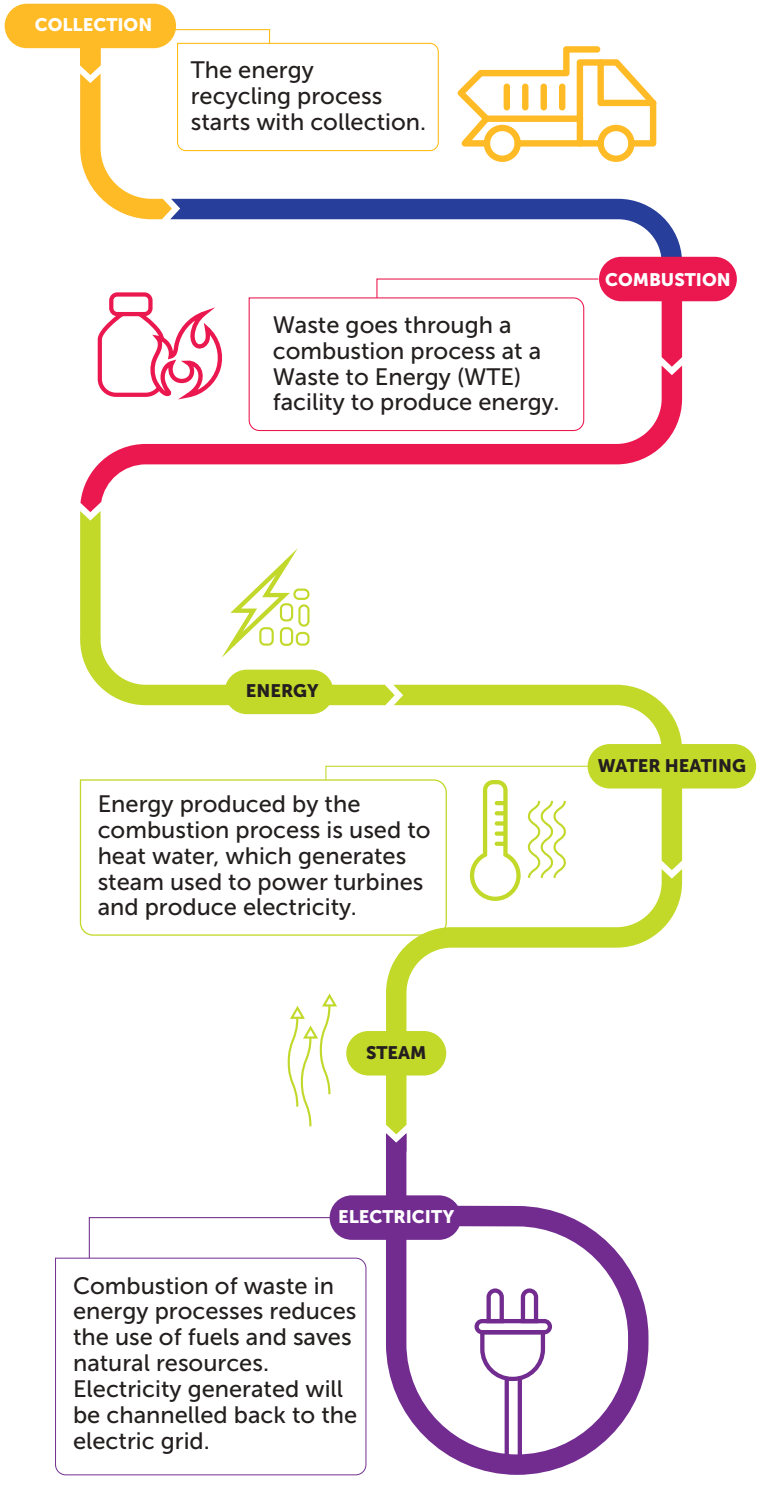


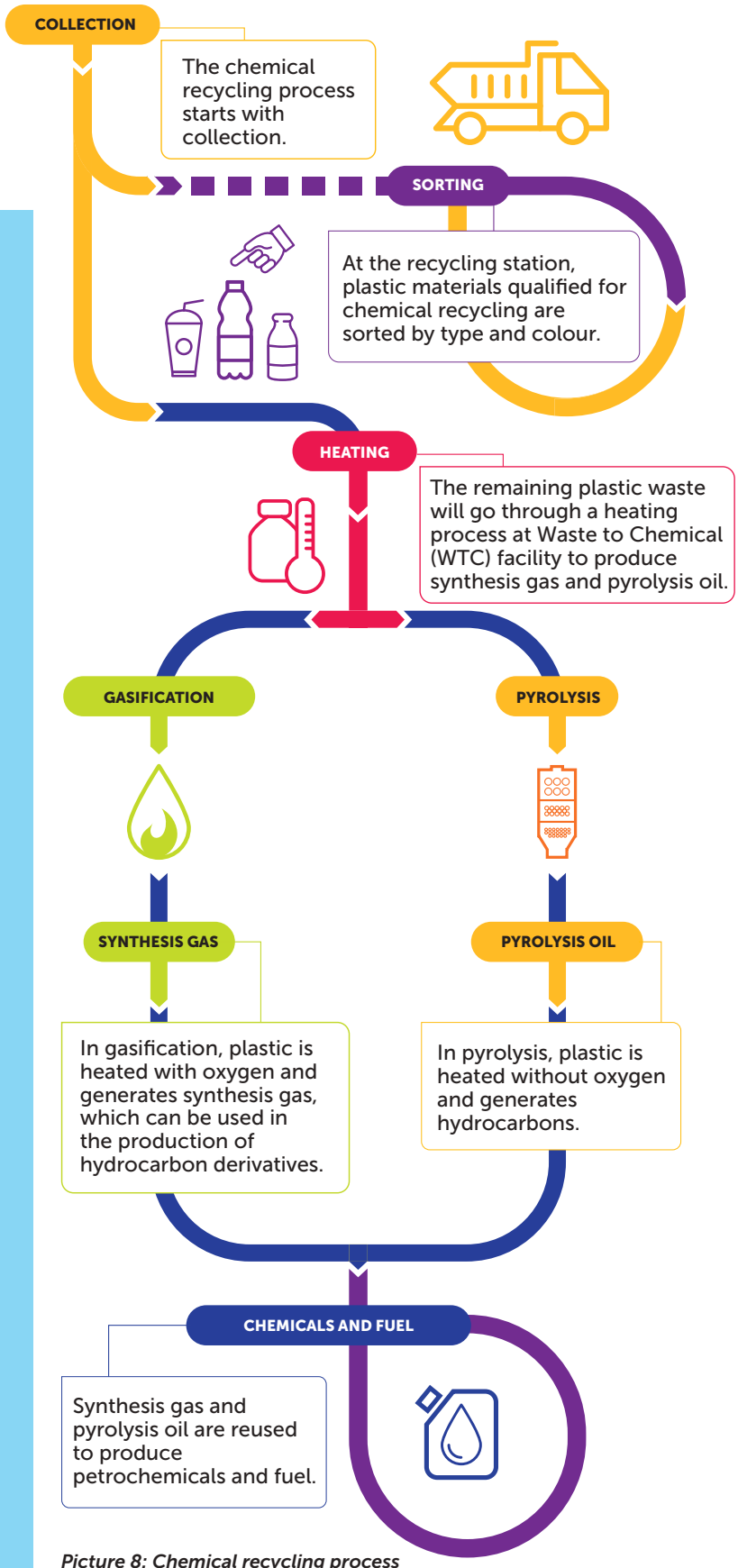
Figure 6: Waste to Energy process

Figure 7: Incinerator by Cypark Resources Bhd

- Solid waste including plastic is converted into electrical energy through technologies such as incineration.
- This technology is useful in cities without the space for landfills.

2. CHEMICAL RECYCLING

- Chemical recycling is the most complex of the three recycling methods.
- It involves changing the chemical structure of plastics so they can be reused as raw materials for different industries or as basic input for new plastic products.
- Enables the recycling of plastics that previously were not easy to recycle, such as multilayered plastic or contaminated plastic.
- This technology has been developed and is being used in several countries.



Picture 8: Chemical recycling process

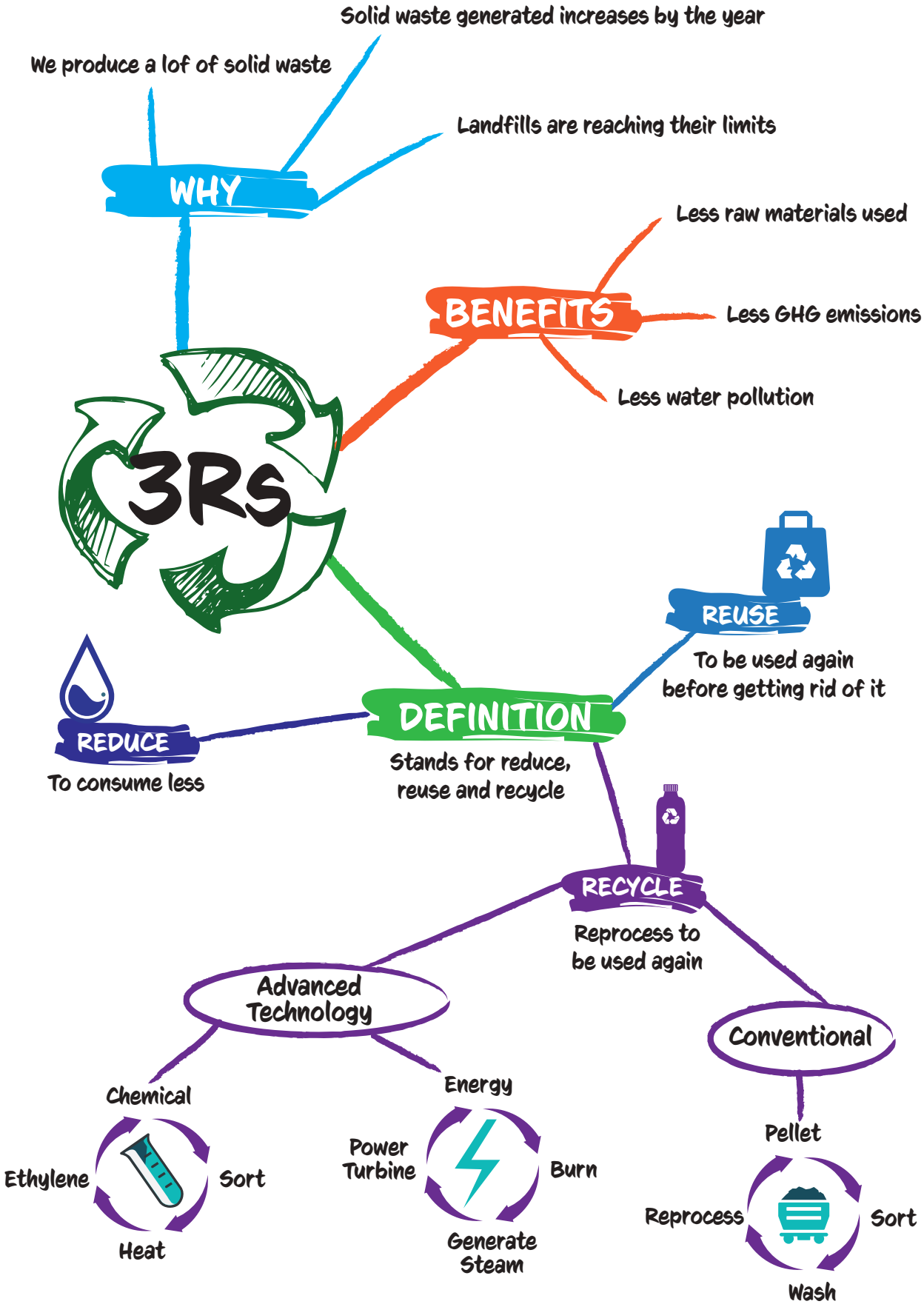
3Rs may seem like a small effort. However, every action to reduce, reuse and recycle contributes to reducing global warming, marine litter and other environmental issues that affect the sustainability of our planet.

Myth:#6

Plastic cannot be recycled.

Fact:

All plastic with the recyclable logo can be recycled using a conventional method also known as mechanical recycling. Complex products that combine different types of plastic are more difficult to recycle. However, new technologies such as chemical recycling have been developed for such products.


Solid waste generated increases by the year
We produce a lof of solid waste
Landfills are reaching their limits
WHY
Less raw materials used
BENEFITS
Less GHG emissions
Less water pollution
3RS
REUSE
To be used again
before getting rid of it
REDUCE
To consume less
DEFINITION
Stands for reduce,
reuse and recycle
RECYCLE
Reprocess to
be used again
Advanced
Technology
Conventional
Chemical
Ethylene
Sort
Heat
Energy
Power
Turbine
Burn
Generate
Steam
Pellet
Reprocess
Sort
Wash

WORKSHEET

ACTIVITY 1

Teacher shows nine commonly used items (either the real thing or in pictures) to students:

i. Plastic grocery bag
ii. Cling film
iii. Used battery
iv. Old t-shirt
v. Pizza cardboard box
vi. Pen
vii. Tissue paper
viii. Mobile phone
ix. Pencil

Teacher asks students to note down which items can be recycled and which items cannot be recycled, then discusses the answers with them.

ACTIVITY 2

Students go through rubbish bins in all classes and sort out items that can be recycled. These are then sent by the school to a recycling centre. Students also share tips with the other classes on how they can reduce their waste. The students keep a log for a month to record their own waste. At the end of the month, they audit the waste in the same classes as before to see if there was any reduction in waste.

Questions

1. Fikri is shopping in a mall when he sees the posters in Figure 1. In your opinion, how could he best practise the second part of the 3Rs, i.e. Reuse?

   A. Only buying the products he really needs
   B. By buying expensive products so they last longer
   C. By buying products made from organic materials
   D. By buying alkaline batteries that can be charged repeatedly

Figure 1

2. The mixing of waste materials in rubbish bins as shown in Figure 2 will complicate the recycling process. This is the result of not separating at source. Why do you think separation at source is very important?

   i. To prevent the disposal of recyclable materials
   ii. To reduce the amount of solid waste sent to landfills
   iii. To reduce the country's allocation for solid waste disposal
   iv. To reduce the release of toxic gases when the waste materials are recycled in incinerators

   A. i and ii **B.** ii and iv **C.** i and iii **D.** i, ii and iii

Figure 2

3. The recycling centre in Figure 3 shown below is used to process what type of solid waste into which end-product?

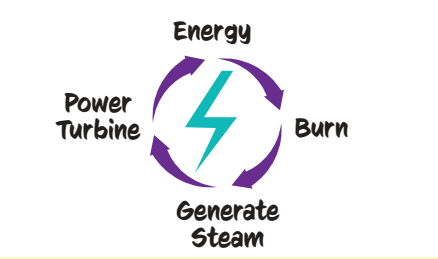


Figure 3

	Solid Waste	*End Product*
A	Food waste	Biomass
B	Food waste	Oil
C	Composite plastic	Electrical energy
D	PET plastic	Plastic pellets

4. Sammy is emptying his trash bin and finds the items in Figure 4. The items share which common characteristic?

   A. Can be burnt safely in an open space

   B. Can only be incinerated to generate energy

   C. Must be chemically recycled since they are composite plastics

   D. Can be mechanically recycled but must first be separated according to type

Figure 4

Figure 5

5. Mei Ling is shopping for school items as illustrated in Figure 5. She is looking to follow the 3R campaign promoted by her teacher. Pick the best answer on how she can reduce her waste generation.

   A. Separate her waste materials at source

   B. Reuse her plastic bottles as decoration items

   C. List down the items that she needs prior to shopping

   D. Boycott all products made from plastic since it is detrimental to the world

6. The current low rate of recycling and excessive solid waste generation are among the factors contributing to an increasing number of landfills. What are some of the consequences of building more landfills?

   i. Contamination of groundwater in the landfill

   ii. Rapid degradation of air quality in the surrounding area

   iii. Rapid rusting of metals in the surrounding area due to acid rain

   iv. Rapid growth of plants in the surrounding area due to the landfill's waste acting as fertilizer

   A. i and ii **B.** iii and iv **C.** i and iii **D.** All of the above

7. If plastic waste is dumped in a landfill as shown in Figure 6, what would happen to it over a period of 30 years?

   A. The plastic will biodegrade in the absence of oxygen

   B. Plastic is chemically inert hence it will not degrade in 30 years

   C. The landfill will attract wild animals that will break down the plastics

   D. Exposure to sunlight will degrade the plastic completely as UV rays will break down its molecules

Figure 6

8. Figure 7 shows an example of open burning of waste including plastic. This method of disposal is dangerous as toxic fumes will be released from the burning plastic.

Figure 7

a. Which is the best method of plastic disposal from the list below?

	Disposal method
A	Bury the plastic in the backyard
B	Dump in a landfill with concrete base
C	Release the plastic into the sea for it to degrade
D	Incinerate in a controlled incinerator that converts the plastics into energy

b. Explain your answer.

.....

.....

9. Raju's sister brings home several items from her kindergarten's art class as shown in Figure 8. Her kindergarten's art class is promoting which part of the 3Rs?

Figure 8

A. Reduce
B. Reuse
C. Recycle
D. Remake

10. Among the benefits of the 3Rs are:

i. Reduces the cost of crude oil extraction
ii. Reduces the usage of raw materials to make new products
iii. Reduces water pollution from leachate produced by landfills
iv. Reduces GHG emissions from the decomposition of waste in landfills

A. i, ii and iv
B. i, iii and iv
C. ii, iii and iv
D. All of the above

11a. Tick (√) the right recycling technology for each of the different types of solid waste.

Type of Waste	*Mechanical recycling*	*Energy recycling*	*Chemical recycling*
PET bottle			
Food waste			
Shampoo bottle			
Multilayered plastic			

11b. Explain your answer.

.....

.....

ANSWER SCHEME

ACTIVITY 1

Objectives:

a. ***For students to learn what can be recycled and what cannot be recycled.***
b. ***For them to understand how much waste is being generated daily.***

ACTIVITY 2

Objectives:

a. ***For students to learn about which of our commonly used products can or cannot be recycled.***
b. ***To encourage the practice of separating at source, thus reducing solid waste to landfills.***
c. ***For students to share their ideas on solid waste reduction.***

Question 1 - D
Alkaline batteries have longer lifespans than conventional single-use batteries and can be recharged for extended use.

Question 2 - D

Question 3 - C
Incinerators are used to convert complex or composite plastics into electrical energy.

Question 4 - D
It is important for the plastic products to be separated into similar types before they can be mechanically recycled.

Question 5 - C
Listing down what she needs to buy prior to shopping will help her to reduce spending by buying only what she needs.

Question 6 - A

Question 7 - B
Plastic is non-biodegradable.

Question 8a - D
Plastic can be safely recycled for energy via incinerators.

Question 9 - B
Raju's sister is repurposing plastic bottles into decorative pots. This falls under the Reuse part of 3Rs.

Question 10 - C

Question 11

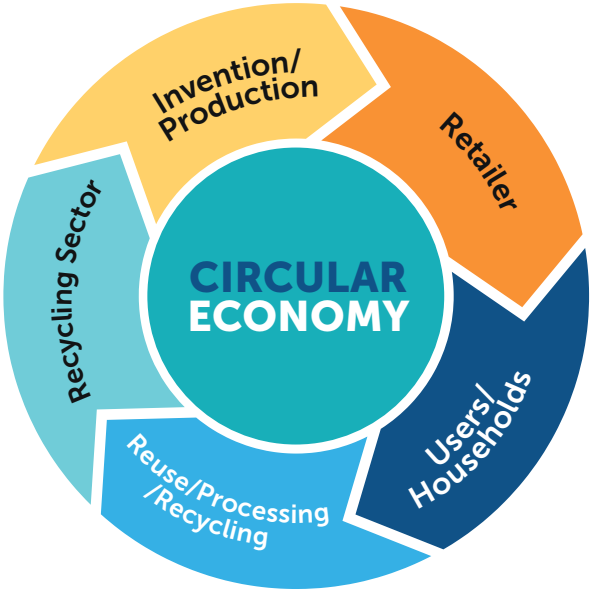
Type of Waste	*Mechanical recycling*	*Energy recycling*	*Chemical recycling*
PET bottle	√	√	√
Food waste		√	
Shampoo bottle	√	√	√
Multi layered plastic		√	√

CONCLUSION

Creating a Circular Economy

To address global environmental concerns such as global warming and marine litter will require an understanding of sustainability and waste management practices such as using a bin to avoid littering, separation at source to reduce waste going to landfills and 3Rs. These practices have one common end goal; to recover as much resources as possible through reducing leakages and wastage into the environment.

Besides doing our part as an individual by incorporating these practices into our daily life, companies and businesses are also taking initiatives to lead by example in realising and achieving this end goal. One main initiative taken is to adopt the circular economy.



What is a circular economy?

A circular economy is a regenerative economy that minimises waste and makes the most of resources. Such a system resembles nature, where there is no waste. For example, a fallen leaf decomposes and adds nutrients to the soil which then promotes further growth of plants.

In the circular economy, products are 'made to be made again'. This means regenerating products back to its original form; or regenerating business outputs - back into its systems.

As the world continues to find ways to tackle environmental issues, we must be more responsible and take proactive actions towards managing the waste we produce.

This **'Plastic, Sustainability & You'** module serves as a guide towards achieving a sustainable future for us and generations to come.

GLOSSARY

Acidification
The action or process of making or becoming acidic.

Anaerobic
Environment with little or no oxygen.

Bakelite
A synthetic thermoset plastic used to make telephones, toys, radios and jewellery. It is also a good electrical insulator.

Barrier Property
Ability to significantly restrict the passage of gases, vapours and liquids.

Biocompatible
Not harmful or toxic to living tissue.

Biodegradable
A substance or object capable of being decomposed by bacteria or other living organisms.

Biodiversity
The variety of plant and animal life in the world or in a particular habitat.

Bioplastic
Biodegradable/non-biodegradable plastic material derived from renewable sources such as plants.

Cellulose Acetate
A non-flammable thermoplastic polymer made by acetylating cellulose, used as the basis of artificial fibres and plastic.

Climate Change
A change in global or regional climate patterns attributed largely to increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.

Corrosion
A process or act that slowly corrodes or damages materials.

Degradation
The breakdown of an item into its elements.

Disposal
The action or process of getting rid of something.

Downcycle
A recycling practice that involves breaking an item down into its components or material. Once the constituent elements or materials are recovered, these are reused if possible but usually as a lower-value product.

Ecosystem
A community of organisms that interact with each other and the environment consisting of biotic elements (plants, humans and animals) and abiotic elements (sunlight, water, air, and soil).

Epoxy
A type of reactive prepolymers and polymers which contain epoxide groups.

Ethylene
Monomer used in production of polyethylene.

Eutrophication
Eutrophication, or hypertrophication, is when a body of water becomes overly enriched with minerals and nutrients which induce excessive growth of algae. This process may result in oxygen depletion of the water body.

Global Warming
A gradual increase in the overall temperature of the earth's atmosphere generally attributed to greenhouse gases and other pollutants.

Habitat
Natural home or environment of an animal, plant or other organism.

Inert
Chemically inactive.

Life Cycle Assessment
Technique to assess the enviromental impact associated with a product's life cycle from cradle to grave.

Melamine Resin
Thermosetting plastic material which is made from melamine and formaldehyde.

Open Burning
Any type of uncontrolled burning that occurs in open air.

Organic Waste
Comes from either plant or animal which include food and garden waste.

Ozone
A colourless gas and a form of oxygen consisting of 3 atoms in its molecule.

Permeability
Materials' ability to allow liquids or gases to pass through.

Phenol Formaldehyde
A class of plastics and resins made by the condensation of phenols with formaldehyde.

Polyethylene
A tough, light flexible synthetic resin made by polymerising ethylene, chiefly used for plastic bags, food containers and other packaging.

Polyethylene Terephthalate
A synthetic resin made by copolymerising ethylene glycol and terephthalic acid, widely used to make polyester fibres.

Polylactid Acid
Thermoplastic aliphatic polyester derived from renewable biomass such as corn and cassava.

Polypropylene
A synthetic resin which is a polymer of propylene, used chiefly for films, fibres or moulding materials.

Polystyrene
A polymer synthetic resin, commonly used to produce food containers, body kit of vehicles and housing for electrical and electronic appliances.

Polyurethane
A synthetic resin in which the polymer units are linked by urethane groups, used chiefly as constituents of paints, varnishes, adhesives and foams.

Polyvinyl Chloride
A tough chemically resistant synthetic resin made by polymerising vinyl chloride and used for a wide variety of products including pipes, flooring and sheeting.

Propulsion
The action of driving or pushing forward.

Propylene
Monomer used in the production of polypropylene .

Recycle
Way or technique to process recyclable items or materials (used aluminium, glass, paper and plastic) to allow for new usage.

Reduce
Reducing the generation of waste before and during the usage of a product.

Reuse
Reusing products or materials which can be used again.

Separation at Source
Process of separating solid waste at source (home, office, schools) according to the type of waste i.e. recyclable and non-recyclable waste, before disposal.

Solid Waste
Anything in solid form to be disposed of because it is broken, contaminated, old, unwanted, etc. Types of solid waste are plastic, garden waste, rubber, paper, metals, textiles and glass.

Stiffness
The quality of being firm and difficult to bend.

Styrene
A monomer used in production of polystyrene.

Thermal Insulation
Material that will not transmit heat.

Thermoplastic
Plastic that melts on heating and hardens on cooling and able to repeat this without losing it properties.

Thermoset
Plastic which sets permanently when heated.

Toughness
The quality of not easy to break or separate, even when bent.

Transfer Station
Station where solid waste collected from households is segregated before being sent to landfills.

Upcycle
Reuse (discarded object/material) in such a way as to create a product of higher quality or value than the original.

Urea-Formaldehyde
Non-transparent thermosetting resin or polymer produced from urea and formaldehyde.

Vinyl Chloride
Monomer used in the production of polyvinyl chloride.

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making this effort possible.

It is our sincere hope that our collective efforts will ensure a sustainable
world for future generations.

In collaboration:

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