

DP IB Environmental Systems & Societies (ESS): SL

7.3 Solid Waste

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Introduction to Waste

Sources & Types of Waste

- The use of natural resources generates **waste**
 - This waste can be classified by **source** or **type**

Sources of waste

- **Domestic waste:**
 - Waste generated from households, including food scraps, packaging and broken items
- **Industrial waste:**
 - Produced by factories and industries, such as chemicals, metals and manufacturing by-products
- **Agricultural waste:**
 - Created by farming activities, including animal manure, crop residues and empty containers from chemicals like pesticides and herbicides

Types of waste

- **E-waste:**
 - Electronic waste, such as old computers, mobile phones and televisions
 - E-waste contains toxic materials like lead and mercury
- **Food waste:**
 - Edible food that is discarded, often due to over-purchasing or spoilage
- **Biohazardous waste:**
 - Dangerous waste from hospitals or laboratories, such as medical equipment, needles and blood products (e.g. blood or plasma samples)

Solid Domestic Waste

- Solid domestic waste (SDW) refers to the non-liquid waste produced in **homes**
 - SDW typically includes a wide variety of materials, making it a challenge to manage and recycle

Common components of solid domestic waste

- **Paper:** newspapers, magazines and packaging materials
- **Cardboard:** packaging boxes and containers
- **Glass:** bottles and jars
- **Metal:** aluminium cans and tin containers
- **Plastics:** bottles, food containers and plastic bags
- **Organic waste:** food scraps, garden clippings and other biodegradable materials
- **Packaging:** items such as plastic wrap, Styrofoam and boxes
- **Construction debris:** waste from home repairs or renovations, such as bricks and wood
- **Clothing:** old or unwanted clothes and textiles

Volume & Composition of Waste

- The **volume** and **composition** of waste vary across time and between societies
- Numerous factors play a role in this

Factors influencing waste volume and composition

Socio-economic factors

- Wealthier societies often generate more waste
 - This is due to:
 - Higher consumption levels
 - Single-use products
 - Excessive packaging
 - Culture of convenience
 - Fast fashion
 - For example, high-income countries like the United States generate more waste per person compared to lower-income countries like India
- Lower-income countries may produce less waste
 - However, they often have **less capacity to manage it properly**

Political factors

- Government policies can impact waste production, such as:
 - Recycling laws
 - Waste taxes
 - Bans on certain materials
 - Landfill regulations
- Countries with strong waste management policies tend to have lower levels of unmanaged waste
 - For example, the European Union's ban on single-use plastics has reduced plastic waste in member countries

Environmental Factors

- **Environmental awareness** can lead to reduced waste, such as more recycling or composting programmes
- Geographical location:
 - Popular tourist destinations experience high amounts of waste production during peak seasons

- Large amounts of crop waste follow harvest seasons in the agricultural sector
- Natural disasters can also increase the amount of waste generated
 - For example, after powerful hurricanes, large volumes of construction and debris waste can be generated during rebuilding efforts

Technological Factors

- Advancements in technology can **reduce** waste, such as:
 - Creating biodegradable plastics
 - More efficient recycling methods
- However, the rapid pace of **technological advancements** causes large amounts of **electronic waste**
 - This is because consumers want to regularly update their devices to newer versions with better features
 - Renewable energy sources can also produce large amounts of electronic waste, e.g. old or damaged solar panels and wind turbine blades
- New products can also increase waste if they are designed for **short-term use** (e.g. disposable electronics such as e-cigarettes or vapes)

Environmental & Social Impacts of Waste

Environmental & Social Impacts of Waste

Environmental impacts of waste

- The **production**, **treatment** and **disposal** of waste can have severe environmental consequences, both locally and globally

Pollution

- **Air pollution:** burning waste, especially in open landfills, can release harmful gases like methane and carbon dioxide
 - These gases contribute to climate change
 - Decomposing organic waste in landfills also produces methane (a potent greenhouse gas)
- **Water pollution:** improper waste disposal can lead to chemicals and hazardous materials leaching into rivers, lakes and oceans
 - This harms aquatic life and contaminates drinking water sources
- **Soil pollution:** hazardous waste, chemicals and heavy metals from landfills or improper waste disposal can seep into the soil
 - These pollutants contaminate soils and harm plant growth, as well as enter food chains through plants and crops

Habitat destruction

- Landfills and waste dumps take up **large areas of land**
 - This often leads to the destruction of natural habitats and loss of biodiversity
 - For example, in Ghana, the Agbogbloshie e-waste dump has not only polluted local water sources but also destroyed large areas of natural land

Social impacts of waste

- Waste management also has important social consequences
 - These particularly affect **low-income communities** and **countries**

Health risks

- Exposure to waste, especially **e-waste** and **biohazardous materials**, can lead to serious health issues

- This can include respiratory diseases, skin infections and cancers
- Low-income countries that receive waste from high-income nations often **lack proper facilities** to safely **handle** and **treat** waste
 - This can result in dangerous living and working conditions for local people

Environmental injustice

- **Waste exports:** high-income countries often export their waste to low-income countries, which struggle to manage it safely
 - This leads to environmental injustice
 - This occurs when the negative impacts of waste are disproportionately experienced by poorer countries
- The **Basel Convention** was introduced by the **United Nations Environment Programme (UNEP)** in **1992**
 - It is an international treaty designed to:
 - Regulate the movement of hazardous waste between countries
 - Prevent the export of such waste from high-income to low-income nations
 - Protect human health and the environment from the dangers of improper waste disposal
 - However, illegal waste exporting and dumping still occurs

Impact on local communities

- The presence of landfills or waste processing plants near communities can decrease the quality of life for local people due to:
 - Bad smells
 - Noise
 - Potential contamination of local water and soil
- Communities near waste sites often suffer from:
 - Lower property values
 - Reduced economic opportunities
 - Poor health outcomes

Ecosystems & Pollution

- Pollution occurs when harmful substances are added to the environment at a rate **faster** than ecosystems can **process** or **transform** them into **harmless substances**
 - Ecosystems naturally have the ability to absorb and manage a certain amount of waste and pollution
 - They achieve this through processes like photosynthesis and nutrient cycling
 - However, when the amount of waste exceeds their capacity, pollution builds up
 - At this point, it causes harm to the environment

Ability of ecosystems to absorb waste

- **Ecosystems as natural filters:** many ecosystems can absorb and transform pollutants into less harmful substances
- Some examples include:
 - **Forests:** trees absorb **carbon dioxide** during **photosynthesis**
 - They convert it into oxygen, reducing the amount of CO₂ in the atmosphere
 - **Wetlands:** ecosystems like **salt marshes** and **mangroves** can absorb **nitrogen, phosphorus** and other pollutants from water
 - They act as natural filters, trapping these substances and using them for plant growth
 - **Grasslands and farmlands:** plants can take up nitrogen and phosphorus from the soil as nutrients for their growth
 - This can help reduce the impact of agricultural runoff
- **Ecosystem services:** ecosystems provide services that help manage pollution, such as:
 - **Carbon sequestration:** plants absorb CO₂ from the atmosphere and store it in their tissues, reducing greenhouse gases
 - **Water filtration:** wetlands and forests filter pollutants from water before they enter rivers, lakes, or oceans, improving water quality
 - For example, salt marshes along coastlines can absorb pollutants like heavy metals and excess nutrients
 - This reduces the flow of these substances into the ocean, protecting marine ecosystems

Limits to ecosystem absorption

- **Overloading ecosystems:** when pollutants are added at a faster rate than ecosystems can process them, pollution occurs
- For example:
 - **Excess CO₂:** while forests can absorb CO₂, human activities like deforestation reduce the number of trees
 - This limits their ability to manage rising CO₂ levels
 - **Eutrophication:** wetlands can absorb nutrients, but when agricultural runoff contains too much nitrogen and phosphorus, these ecosystems become overloaded
 - This leads to water pollution and eutrophication

Biodegradability and half-lives

- The term **biodegradability** refers to how quickly natural processes can break down a substance into harmless components
 - **Biodegradable materials:** substances like paper and food waste decompose quickly
 - This is because bacteria and other organisms break them down into harmless materials
 - **Non-biodegradable materials:** substances like plastic, glass or synthetic chemicals do not break down easily
 - They can remain in the environment for hundreds or thousands of years
- **Half-lives:** this concept refers to the time it takes for half of a substance to decay or break down
- Some pollutants, especially chemicals or radioactive materials, have long half-lives, meaning they remain dangerous in the environment for extended periods
 - **Long half-lives:** pollutants like **pesticides** (e.g. DDT) or **radioactive waste** have long half-lives
 - They persist in ecosystems for years or decades
 - For example, DDT has a half-life of around 15 years, meaning it can stay in the soil and water for decades, affecting wildlife, food chains and whole ecosystems
 - **Short half-lives:** substances like organic waste decompose quickly
 - This reduces their environmental impact

Waste Disposal

Waste Disposal Methods

- Waste disposal is critical in **managing** and **minimising** the environmental impact of waste
- Various methods are available
 - Each has advantages and disadvantages that should be taken into account when considering their impact on societies and ecosystems

1. Landfill sites

- Landfills involve burying waste in designated areas in large holes dug into the ground

Advantages

- Centralised waste management:** provide a single location for managing large volumes of waste
- Flexible:** handle a wide range of materials, including non-recyclable materials
- Lower operational costs:** relatively inexpensive compared to other waste disposal methods
- Reduced environmental impact:** can be engineered with liners and **leachate** collection systems to minimise environmental impact
- Gas capture potential:** some capture methane gas, which can be used as an energy source

Disadvantages

- Methane generation:** produces methane, a potent greenhouse gas
- Land requirements:** needs significant land, which can be difficult to find
- Risk of contamination:** potential for groundwater and soil pollution from leachate
- Long-term monitoring:** requires management long after closure
- Environmental injustice:** often causes noise and smell pollution in less affluent urban outskirts
 - This disproportionately impacts the health and quality of life of residents in these areas

2. Incineration

- Incineration involves burning waste materials at high temperatures to reduce their volume

Advantages

- Reduces waste volume:** drastically cuts down the physical size of waste

- **Less reliance on landfills:** reduces amount of waste sent to landfill sites
- **Handles hazardous waste:** can process hazardous materials safely

Disadvantages

- **Air pollution:** emits harmful gases and pollutants, including greenhouse gases
- **High operational costs:** requires expensive technology and maintenance.
- **Ash disposal:** produces toxic ash that requires careful disposal
- **Public concern:** communities often oppose incinerators due to health and environmental concerns

3. Waste-to-energy (WtE)

- Waste-to-energy (WtE) or energy-from-waste (EfW) plants burn waste to generate electricity or heat

Advantages

- **Energy recovery:** converts waste into usable energy, reducing reliance on fossil fuels
- **Reduces landfill use:** decreases the amount of waste sent to landfills
- **Waste volume reduction:** significantly reduces the amount of waste

Disadvantages

- **Pollution risks:** can release harmful emissions and greenhouse gases unless controlled properly
- **High capital investment:** expensive to build, operate and maintain WtE plants
- **Limited by waste composition:** not all types of waste can be efficiently converted to energy
- **Not a perfect solution:** still encourages waste generation instead of focusing on reduction and recycling.

4. Exporting Waste

- Exporting waste involves sending waste materials to other countries for treatment, recycling or disposal

Advantages

- **Offloads waste responsibility:** countries with waste management challenges can send waste to others
- **Reduces domestic pressure:** eases the burden on local waste management systems
- **Access to advanced facilities:** may provide waste producers with access to specialised waste treatment options

- **Economic benefit:** may be cheaper for some countries to export waste than to process it locally

Disadvantages

- **Environmental injustice:** exporting to low-income countries may cause environmental and social harm there, raising ethical concerns
- **Environmental impact of transport:** shipping waste long distances increases carbon emissions
- **Legal risks:** can lead to legal issues between exporting and importing nations
- **Long-term effects:** does not help solve the root cause of excessive waste generation

5. Recycling

- Recycling involves converting waste materials into new, usable products

Advantages

- **Resource conservation:** saves raw materials and reduces the need for new resource extraction, which can be environmentally damaging and polluting
- **Energy savings:** recycling typically uses less energy than producing new materials
- **Economic cost:** may be cheaper than other waste disposal options
- **Reduces landfill and incineration:** keeps recyclable materials out of waste disposal facilities

Disadvantages

- **Energy use in processing:** sorting, collecting and processing recyclables can be energy-intensive
- **Limited recycling facilities:** availability and access to recycling facilities can vary between countries and regions
- **Contamination:** contaminated recyclables can reduce the efficiency of the recycling process
- **Limited market:** not all materials are recyclable and there can be limited demand for recycled products

6. Composting

- Composting is the process of breaking down organic waste into nutrient-rich soil

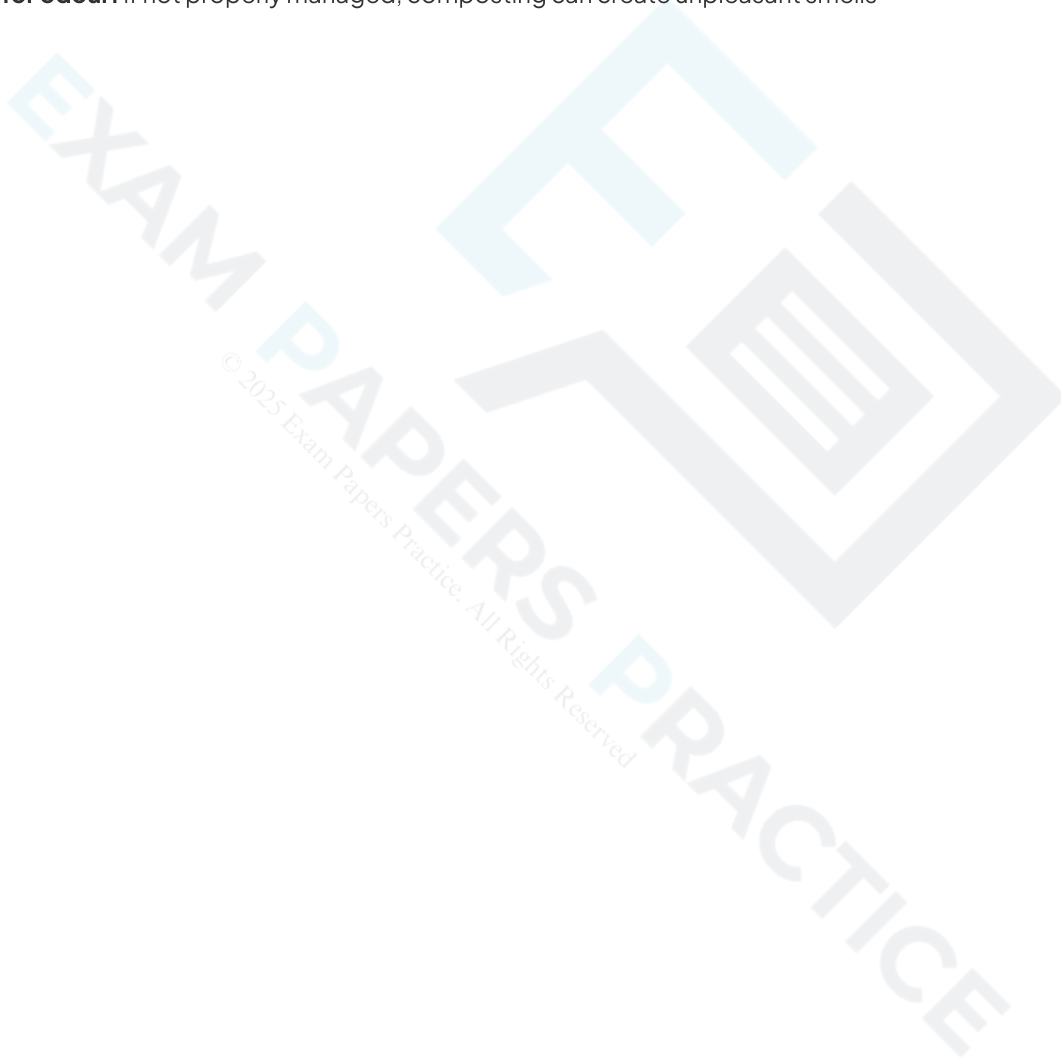
Advantages

- **Environmentally friendly:** composting produces natural fertilisers, reducing the need for chemical alternatives
- **Reduces landfill waste:** organic matter is kept out of landfills, lowering methane emissions

- **Enriches soil:** compost improves soil health and can enhance crop growth
- **Low cost:** can be done on a small scale at home or in local communities

Disadvantages

- **Limited to organic waste:** can only handle biodegradable materials
- **Space and time requirements:** requires space for compost piles and can take time to break down waste
- **Potential for odour:** if not properly managed, composting can create unpleasant smells



Waste Management

Waste Management Strategies

- Waste management strategies aim to minimise the impact of waste on the environment and human health
- They can be divided into **preventative** and **restorative** strategies

Preventative strategies

- Preventative strategies focus on **reducing waste generation** and controlling pollution **before it happens**
 - These strategies are generally **more sustainable** than restorative approaches
- Changing human behaviour**: encouraging people to reduce consumption and recycle more effectively can prevent waste from accumulating.
 - E.g. **reduced consumption** through campaigns encouraging people to buy only what they need or use reusable products like bags and bottles
 - E.g. **composting food waste** at home reduces organic waste sent to landfills and returns nutrients to the soil
- Controlling the release of pollutants**: limiting the amount of pollution and waste released into the environment can help prevent damage
 - E.g. **waste disposal legislation** sets strict rules about how and where waste can be disposed of to minimise environmental harm
 - E.g. **recycling and reuse programmes** help conserve natural resources and reduce the need for landfills and incinerators
- The most effective preventative strategy is to consume fewer products, leading to **less waste**

Restorative strategies

- Restorative strategies focus on:
 - Cleaning up waste**
 - Repairing environmental damage** caused by waste mismanagement
- Oceanic garbage patch clean-up**: efforts to remove plastic waste from the Great Pacific Garbage Patch are an example of a restorative strategy
 - Though challenging and expensive, it helps to reduce harm to marine life

- **Landfill reclamation:** some landfills are being reclaimed by **removing waste** and turning the land into parks or other usable spaces
 - This process restores the land but is costly and time-consuming
- **Restoration of contaminated sites:** some areas heavily polluted by industrial waste or hazardous materials undergo clean-up efforts to make the land safe again
 - This often involves removing soil or water contamination

Sustainability of preventative vs. restorative strategies

- Preventative strategies are more sustainable because they stop the problem **before it happens**
 - They require less energy and resources compared to cleaning up waste after the damage has been done
- Restorative strategies are important but less sustainable
 - They usually require large amounts of money, time and effort
 - Often the damage cannot be fully undone

Hierarchy of waste management strategies

- Different waste management strategies can also be viewed as being part of a hierarchy
 - The hierarchy of waste management strategies ranks options from the most to least sustainable
 - It prioritises reducing waste at the source, followed by reusing, recycling, recovering energy, and finally, disposing of waste in landfills or through incineration



Sustainable Waste Management

- Sustainable waste management focuses on:
 - Minimising the environmental and social impacts of waste
 - Promoting more efficient use of resources
- It encourages reducing, reusing and recycling waste rather than relying on disposal methods like landfills and incineration

Strategies for promoting sustainable waste management

- Societies can adopt various strategies to promote more sustainable management of solid domestic waste (SDW):
- **Taxes:**
 - Governments can impose taxes on activities or products that generate excessive waste
 - E.g. plastic bag taxes in the UK have reduced single-use plastic consumption by over 90% since 2015
- **Incentives:**
 - Financial rewards can encourage sustainable behaviour, such as recycling or composting
 - E.g. deposit-return schemes for bottles and cans provide consumers with a financial incentive to recycle
- **Social policies:**
 - Social policies can regulate the way waste is managed at a societal level
 - E.g. **pay-as-you-throw** (PAYT) waste schemes: in some areas, residents are charged based on the amount of waste they produce
 - This encourages people to recycle more and generate less waste, as they can save money by reducing their waste output
- **Legislation:**
 - Laws can require businesses and individuals to follow sustainable waste management practices
 - E.g. the European Union's **Waste Framework Directive** sets clear guidelines for recycling and waste reduction
- **Education and campaigns:**
 - Educating the public about the importance of sustainable waste management can change behaviours
 - E.g. **school recycling programmes**, where students are taught about waste separation, recycling and environmental conservation
- **Improved access to disposal facilities:**

- Making it easier for people to dispose of waste sustainably can encourage more responsible behaviour
- E.g. increasing the number of **recycling points** in **urban areas** can reduce improper waste disposal

The circular economy and sustainable waste management

- A **circular economy** is a sustainable approach to managing resources and waste by:
 - Keeping materials in use for as long as possible
 - Minimising waste
 - Recovering resources at the end of a product's life
- This system contrasts with the traditional **linear economy**
 - This is where products are made, used and then discarded
- Principles of the circular economy:
 - **Design for longevity**: making products that last longer and can be reused or repaired
 - **Resource efficiency**: minimising the use of raw materials by recycling and reusing
 - **Product recovery**: recovering and reusing materials at the end of a product's life

- Example of a **circular economy path** (aluminium cans):
 - **Manufacturing:** aluminium cans are made from recycled aluminium
 - **Use:** consumers purchase and use the cans
 - **Collection:** used cans are collected through recycling bins or deposit-return schemes
 - **Recycling:** the cans are cleaned, melted and reformed into new cans, reducing the need for new raw materials
 - **Reuse:** the recycled cans are used to package new products (e.g. soft drinks) and the cycle begins again
- This example demonstrates how the circular economy reduces waste, conserves resources and reduces the need for raw material extraction

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