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POLITEKNIK MALAYSIA
TUANKU SULTANAH BAHIYAH

Smart Solutions for Municipal Solid Waste Management

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ENVIRONMENTAL POLLUTION & CONTROL

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“ This book is dedicated to all our students, who make it worthwhile”

ACKNOWLEDGEMENT

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Preface

The aim of this book is written to be used as a reference by Polytechnic Malaysia students. This e-book provides knowledge about effective solutions in managing municipal solid waste and with the hope that those who use this book may make the environment of the future a sustainable one.

Table of Content

WHAT MUNICIPAL SOLID WASTE?

Municipal solid waste (MSW) refers to the waste generated from households, commercial establishments and institutions within a municipality. It includes a wide range of materials,
such as:

1. **Organic Waste**: Food scraps, yard waste and other biodegradable materials.

2. **Recyclables**: Paper, cardboard, glass, metals, and certain plastics that can be reprocessed.

3. **Non-Recyclables**: Items that cannot be recycled or composted, such as certain types of plastic and other materials.

4. **Hazardous Waste**: E-waste, batteries, chemicals, and other materials that require special handling.

COMPONENTS OF MSW

Municipal solid waste (MSW) is made up of a variety of materials that are commonly generated by households and commercial establishments. The main components typically include:

i. **Organic Waste:**
- Food scraps
- Yard waste (leaves, grass, branches)

ii. **Paper Products**:
- Newspapers
- Cardboard
- Office paper
- Magazines

iii. **Plastics:**
- Bottles
- Containers
- Bags

iv. **Metals:**
- Aluminum cans
- Steel cans
- Foil

COMPONENTS OF MSW

v. **Glass:**
- Bottles
- Jars

vi. **Textiles:**
- Clothing
- Fabrics

vii. **Hazardous Waste:**
- Batteries
- Paint
- Chemicals

viii. **Other:**
- Electronics (e-waste)
- Furniture
- Appliances

The composition of MSW can vary significantly based on factors like location, season, and socioeconomic status. Proper management and recycling of these components are crucial for reducing environmental impact.

KEY ISSUES AND MANAGEMENT STRATEGIES

- **Waste Reduction**: Encouraging practices like composting, recycling, and minimizing single-use items to reduce the amount of waste generated.

- **Recycling Programs**: Implementing systems for collecting and processing recyclables to reduce landfill use and conserve resources.

- **Composting**: Diverting organic waste from landfills by turning it into compost, which can be used to enrich soil.

- **Landfilling and Incineration**: While these are common disposal methods, they come with environmental concerns, including greenhouse gas emissions and pollution.

- **Public Education**: Raising awareness about waste management practices and the importance of reducing, reusing, and recycling.

SIGNIFICANCE OF EFFECTIVE WASTE MANAGEMENT

Effective waste management is crucial for both public health and environmental protection.

Here are some key points highlighting its significance:

Public Health

- **Disease Prevention**: Proper waste disposal reduces the risk of vector-borne diseases (like those spread by rats and mosquitoes) and prevents the contamination of food and water sources.
- **Air Quality**: Reducing open burning of waste minimizes air pollution, which is linked to respiratory issues and other health problems.
- **Water Safety**: Proper management prevents leachate (toxic liquid that can seep from waste) from contaminating groundwater and surface water, protecting drinking water sources.
- **Community Well-being**: Clean and well-managed environments contribute to mental health and quality of life, fostering community pride and engagement.

SIGNIFICANCE OF EFFECTIVE WASTE MANAGEMENT

Environmental Protection

- **Resource Conservation**: Effective waste management promotes recycling and recovery, conserving natural resources and reducing the need for new materials.
- **Reduction of Landfill Impact**: Proper waste management decreases the volume of waste sent to landfills, reducing land use and methane emissions (a potent greenhouse gas) from decomposing organic waste.
- **Biodiversity Preservation**: Proper disposal and treatment of hazardous materials prevent soil and water contamination, protecting ecosystems and wildlife.
- **Sustainable Development**: Integrating waste management into broader environmental strategies supports sustainable urban development and reduces the ecological footprint of communities.

Economic Benefits

- **Cost Savings**: Efficient waste management can reduce costs associated with waste collection and disposal, and lower health care costs related to pollution-related diseases.
- **Job Creation**: The waste management sector creates jobs in recycling, waste treatment, and resource recovery.

Overall, effective waste management is essential for safeguarding public health, protecting the environment, and promoting sustainable development.

TYPES OF WASTE

Municipal solid waste (MSW) can be categorized into several types based on its source and composition. Here's a breakdown of the main types:

1. Residential Waste

- **Description**: Waste generated from households.
- **Components**:
  - Food scraps
  - Yard waste (leaves, grass)
  - Paper products (newspapers, cardboard)
  - Plastics (bottles, containers)
  - Glass (bottles, jars)
  - Textiles (clothing, linens)

2. Commercial Waste

- **Description**: Waste produced by businesses and institutions.
- **Components**:
  - Office waste (paper, electronics)
  - Retail waste (packaging materials, unsold products)
  - Food service waste (from restaurants and cafes)
  - Construction materials (from office renovations)

3. Industrial Waste

- **Description**: Waste generated from manufacturing and industrial processes.
- **Components**:
  - Scrap metal
  - Plastics and rubber
  - Chemicals and solvents
  - Packaging materials
  - Byproducts from production processes

4. Construction and Demolition Debris

- **Description**: Waste produced from construction, renovation, and demolition activities.
- **Components**:
  - Wood (from framing and pallets)
  - Concrete and masonry
  - Metals (steel, aluminum)
  - Drywall

SOURCES OF WASTE

Each type of MSW has its own management challenges and requires different strategies for effective recycling, disposal, and treatment. Proper classification helps in implementing appropriate waste management practices to minimize environmental impact and enhance resource recovery.

In urban areas, municipal solid waste (MSW) typically comes from a variety of sources. Here are some common sources of MSW :

1. Residential Sources

- **Households**: Waste generated from daily living activities, including food scraps, packaging, paper products, and yard waste.

2. Commercial Establishments

- **Retail Stores**: Waste from packaging materials, unsold items, and shop displays.
- **Restaurants and Cafes**: Food waste, packaging, and disposables like cutlery and plates.
- **Offices**: Paper waste, electronics, and office supplies

3. Institutional Sources

- **Schools and Universities**: Waste from cafeterias, classrooms, and events, including paper, food scraps, and plastics.
- **Hospitals and Healthcare Facilities**: Medical waste, packaging, and general refuse from patient care.

4. Construction and Demolition Sites

- **Construction Projects**: Waste from building materials, such as wood, concrete, metals, and drywall, generated during construction, renovation, and demolition.

5. Public Spaces

- **Parks and Recreation Areas**: Litter, food waste from picnics, and debris from events.

- **Streets and Sidewalks**: Trash generated from pedestrians, including cigarette butts, packaging, and other litter.

6. Events and Festivals

- **Large Gatherings**: Waste generated from concerts, fairs, and public events, which can include a significant amount of food waste and single-use plastics.

7. Illegal Dumping

- **Unregulated Disposal**: Waste that is illegally disposed of in public spaces, contributing to environmental issues.

8. Street Cleaning and Maintenance

- **Street Sweeping**: Debris collected during street cleaning operations, including leaves, dirt, and litter.

WASTE GENERATION

Malaysia has experienced significant growth in waste generation in recent years, largely due to urbanization and population growth. Here are some key statistics on waste generation in Malaysia:

- **Total Waste**: As of recent reports, Malaysia generates approximately **38,000 to 40,000 tons**

  of solid waste per day.
- **Annual Growth Rate**: The waste generation rate has been increasing at about **1.5% to 3%** per year.

COMPOSITION OF WASTE

- **Organic Waste**: About **45% to 60%** of the total waste is organic, including food scraps and yard waste.
- **Plastic Waste**: Plastics account for around **15% to 20%** of the total waste generated.
- **Paper and Cardboard**: These materials make up approximately **10% to 15%** of the waste stream.
- **Hazardous Waste**: Industrial and hazardous waste comprises about **1% to 3%** of the total waste.

RECYLING RATES

Recycling Rate: The national recycling rate has improved, reaching around **30%** in recent years, but there are goals to increase this further to **40%** by 2025.

REGIONAL DEFFERENCES

Regional Differences

- **Urban vs. Rural**: Urban areas tend to generate significantly more waste per capita compared to rural areas, with major cities like Kuala Lumpur producing a higher volume of waste.

FUTURE PROJECTION

Future Projections

- With ongoing urbanization and economic growth, waste generation is projected to increase, necessitating improved waste management strategies and infrastructure.
- These statistics highlight the challenges Malaysia faces in managing solid waste and the importance of sustainable practices to reduce waste generation and improve recycling efforts.

COMMON CHALLENGES IN WASTE MANAGEMENT

Waste management is a critical issue that encompasses several challenges, including waste segregation, illegal dumping, and insufficient infrastructure. Some of the issues are as outlined below:

WASTE SEGREGATION

- Waste segregation involves separating different types of waste at the source—typically into categories like recyclables, compostables, and general waste. Effective segregation is vital for:
- **Recycling Efficiency:** Properly sorted materials can be recycled more effectively, reducing the amount of waste sent to landfills.
- **Resource Recovery:** Segregation facilitates the recovery of valuable materials, conserving natural resources.
- **Public Awareness:** Educating the community about the importance of segregation encourages responsible waste management practices.
- Challenges include a lack of public awareness, inadequate access to bins, and inconsistent policies across regions.

ILLEGAL DUMPING

Illegal dumping refers to the disposal of waste in unauthorized locations, which poses significant environmental and health risks.

Key issues include:

- **Environmental Impact:**

Dumping can lead to soil and water contamination, harming local ecosystems.

- **Public Health Concerns:**

Accumulated waste can attract pests and create breeding grounds for diseases.

- **Economic Costs:**

Local governments often face increased cleanup costs and lost revenue from proper waste disposal.

Addressing illegal dumping requires community engagement, enforcement of regulations, and improved access to legal disposal facilities.

- Addressing illegal dumping requires community engagement, enforcement of regulations, and improved access to legal disposal facilities.
- **Insufficient Infrastructure**
- Many areas struggle with inadequate waste management infrastructure, which can exacerbate both segregation and illegal dumping issues. Key aspects include:
- **Limited Collection Services:** In some regions, waste collection services may be infrequent or nonexistent, leading to accumulation and dumping.
- **Insufficient Recycling Facilities:** A lack of recycling centers means that even well-sorted recyclables may end up in landfills.
- **Inaccessible Disposal Options:** If proper disposal sites are far or difficult to access, residents may resort to illegal dumping.

STRATEGIES FOR REDUCING WASTE GENERATION

1. Reduce and Reuse
2. Consumer Education and Awareness
3. Encourage Minimalism
4. Incentivize Businesses
5. Legislation and Policies
6. Implement Composting Programs
7. Support Local and Sustainable Products
8. Innovative Packaging Solutions
9. Community Initiatives
10. Use Technology such as Waste tracking App

RECYCLING PROGRAMS

Purpose and Benefits:

- Resource Conservation: Recycling recovers valuable materials such as metals, plastics, and paper, reducing the need for raw resources.
- Energy Savings: Recycling often uses less energy than producing new materials from raw resources.
- Pollution Reduction: It minimizes greenhouse gas emissions and other pollutants associated with raw material extraction and processing.

Key Components:

- Materials Recovery:
  - Collection: Regular curbside collection of recyclables, drop-off centers, and community recycling events.
  - Sorting Facilities: Facilities that sort recyclables into different categories for processing.
- Education and Outreach:
  - Public Awareness Campaigns: Educating the community about what can and cannot be recycled, and the importance of recycling.
  - School Programs: Integrating recycling education into school curriculums to instill habits in future generations.
- Incentives and Regulations:
  - Container Deposit Systems: Implementing systems where consumers receive money back for returning containers.
  - Extended Producer Responsibility (EPR): Holding manufacturers accountable for the end-of-life management of their products.
- Partnerships:
  - Collaboration with Local Businesses: Partnering with businesses to enhance recycling efforts and promote sustainable practices.

COMPOSTING PROGRAMS

Purpose and Benefits:

- Organic Waste Reduction: Composting diverts food scraps and yard waste from landfills, significantly reducing methane emissions.
- Soil Enrichment: Compost enhances soil health, improves water retention, and promotes plant growth.

Key Components:

- Types of Composting:
  - Backyard Composting: Encouraging residents to compost at home using simple methods and bins.
  - Community Composting: Establishing local composting sites where residents can drop off organic materials.
  - Municipal Composting: Implementing large-scale composting operations that collect organic waste from households and businesses.
- Education and Outreach:
  - Workshops and Training: Providing hands-on training on how to compost effectively.
  - Informational Materials: Distributing guides on what materials can be composted and how to manage compost piles.
- Incentives:
  - Subsidies for Composting Bins: Offering discounts or subsidies for purchasing compost bins.
  - Participation Programs: Encouraging participation through rewards for residents who engage in composting.
- Regulations:
  - Food Waste Diversion Laws: Implementing laws that require businesses and municipalities to divert organic waste from landfills.

WASTE PROCESSING TECHNOLOGIES

- Waste processing technologies play a crucial role in managing waste effectively, reducing its environmental impact, and recovering valuable resources. Here are three key technologies used in waste processing:

1. Anaerobic Digestion

Anaerobic digestion is a biological process that breaks down organic waste in the absence of oxygen. It converts biodegradable materials, such as food scraps andagricultural waste, into biogas and digestate.

Benefits:

- **Biogas Production:** The process generates biogas, primarily composed of methane, which can be used for energy production (electricity and heat) or as a renewable natural gas.
- **Nutrient-Rich Fertilizer:** The digestate produced can be used as a nutrient-rich soil amendment, enhancing agricultural productivity.
- **Reduced Landfill Waste:** Diverts organic waste from landfills, minimizing methane emissions and reducing landfill burden.

WASTE PROCESSING TECHNOLOGIES

2. Mechanical Biological Treatment (MBT)

Mechanical Biological Treatment combines mechanical and biological processes to treat mixed waste. The mechanical stage involves sorting and shredding, while the biological stage often involves composting or anaerobic digestion.

Benefits:

- **Resource Recovery:** MBT facilities can recover recyclables, such as plastics, metals, and paper, while treating organic waste biologically.
- **Reduction of Landfill Volume:** By processing waste, MBT reduces the volume of waste sent to landfills.
- **Energy Generation:** Depending on the biological treatment used, MBT can produce energy in the form of biogas or compost that can be used as a soil amendment

WASTE PROCESSING TECHNOLOGIES

3. Pyrolysis and Gasification

Pyrolysis and gasification are thermal processes that convert organic materials (such as plastics and biomass) into useful products like syngas (synthetic gas), bio-oil, and char. These processes occur in the absence (gasification) or limited oxygen (pyrolysis).

Benefits:

- **Energy Recovery:** Both processes convert waste into syngas, which can be used for electricity generation or as a fuel for vehicles.
- **Reduced Landfill Dependency:** By converting waste into energy and useful products, these technologies help reduce the volume of waste going to landfills.
- **Diverse Feedstocks:** They can process a wide range of waste materials, including municipal solid waste, agricultural residues, and plastics, making them versatile solutions.

WASTE PROCESSING TECHNOLOGIES

4. Solar-Powered Trash Compactors

Manufacturer Ecube Labs created a solar-powered trash compactor that can hold up to five times more than traditional trash bins. Solar-powered trash compactors have built-in waste level sensors.

These machines compress trash as it accumulates to increase bin capacity and they collect and transmit data on fill and collection times to help streamline the collection process.

Benefits:

- **Waste Recovery:** This process convert waste into energy that can used to charge electric vehicles.
- **Reduced Volume :** By converting waste into energy and useful products, these technologies help reduce the size and volume of waste.

WASTE PROCESSING TECHNOLOGIES

5. E-Waste Kiosks

Electronic waste, like old computers, phones and TVs contains a lot of harmful substances. Instead of being sent to landfill, e-waste should be recycled or repaired and reused. This will help to prevent harmful chemicals seeping into soil and water. EcoATM kiosks allow you to dispose of your unwanted electronics safely and easily.

6. Waste Level Sensors

Waste level sensors allow users to instantly see how full each waste bin is, allowing them to plan ahead and take data-driven actions. Waste collection employees may arrange how collections are carried out, focusing only on the locations of full garbage cans, with the help of a live monitoring platform.

Benefits:

- **Sustainable Economy:** This process convert waste into energy that can used to charge electric vehicles.
- **Reduced Volume :** More efficient waste sorting in recycling centers and helps to divert as many recyclable materials away from landfills as possible.

ACTIVITIES

ACTIVITY 1

Waste Sorting Relay

Objectives

- Identify recyclable materials and sort household waste.

In this activity, students are challenged to sort household waste items into their appropriate bins in a relay. Students must choose an item from the discarded material and sort the items into one of the following bins:

- mixed paper
- newspaper
- containers (glass, metal, and plastic triangles 1, 2, 4, and 5)
- garbage
- compostable material

ACTIVITY 2

Art from Waste

Objectives

- Inspire creativity while raising awareness about waste.

In this activity, collect old and used crayons to make decorative candles.

Things needed :

- Pieces of old crayons
- Used candles
- Metal bottle caps
- Wicks
- Glue
- Hot water
- Scissors
- Vessel for heating the wax
- Large pan
- Small twig
- Stove

ACTIVITY 3

Composting 101

Objectives

- Differentiate between compostable waste and non-biodegradable waste.

In this activity, students get a chance to learn more about **composting** in a fun and interactive way.

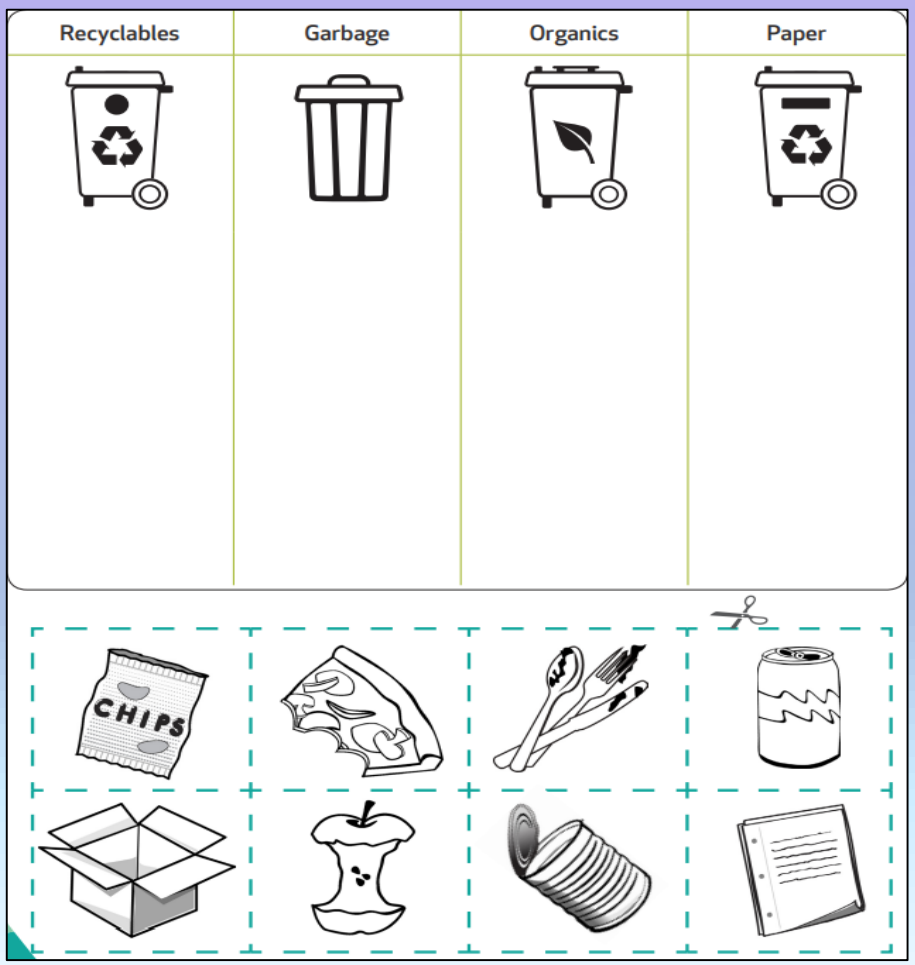
ACTIVITY 4

Recycling Workshop

Objectives

- Educate the students with the knowledge and skills on what can and cannot be recycled.

In this activity, each student cuts out the waste items and glues them into the correct sections.



ACTIVITY 5

Pledge for the Planet

Objectives

- Provide behavioural solutions to save the planet.

In this activity, take actions to reduce your impact on the planet, set the pace for change and preserve our planet for future generations. For example, cycling to reduce CO2 emissions and carbon footprint.

ACTIVITY 6

Components Crossword

Use the following clues about the different parts of a cell phone to fill in the crossword.

Across

1. The battery, the LCD, and the _____ board create 98 percent of a cell phone's environmental impacts.
4. Cell phones that are thrown away waste energy and result in the loss of valuable _____.
7. Each part of a cell phone must be _____ and transported, which requires energy and often creates waste.
9. Some facilities will recycle _____ batteries when they can no longer be reused.
10. Cell phones are actually not phones at all but sophisticated two-way _____.
11. LCDs are a low-power, flat panel display made by sandwiching liquid _____ between layers of glass or plastic.

Down

1. Circuits and wires on a circuit board are primarily made from _____.
2. Ni-MH and Ni-Cd batteries contain nickel, cobalt, cadmium, _____, and copper, metals that need to be mined and processed, which creates pollution and waste.
3. Many cell phone parts can be removed from the phone and _____ or recycled.
5. Batteries consist of two separate parts, called _____.
6. Plastics and _____ are used to make the basic shape of a circuit board.
8. Crude oil is combined with natural gas and chemicals to make _____.

Answers

Components Crossword:

Across	Down
1. Circuit	1. Copper
4. Resources	2. Zinc
7. Packaged	3. Reused
9. Rechargeable	5. Electrodes
10. Radios	6. Fiberglass
11. Crystal	8. Plastic

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