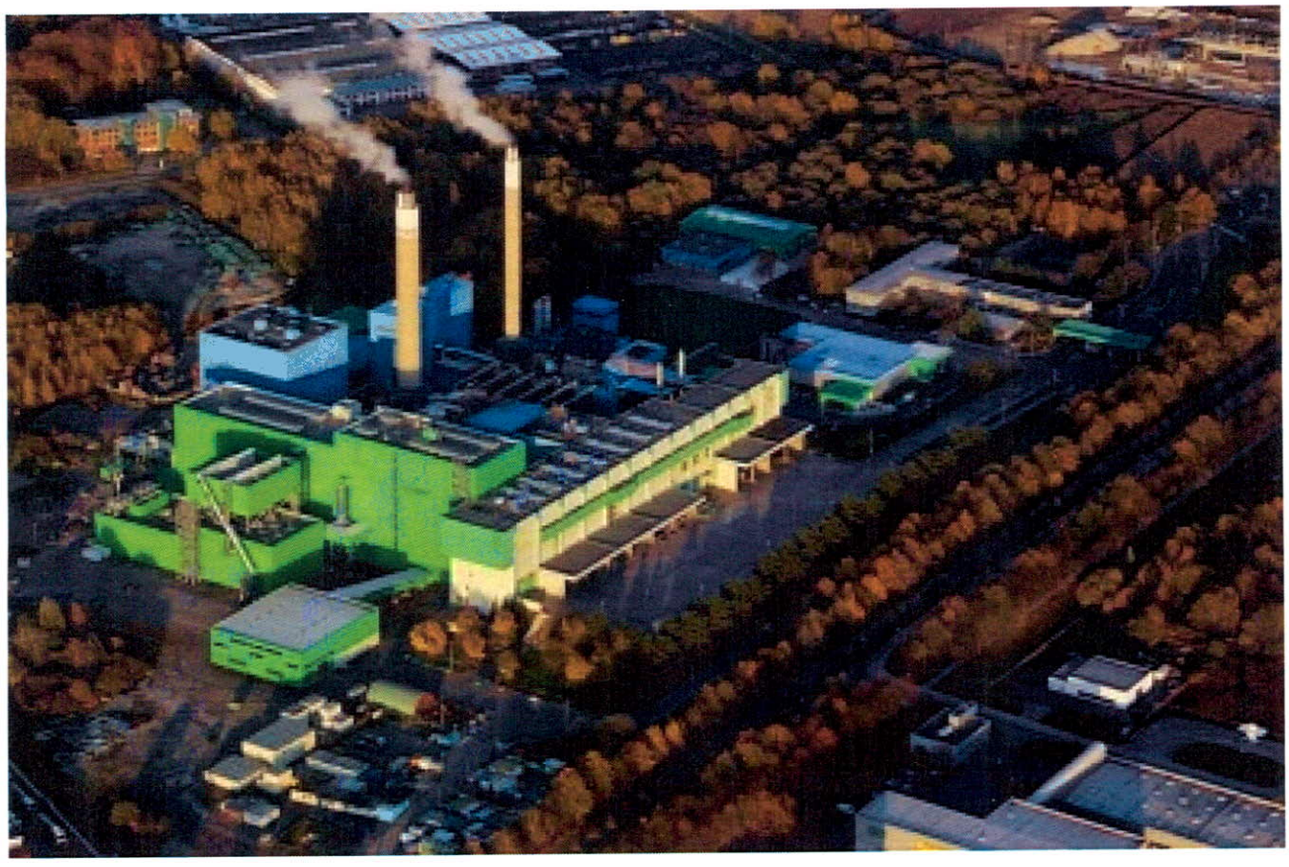

POWERPOINT PRESENTATION

(Peserta)

COURSE ON TREATMENT AND DISPOSAL OF HAZARDOUS WASTE

SEPTEMBER 2011

Environment Institute of Malaysia (EiMAS)

Bangi, Selangor

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Environment Institute of Malaysia (EiMAS)
Department of Environment

TREATMENT AND DISPOSAL OF HAZARDOUS WASTE

MODULE 1

Introduction to Treatment and Disposal of Hazardous Waste

SLIDES (PESERTA)

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TREATMENT AND DISPOSAL OF HAZARDOUS WASTES

MODULE 1:

Introduction to Treatment and Disposal of Hazardous Waste

EiMAS
Institut Alam Sekitar Malaysia
Environment Institute of Malaysia

Contents

- Introduction
- Purpose
- Definition of Waste, Hazardous Waste and Scheduled Waste
- Identification and Classification of Hazardous Waste
- Hazardous Waste Characteristics
- Sources of Hazardous Waste

Contents

- Background to Hazardous Waste Regulatory Requirements
- Overview of Treatment and Disposal of Hazardous Waste

Introduction

- Hazardous waste treatment and disposal technologies have been developed to:
  - Handle several types of waste and new technologies are still emerging
  - Represent an opportunity to take highly theoretical scientific knowledge and apply it to a real-world problem
  - Represent a solution to a problem and a tangible business expense

Purpose

- To provide participants with:
  - Definition of waste, hazardous waste and scheduled waste
  - Principle of identification, classification and characterization of hazardous waste
  - National law and regulatory requirements on hazardous waste treatment and disposal technologies
  - Overview to the treatment and disposal of hazardous waste technologies

DEFINITION OF WASTE, HAZARDOUS WASTE AND SCHEDULED WASTE

Definition of Waste

Basel Convention:

"**Substance** or **objects** which are **disposed of** or are **intended** to be disposed of or are **required** to be disposed of by the provisions of national law"

Definition of Waste

USEPA under RCRA:

"Any **garbage**, **refuse**, **sludge** from a wastewater treatment plant, water supply treatment plant, or air pollution control facility, and other discarded material, including solid, liquid, semisolid, or contained gaseous material, resulting from industrial, commercial, mining, and agricultural operations and from community activities"

Definition of Waste

EQA 1974:

"Any matter prescribed to be scheduled waste or any matter whether in a **solid**, **semi-solid** or **liquid** form, or in the form of a **gas** or **vapour**, which is **emitted**, **discharged** or **deposited** in the **environment** in such volume, composition or manner as to cause pollution"

Definition of Hazardous Waste

- Two definitions under RCRA program:

1. **Statutory definition**
2. **Regulatory definition**

Definition of Hazardous Waste

1. Statutory definition

"A solid waste, or combination of solid waste, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (a) cause, or significantly contribute to, an **increase** in **mortality** or an increase in **serious irreversible**, or **incapacitating reversible**, **illness**; or (b) pose substantial present or **potential hazard** to **human health** or the **environment** when improperly treated, stored, transported, or disposed of, or otherwise managed"

Definition of Hazardous Waste

2. Regulatory definition

"Waste that appears on one of the four hazardous wastes **lists**, or exhibits at least one of four **characteristics**"

Definition of Hazardous Waste

- RCRA introduce concept of **"Cradle to Grave"**

Hazardous Waste Generation | Hazardous Waste Transportation | Hazardous Waste Disposal

RCRA's "Cradle to Grave" Hazardous Waste Management System

Definition of Hazardous Waste

- **"Cradle to Grave"** concept

Definition
- Concept of accounting for hazardous waste from the point of generation until it is no longer hazardous

Aim
- To ensure that hazardous materials are controlled throughout their life cycle, from the point of generation to their final disposal

Definition of Hazardous Waste

Definition of Hazardous Waste at International Level

Term	Country/Organization
Hazardous	Basel Convention, United States of America, Canada, China, Organization for Economic Cooperation and Development (OECD)
Chemical	Denmark, The Netherlands
Special	United Kingdom, Federal Republic of Germany
Toxic and dangerous	Italy, France, European Economy Community (EEC)
Toxic	Belgium
Problem	Finland
Scheduled wastes	**Malaysia**

Definition of Scheduled Waste

- Definition of scheduled waste in Malaysia

"Waste materials that are specified in the **First Schedule** of Regulation 2, Environmental Quality (Scheduled Wastes) Regulations 2005"

Definition of Scheduled Waste

First Schedule: 5 groups of scheduled waste category codes

Group 1 – SW 1 (10 Categories)	Metal and metal-bearing wastes
Group 2 – SW 2 (7 Categories)	Wastes containing principally inorganic constituents which may contain metals and organic materials
Group 3 – SW 3 (27 Categories)	Wastes containing principally organic constituents which may contain metals and inorganic materials
Group 4 – SW 4 (32 Categories)	Wastes which may contain either inorganic or organic constituents
Group 5 – SW 5 (1 Category)	Other wastes

IDENTIFICATION AND CLASSIFICATION OF HAZARDOUS WASTE

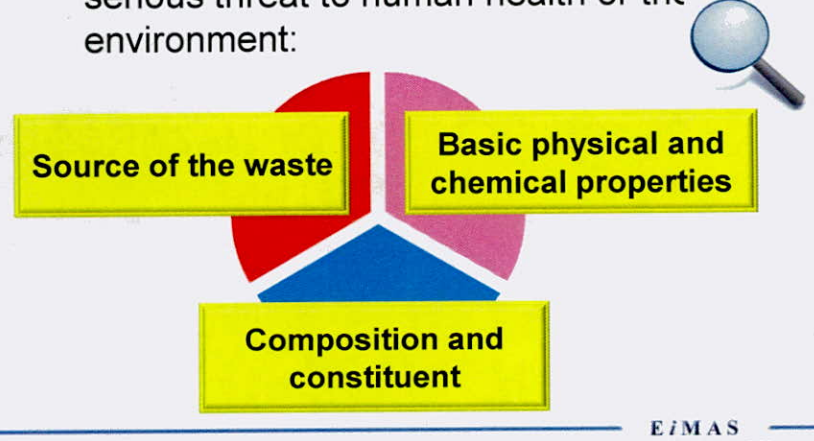
Identification and Classification of Hazardous Waste

- Process of determining whether a specific waste has to be considered as scheduled waste
- Hazardous wastes shall be classified by referring to:

First Schedule
of Scheduled Waste Category Codes, Environmental Quality (Scheduled Wastes) Regulations 2005 of the Environmental Quality Act 1974

Identification and Classification of Hazardous Waste

- Identification of waste that may cause a serious threat to human health or the environment:



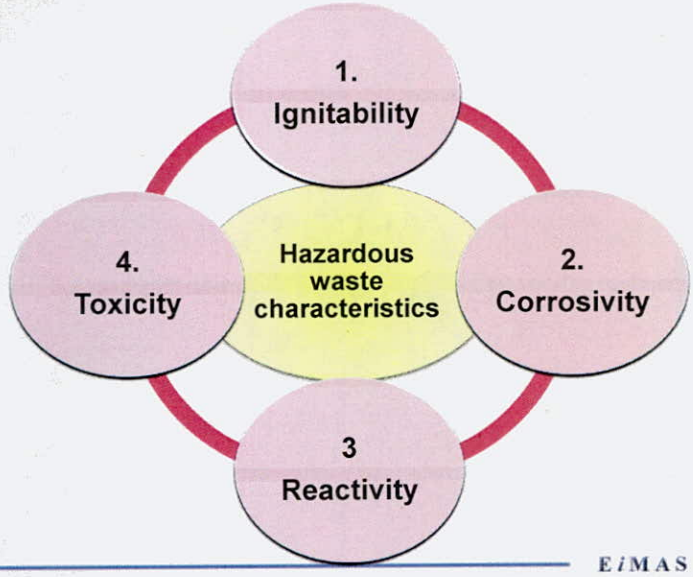
HAZARDOUS WASTE CHARACTERISTICS

Hazardous Waste Characteristics

- Property that poses a sufficient threat to merit regulation as hazardous
- USEPA under Code of Federal Regulations (CFR) defined the waste as hazardous if:

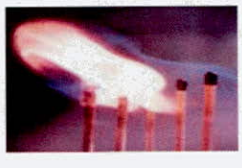
  - ✓ Included on 1 of the 4 "**listed waste**"
  - ✓ Exhibits 1 of the 4 defined **hazardous waste characteristics**

Hazardous Waste Characteristics



Hazardous Waste Characteristics

1. Ignitability



- Liquids with flash point less than 60°C (140°F)
- Solids that spontaneously combust and burn vigorously and persistently
- Ignitable compressed gases and oxidizers
- Examples: spent solvents, spent fuels, spent degreasers

Hazardous Waste Characteristics

2. Corrosivity

- Aqueous solutions with pH of less than or equal to 2 or greater than or equal to 12.5 (pH 11.5 for Basel Convention)
- Liquids that corrode steel
- The corrosivity characteristic does not apply to solids
- Examples: Waste of rust removers, alkaline cleaning fluids, battery acid

Hazardous Waste Characteristics

3. Reactivity

- Capable of detonation or explosive reaction if subjected to a strong initiating force or if heated under confinement
- Readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure

Hazardous Waste Characteristics

4. Toxicity

- Waste or its extract from the Toxicity Characteristic Leaching Procedure (TCLP) has any of the contaminants listed in Table A1 of Appendix A exceed the specified concentration limits
- Waste or its extract contains any of the contaminants listed in Table A2 of Appendix A

Hazardous Waste Characteristics

- For European Community, Basel Convention and Malaysia, waste is also classified as hazardous if it:
  - Contains infection or pathogen

Hazardous Waste Characteristics

Infectious and Pathogenic

- Waste consists of wholly or partly of human or animal tissue, blood or other body fluids, excretions, drugs or
- Other pharmaceutical products, swabs or dressings, syringes, needles or other sharp instruments, being waste which unless rendered safe may prove hazardous to any person coming into contact with it

SOURCES OF HAZARDOUS WASTE

SourceS of Hazardous Waste

- Three main sources:

First source - chemical manufacturing processes, all of which produce certain wastes (raw materials such as natural gas and crude oil)

Second source - numerous chemicals used as solvents, cleaning fluids or other agents in various processes

Sources of Hazardous Waste

Third source - residues that remain as residuals in "empty" containers and drums along with unused portions of chemicals that are discarded

Sources of Hazardous Waste

Waste Generators	Waste Types
Chemical manufacturers	• Strong acid and bases • Reactive wastes • Ignitable wastes • Discarded commercial chemical products
Vehicle maintenance shops	• Paint wastes • Ignitable wastes • Spent solvents • Acids and bases
Printing industry	• Photography wastes with heavy metals • Heavy metal solutions • Waste inks • Spent solvents
Paper industry	• Ignitable wastes • Corrosive wastes • Ink wastes, including solvents and metals

Sources of Hazardous Waste

Waste Generators	Waste Types
Construction industry	• Ignitable wastes • Paint wastes • Spent solvents • Strong acids and bases
Cleaning agents and cosmetic manufacturing	• Heavy metal dusts and sludges • Ignitable wastes • Solvents • Strong acids and bases
Furniture and wood manufacturing and refinishing	• Ignitable wastes • Spent solvent • Paint wastes
Metal manufacturing	• Paint wastes containing heavy metals • Strong acids and bases • Cyanide wastes • Sludges containing heavy metals

BACKGROUND TO HAZARDOUS WASTE REGULATORY REQUIREMENTS

Background to Hazardous Waste Regulatory Requirements

- Environmental Quality Act 1974 (Act 127)
  - Enacted on March 22, 1974
  - To prevent, abate and control pollution and enhance the environment
  - Amendments:
    - Act A636 (1985)
    - Act A953 (1996)
    - Act A1030 (1998)
    - Act A1102 (2001)
    - Act A1315 (2007)

Background to Hazardous Waste Regulatory Requirements

- Main provisions under EQA 1974
  - Section 34B

Prohibition against any placement, deposition or disposal, etc. without prior written approval from the Director General of the Environment

Background to Hazardous Waste Regulatory Requirements

- Regulations and Orders under EQA 1974:
  - Environmental Quality (Scheduled Wastes) Regulations 2005
  - Environmental Quality (Prescribed Premises)(Scheduled Waste Treatment and Disposal Facilities) Order 1989. Amendment-PU(A) 252/2006
  - Environmental Quality (Prescribed Premises)(Scheduled Waste Treatment and Disposal Facilities) Regulations 1989. Amendment-PU(A) 253/2006
  - Environmental Quality (Prescribed Conveyance) (Scheduled Wastes) Order 2005
  - Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987
  - Environmental Quality (Dioxin and Furan) Regulations 2004 – Emission Limit

Background to Hazardous Waste Regulatory Requirements

- Environmental Quality (Scheduled Wastes) Regulations 2005

- Came into force on 15 August 2005
- Based on "cradle to grave" concept
- Total of 77 waste category codes are prescribed as scheduled wastes
- Scheduled waste categories are divided into five groups:

SW 1, SW 2, SW 3, SW 4 and SW 5

Background to Hazardous Waste Regulatory Requirements

- **Five (5) groups** of scheduled wastes category codes under EQSWR 2005 **(77 categories)**

Group 1 – SW 1 (10 Categories)	Metal and metal-bearing wastes
Group 2 – SW 2 (7 Categories)	Wastes containing principally inorganic constituents which may contain metals and organic materials
Group 3 – SW 3 (27 Categories)	Wastes containing principally organic constituents which may contain metals and inorganic materials
Group 4 – SW 4 (32 Categories)	Wastes which may contain either inorganic or organic constituents
Group 5 – SW 5 (1 categories)	Other wastes

Background to Hazardous Waste Regulatory Requirements

- List of schedules in EQSWR 2005

First Schedule (Regulation 2)	Scheduled waste category
Second Schedule (Regulation 3)	Notification
Third Schedule (Regulation 10)	Labelling
Fourth Schedule (Regulation 2)	Incompatibility of scheduled wastes
Fifth Schedule (Regulation 11)	Inventory
Sixth Schedule (Regulation 12)	Consignment note
Seventh Schedule (Regulation13)	Scheduled waste information

Background to Hazardous Waste Regulatory Requirements

- EQSWR 2005 require scheduled wastes to be treated or disposed of only at prescribed premises/facilities
- Reason:
  - Potential risk and harmful to human health and the environment if they were
    - Disposed of in municipal landfill
    - Dumped illegally
    - Stored on-site or off-site without necessary precautions

Background to Hazardous Waste Regulatory Requirements

- **Prescribed premises** under EQ (Prescribed Premises) (Scheduled Waste Treatment and Disposal Facilities) Order 1989:
  - **Off-site recovery facilities**
  - **Off-site storage facilities**
  - **Off-site treatment facilities**
  - **Scheduled waste incinerators**
  - **Land treatment facilities**
  - **Secure landfills**

OVERVIEW OF TREATMENT AND DISPOSAL OF HAZARDOUS WASTE

Overview of Treatment and Disposal of Hazardous Waste

- Treatment means :

"Any **method**, **technique**, or **process**, designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize such waste, or so as to recover energy or material resources from the waste, or so as to render waste non-hazardous, or less hazardous, safer to transport, store, or dispose of or amenable for recovery, amenable for storage, or reduced in volume"

Overview of Treatment and Disposal of Hazardous Waste

- Important of treatment:
  - Reduce/eliminate the hazards posed by the material
  - Make disposal easier and reduce associated risks
  - Protect human health and the environment

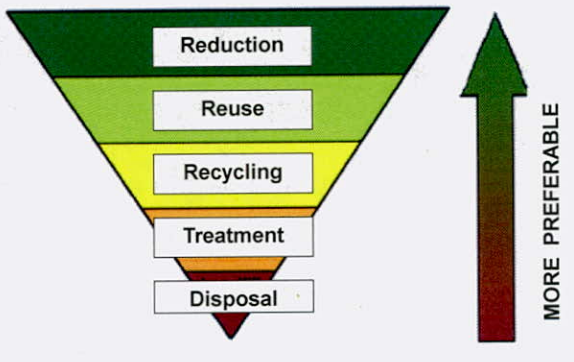
Overview of Treatment and Disposal of Hazardous Waste

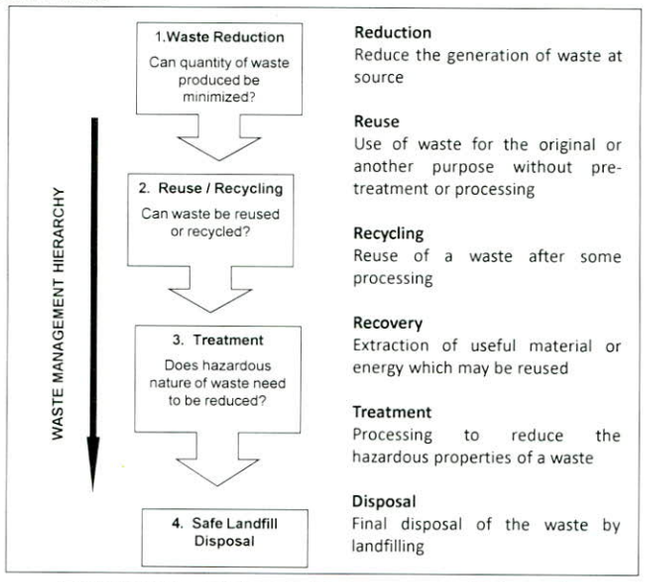
- Treatment covers a broad spectrum of activities
- Reuse and recovery are strongly preferred options over treatment or disposal
- Internationally accepted approach to the scheduled waste problem:

"Waste management hierarchy"

OVERVIEW OF TREATMENT AND DISPOSAL OF HAZARDOUS WASTE

- Hazardous waste management hierarchy:





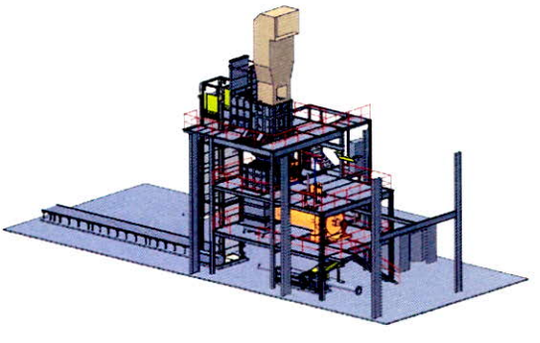
Global approach to waste management hierarchy

Overview of Treatment and Disposal of Hazardous Waste

Technology	Process	Methodology
Resource Recovery	Oil recovery	Reprocessing Refining Hot water injection In situ combustion Cyclic steam injection Steam flood
	Solvent recovery	Batch distillation Continuous distillation
	Metal recovery	Membrane separation Evaporation Precipitation Electrolytic recovery Leaching Ion exchange
	Raw material or Energy Recovery	Reutilization as raw material Reutilization as energy recovery

Technology	Process	Methodology
Treatment	Physical treatment	Separation Filtration Sedimentation Centrifugation
	Physico-chemical treatment	Neutralization Oxidation-Reduction Precipitation Hydrolysis De-chlorination Electrolysis
	Biological treatment	Aerobic Anaerobic
	Thermal treatment	Drying Autoclaving Microwave Irradiation Incineration Pyrolysis Plasma
	Other remediation	Land application
		Bioremediation

Technology	Process	Methodology
Final disposal	Landfill	Deep well injection Special management Surface impoundment



End of Module 1

Thank You

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Department of Environment

TREATMENT AND DISPOSAL OF HAZARDOUS WASTE

MODULE 2

Engineering Concepts in Hazardous Waste Management Hierarchy and Waste Minimization

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TREATMENT AND DISPOSAL OF HAZARDOUS WASTE

MODULE 2:

Engineering Concepts in Hazardous Waste Management Hierarchy and Waste Minimization

EiMAS
Institut Alam Sekitar Malaysia
Environment Institute of Malaysia

Contents

Contents

- Hazardous Waste Recovery and Reclamation
- Hazardous Waste Treatment Techniques
- Hazardous Waste Site Characterization and Remediation Techniques
- Hazardous Waste Disposal Techniques

Introduction

- Hazardous wastes are being characterized as ignitable, corrosive, reactive, toxic and infectious
- Proper disposal is important to avoid it from causing danger to our health and to the surrounding environment
- Proper waste management must consider the impact on all waste streams, not just the targeted one

Purpose

- Information on selecting the most economical methods of management of hazardous waste
- Options for waste minimization and reduction techniques
- Procedure for implementation of waste management hierarchy for the industries

HAZARDOUS WASTE ELIMINATION TECHNIQUES

Sustainability, Pollution Prevention and Control Techniques

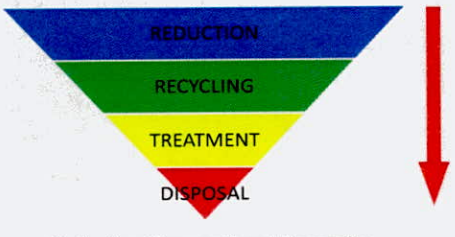
Sustainability

- Sustainability success is a holistic process and the success of sustainability depends on the following stakeholders:

Sustainability, Pollution Prevention and Control Techniques

Pollution Prevention

- Reduction or elimination of wastes and pollutants at their sources.



Pollution Prevention Hierarchy

Sustainability, Pollution Prevention and Control Techniques

Good techniques for pollution prevention are:

Sustainability, Pollution Prevention and Control Techniques

Control Techniques

- The best practice recommends communicating to the customers on definitions of acceptable and unacceptable of waste materials by means of:
  - Advertisements
  - Handouts
  - Large, Readable Signs at the Point of Entry
  - Other Educational and Feedback Methods

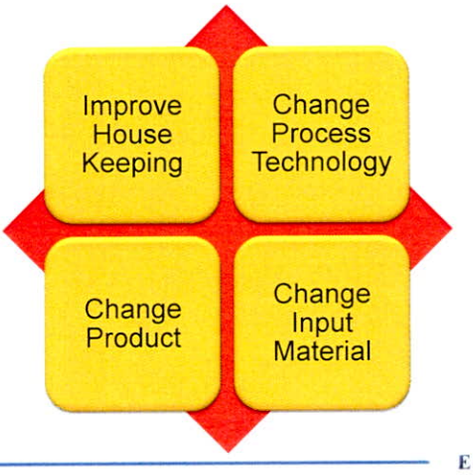
Cleaner Production and Green Technology

Cleaner Production

- A matter of changing attitudes, applying know-how, and improving production processes as well as the product
- Goal - Avoid pollution by using resources and raw materials to the utmost possible

Cleaner Production and Green Technology

Good techniques for cleaner production are:



Cleaner Production and Green Technology

Green Technology

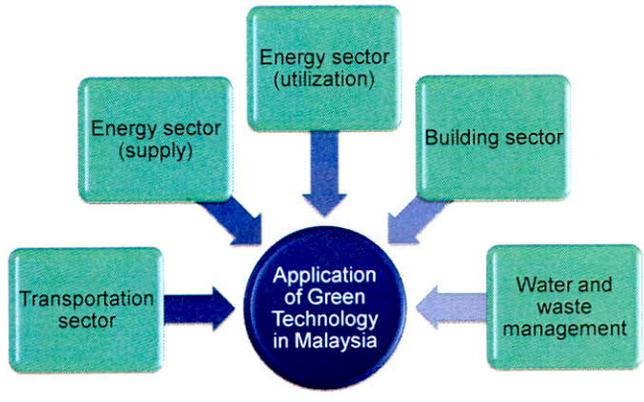
- Criteria of Green Technology products:
  - Minimizes the degradation of the environment
  - It has zero or low green house gas (GHG) emission

Cleaner Production and Green Technology

Four (4) pillars of Malaysia Green Technology Policy

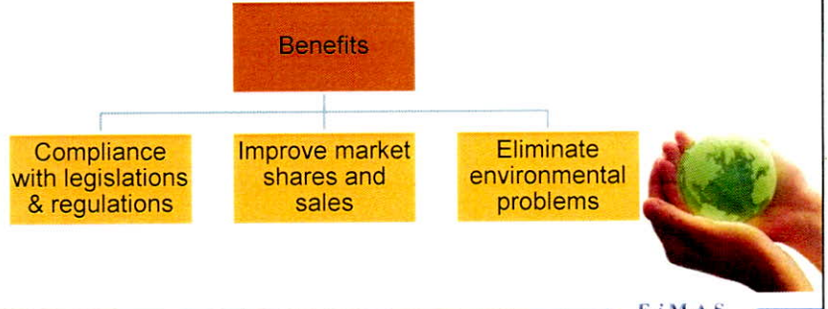
Social	Economy	Environment	Energy
• Improve the quality of life for all	• Enhance the national economic	• Conserve and minimize the impact on the environment	• Seek to attain energy independent and promote efficient utilization

Cleaner Production and Green Technology



Environmental Management System

- Aimed at reducing pollution and environmental damage which include severe penalties for non-compliance



HAZARDOUS WASTE REDUCTION TECHNIQUES

Hazardous Waste Reduction Techniques

ELEMENTS	DESCRIPTIONS
1. Managing Inventory	• Purchase only amount of raw materials needed • Evaluate the expiration dates of raw materials • Review an approval procedures for all raw materials-purchased
2. Modifying Production Processes	• Changing the hazardous materials used in production • Reformulating a product to contain less hazardous material • Modifying equipment to more efficient/cost-effective equipment

Hazardous Waste Reduction Techniques

ELEMENTS	DESCRIPTIONS
3. Operational and Maintenance Practices	• Strict maintenance program can reduce waste generation caused by equipment failure • Fully documented and made part of the employee training program • Developed and followed for each operational step in the production process

HAZARDOUS WASTE REUTILIZATION AND RECYCLING TECHNIQUES

Reutilization as Alternative Raw Materials

- Waste derived within a process
- Expired raw material – re-assay the material for use in production
- In general, reutilization of waste materials did not involve any treatment
- Examples of waste reutilization can be referred to Module 4.5

Energy Recovery

- Examples – plasma gasification and cement kilns
- Benefits:
  - Create power source
  - Reducing negative footprint at landfills
- Applications
  - Fuel boilers
  - Reciprocating engines
  - Gas turbines

Recycling of Hazardous Waste Materials

- Other possible technology which reduce the volume or toxicity of a waste
- Preferable on-site recycling due to risks in shipping hazardous waste off-site
- Examples of waste materials
  - Waste of solvents
  - Waste of oils
  - Contaminated containers
  - Contaminated rags and gloves

Recycling of Hazardous Waste Materials

- Benefits
  - Minimizing waste generation
  - Saves energy
  - Conserves natural resources
  - Prevents pollution
  - Reduce volumes of discarded waste materials
  - Generate income
  - Cost saving

Recycling of Hazardous Waste Materials

- Example of recycled products are:

Waste Type	Recycled Products
Waste Oil	Recycled Oil
Waste Mixed Solvent	Recycled Solvent, Recycle Thinner,
Waste Paint	Recycle Paint, Primer Paint, Rex Oxide, Green Oxide
Waste Acid	Flocculants Chemicals
Waste Alkaline	Flocculants, Metal Scrap
Waste Metal Hydroxide, spent photographic waste, silver paste	Metal Scrap, Flocculants Chemicals
Waste Empty Drum, carboys, containers	Recycled Drum, carboys, plastic
E-Waste	Metal Scrap, Plastic, components
Solder Dross	Solder Powder

Special Management of Hazardous Waste

- Under Regulation 7 (1), Environmental Quality (Scheduled Wastes) Regulations 2005
- Purposes
  - Provide waste generator opportunity to apply for the special management of its scheduled waste
  - Allow waste generator to send its hazardous waste to premise that is not prescribed for scheduled wastes upon approval
  - Allow the DG of DOE to approve hazardous waste for special management or handling at non-prescribed premises for scheduled wastes that have been proven to be non-hazardous

Special Management of Hazardous Waste

- Examples of waste:
  - Spent Sulphuric acid
  - Copper slag
  - Spent fluid cracking catalyst
  - Wastewater treatment sludge
  - Waste of insulation materials

HAZARDOUS WASTE RECOVERY AND RECLAMATION TECHNIQUES

Hazardous Waste Recovery and Reclamation

In 2009, 351 recyclers of hazardous waste were licensed by the DOE Malaysia

Waste Category	Recovery Facility	Handling Percentage, %
Electronic and Electrical Wastes	138	39.32
Dross/Ash/Slag/Catalyst	39	11.11
Oil/Mineral Sludge/ Spent Coolant	34	9.69
Acid/alkaline	29	8.26
Heavy Metal Sludge/Rubber	28	7.98
Used Container/ Contaminated Waste/Ink/Paint/Lacquer	31	8.83
Solvent	22	6.27
Photographic	10	2.85
Phenol/Adhesive/Resin	9	2.56
Battery	7	1.99
Gypsum	4	1.14
TOTAL	**351**	**100.0**

Hazardous Waste Recovery and Reclamation

- Typical waste acceptance criteria

Item	Characteristics	Description
Aluminium Dross	Physical Appearance	Slag nuggets or fine particle form
	Content	30% to 70%aluminium present in waste
Waste oil	Free Water Content (%) Flash Point Pour Point Viscosity	<2% 1500C Min (ASTM D92) -300 Max(ASTM D97) NA (ASTM D 445) (For detail waste oil acceptance criteria, refer to module 4.2
Metal (Cu, Ni, Fe, Ag, Au, Tin), Ferric solution	Pure metals in the form of powder or thin sheet. Reddish brown ferric chloride 38% solution with specific gravity between 1.37 – 1.38	Electrolysis of metal hydroxide sludge (SW204)
Copper/Nickel oxide	Dried bluish green powder	Electrolysis of spent acid (SW206)

Hazardous Waste Recovery and Reclamation

Item	Characteristics	Description
All type of solvent, e.g. - Isoprophyalcohol (IPA), - Xylene - Toulene - Ethyl acetate (EA) - Tricholoroethylene (TCE) - Methylchoride (MC)	Assay purity Other H/C Water Acidity Colour	: 95% min : 4% max : 0.1% max : 100ppm max : Colourless
Recovered coolant	Specific gravity @ 25 °C Viscosity @ 37.8 °C Flash Point Water PCBs Heavy Metals (As, Cd, Cr, Pb) & Chlorine/Halogen	: 0.85 – 0.9 : 50-200 SUS? :71.1 – 82.2 °C : Free : Free
Recycled containers	Clean, leak free metal and plastic containers	Cleaning of used containers (SW409)
Recycled rag	Dry clean rag	Cleaning of used rag/filter (SW410)

Hazardous Waste Recovery and Reclamation

- DOE's Minimum Percentage of Recoverable Components

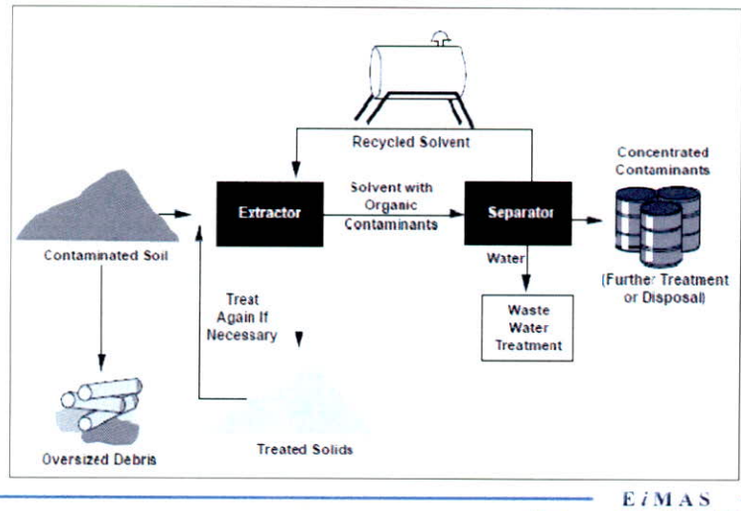
Type of Wastes	Recoverable Components	Minimum Percentage (dry weight basis)
Metal hydroxide sludge	Copper (Cu)	10
	Gold (Au)	0.05
	Nickel (Ni)	5
	Silver (Ag)	2.5
	Zinc (Zn)	20
Spent Catalyst	Chromium Oxide	10
	Cobalt (Co)	20
	Copper compounds	10
	Nickel Oxide	10
	Nickel (Ni)	8
	Palladium (Pd)	1.0
	Platinum (Pt)	0.2
	Zinc Oxide(ZnO)	10

Hazardous Waste Recovery and Reclamation Techniques

Methods	Process	Description
Preliminary	Sorting, Separation and Segregation	Separately store recyclable waste material for reuse, disposal in hazardous waste landfills or appropriate processing
		Minimize waste generation and ensure reduction in landfill space for final disposal
Physical	1. Filtration	Sludge is forced through a medium such as fabric, so that the liquid passes through the medium leaving the solid materials behind
	2. Solvent Extraction	Uses a solvent to separate/remove hazardous organic contaminants from sludges, sediments, or soil

Hazardous Waste Recovery and Reclamation Techniques

Solvent Extraction Process



Hazardous Waste Recovery and Reclamation Techniques

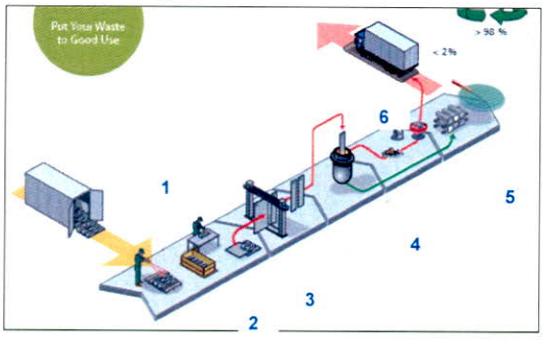
Methods	Process	Description
Physico-Chemical	1. Precipitation	Applied to almost any liquid waste stream containing a perceptible hazardous constituent
		Example • Lime [Ca $(OH)_2$] or caustic soda is used for precipitation of the metal ions as metal hydroxides • Sodium carbonate used to precipitate metals as hydroxides
	2. Electrolysis	Process that use electrical power to alter chemical compounds, remove them from solution
		Involve oxidation and reduction reactions

Hazardous Waste Recovery and Reclamation Techniques

Methods	Process	Description
Thermal	1. Distillation	Usually solvent distillation
		Reduces amount of solvent purchased and disposed of
	2. Re-melting	Lead re-melting Reduce the volume and weight of lead Residual products - slag, sorted material, cutting residues and dust from the ventilation filters

Hazardous Waste Recovery and Reclamation Techniques

Lead Re-Melting Processes



1. Delivered waste
2. Inspection and Sorting Process
3. Segmentation Process
4. Melting Process
5. Formation of End Product
6. Treatment and Disposal for Secondary Waste

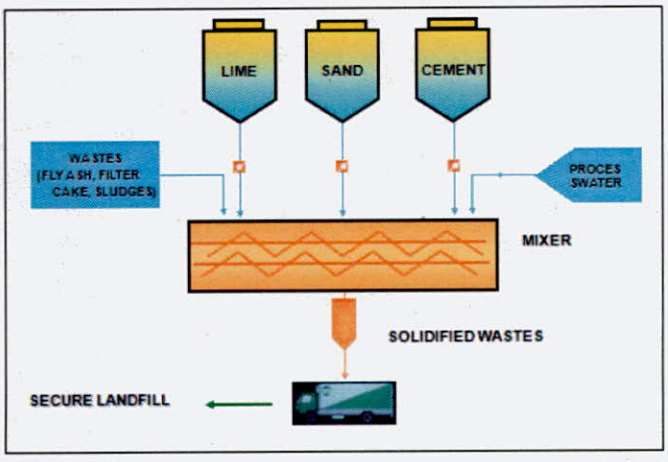
HAZARDOUS WASTE TREATMENT TECHNIQUES

Physical Methods – Solidification, Stabilization, Encapsulation

Solidification	• Process of employing additives by which the physical nature of the wastes is altered during the process
Stabilization	• Process where additives are mixed with waste to minimize the rate of contaminant migration from the waste to reduce the toxicity of the waste
Encapsulation	• Process of surrounding waste particles with a layer of material that is very low in permeability

Physical Methods – Solidification, Stabilization, Encapsulation

Solidification Treatment Plant



Physico-Chemical Methods – Neutralization, Oxidation, Reduction

Neutralization

- Process used to adjust the pH of a liquid waste to between 6 and 10
- Accomplished by using an acid neutralization tank

Chemical Reduction – Oxidation

- Use oxidizing and reducing agents to break down or alter the chemical form of the hazardous constituents
- Oxidizing agents
  - chlorine, sodium and calcium hypochlorite, etc.
- Reducing agents
  - ferrous sulphate and sulphur dioxide

Thermal Methods- Irradiation, Incineration, Plasma

Irradiation

- Use microwave energy to irradiate the volume of waste
- Applied for clinical waste and other infectious or bioactive material

Incineration

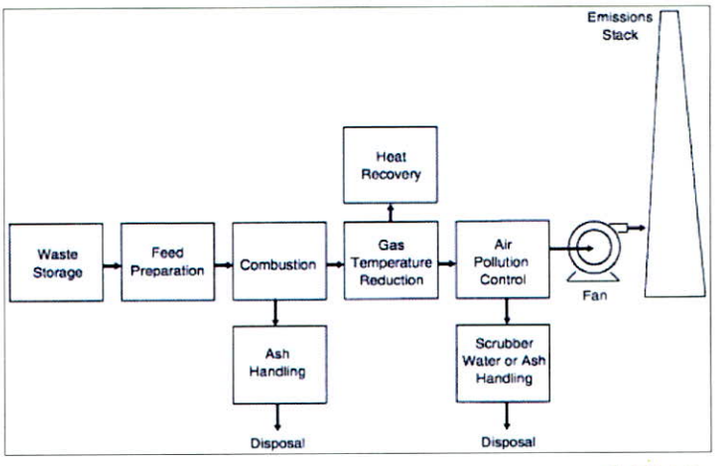
- Wastes are burned at high temperatures
- Reduce the hazard and simplify the final process of waste disposal
- Resulting - Minimum of land is needed compared to the dimensions of waste disposal sites

Plasma

- Ionized gas is formed when an electrical discharge passes through a gas
- Used to convert carbon-containing materials
- Synthesis gas that can be used to generate power (transportation fuels)

Thermal Methods- Irradiation, Incineration, Plasma

Typical Waste-Incineration Facilities



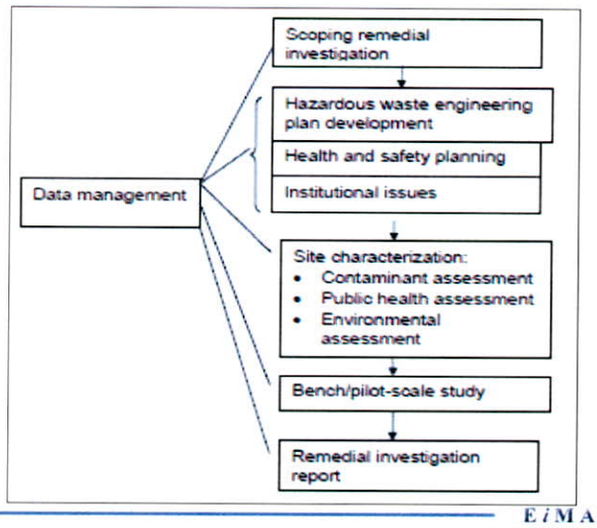
HAZARDOUS WASTE SITE CHARACTERIZATIONS AND REMEDIATION TECHNIQUES

Remedial Investigations

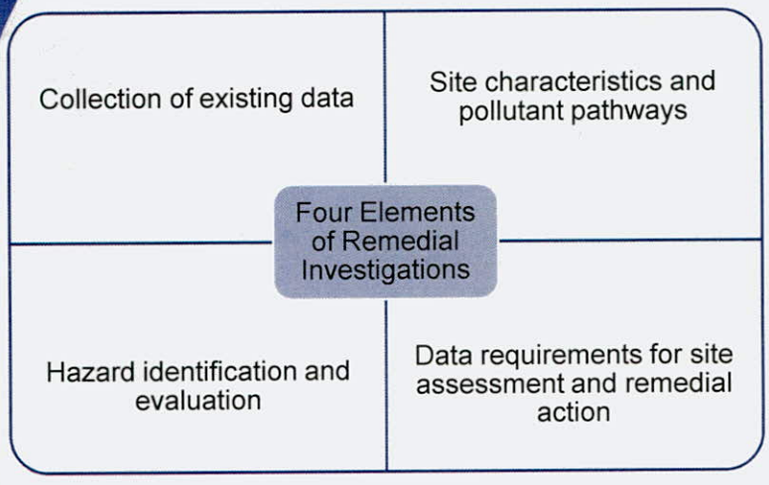
- A series of basic questions regarding the conditions of the site are answered during the site investigation
- Data collection and site characterization are the primary elements of the remedial investigation
- Additional activities include data management and site investigation reports

Remedial Investigations

Remedial Investigation Process

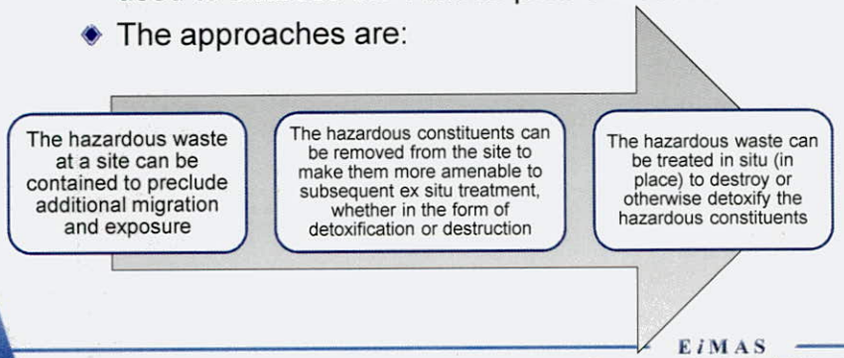


Remedial Investigations



Remediation Objective

- Overall objective is the protection of human health and the environment by reducing risk
- Combination of these 3 approaches may be used to address the various problem at site
- The approaches are:



Remediation Objective

In Situ Treatment

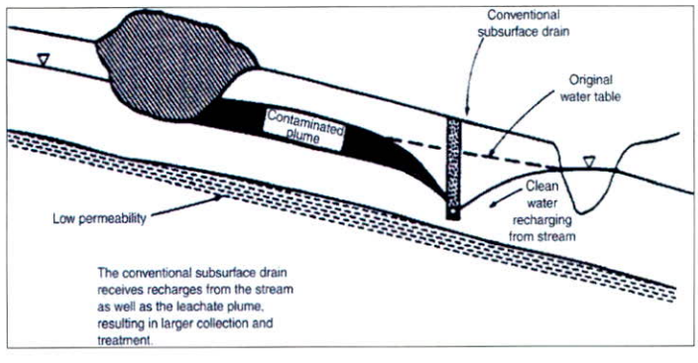
- The technologies that will convert contaminants to less hazardous materials
- Consists of
  - In Situ Groundwater Remediation
  - In Situ Soil Treatment

In Situ Treatment

In Situ Groundwater Remediation

- An alternative to the conventional pump-and treats methods
- Use biological or chemical agents of physical manipulations that degrade, remove, or immobilize contaminants
- Can usually treat both contaminated groundwater and soil

In Situ Treatment



Use of a One-Sided Subsurface Drain for Reducing Flow from Uncontaminated Sources

In Situ Treatment

Process	Description
Biological Treatment	•Aerobic respiration •Fermentation •Anaerobic respiration
Chemical Treatment	•Uses chemicals to immobilize or detoxify the organic or inorganic contaminants •It is easier to control chemical processes in pumped groundwater than in situ groundwater
Permeable Reactive Barrier	Combines a passive chemical/biological treatment zone with subsurface fluid flow management

In Situ Treatment

Process	Description
Air Sparging in Aquifers	The injected air helps to flush the contaminants into the unsaturated zone (example : SVE)
Multiphase Extraction	Uses a vacuum system to remove substance from subsurface
Circulating Wells and In-Well Air Stripping Technologies	Can be used for treatment inside the well, in the aquifer, or a combination of both

In Situ Treatment

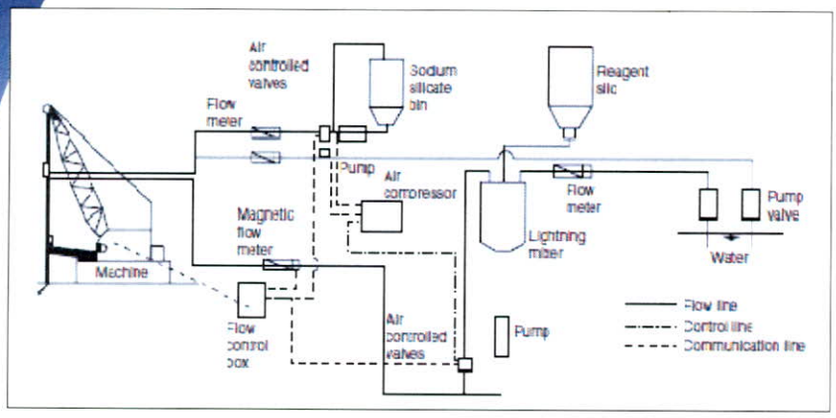
- In Situ Soil Treatment

Process	Description
In Situ Heating	Uses thermal decomposition, vaporization, and distillation techniques to destroy or remove organic contaminants Particularly useful for dense or light non-aqueous phase liquids (DNAPLs or LNAPLs)
Artificial Ground Freezing	Installation of freezing loops in the ground and a self-confined refrigeration system to pumps coolant around the freezing loop
Fracturing	Is a way to crack rock or very dense soil, like clay, below ground.

In Situ Treatment

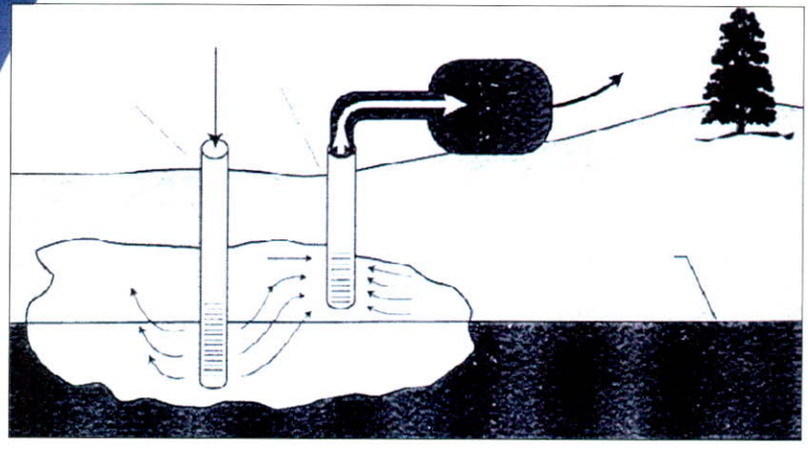
Process	Description
Immobilization and Stabilization	•Render contaminants insoluble and prevent leaching of the contaminants from the soil and their movement from the contamination area •Can be applied to soils contaminated with heavy metals, petroleum products, PCB, peroxyacetyl nitrate (PAN)
Soil vapor extraction	Can be used to remove volatile contaminants and, when combined with another technology, to treat non-volatile contaminants
Soil Flushing	Large volumes of water, at times supplemented with surfactants or treatment compounds are applied to the soil or injected into the groundwater to raise the water table into the contaminated soil zone

In Situ Treatment



In Situ Solidification Batch Mixing Plant Process

In Situ Treatment



Soil Vapor Extraction and Air Sparging

Containment System

- Use to isolate wastes deemed as hazardous from man and environmental systems of air, soil, and water
- Comprised of materials from two broad categories:
  - Natural soils
  - Geosynthetics

Containment System

Basic Considerations

Material Selection

- The following is list that need to be addressed at the early stages of design
  - Minimum technology criteria
  - Mechanical properties
  - Hydraulic properties
  - Construction factors
  - Long-term performance factors

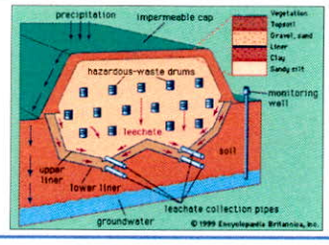
Containment layer

- Consists of:
  - Compacted soil
  - Geo membranes
  - Geo synthetic Clay Liners
  - Drainage Materials
  - Filters and Cushioning
  - Landfill Cover Systems
  - Cover Soils

HAZARDOUS WASTE DISPOSAL TECHNIQUES

Secure Landfill/Specially Engineered Landfill

Type of Landfill	Description
Landfill	Construct to contain discarded waste so as to minimize releases of contaminants to the environment
Secure landfill	Construct to highest standards to cater scheduled wastes
Specially engineered landfill	Provides the means for controlled deposit of wastes on land



Deep Well Injection

- Techniques in disposing of liquids hazardous waste

Special Management

- Exclude wastes that are not characterized as hazardous
- Improve tracking of wastes
- Encourage waste reduction at source and recovery

End of Module 2

Thank You

Environment Institute of Malaysia (EiMAS)
Department of Environment

TREATMENT AND DISPOSAL OF HAZARDOUS WASTE

MODULE 3

Options of Hazardous Waste Minimization, Treatment and Disposal

SLIDES (PESERTA)

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TREATMENT AND DISPOSAL OF HAZARDOUS WASTE

MODULE 3:

Options of Hazardous Waste Minimization, Treatment and Disposal

EiMAS
Institut Alam Sekitar Malaysia
Environment Institute of Malaysia

Contents

- Introduction
- Purpose
- Economic Values and Benefits
- Changes of Input Materials
- Improvement of Operating Practices
- Products Changes
- Compliance with International Requirements
- Treatment Efficiencies
- Capital and Operating Costs

Introduction

- Quantities (in tonnes) of scheduled waste generation in Malaysia have been increasing from 2003 to 2009:

2003	– 460,865.74
2004	– 469,584.07
2005	– 548,916.11
2006	– 1,103,457.06
2007	– 1,138,839.491
2008	– 1,304,898.77
2009	– **1,705,308.14**

Introduction

- These scheduled wastes have been managed or handled in the following manners:
  - Sent for off-site recovery
  - Treated on-site
  - Stored on-site
  - Disposed of at secure landfill
  - Exported for recovery

Introduction

- Most industries managing hazardous waste in accordance with control procedures
- Issues confront the authorities:
  - Illegal dumping
  - Illegal dumping
  - New and emerging issues of contaminated land

Purpose

- To provide participants with:
  - Principle elements for the implementation of waste reduction through source reduction program
  - Key elements for developing a successful operational improvements in the hazardous waste minimization strategies
  - Mechanisms for identification of all the relevant elements of capital and operating costs of hazardous waste treatment and disposal

ECONOMIC VALUES AND BENEFITS

Economic Values and Benefits

- Hazardous waste minimization program
  - Goal - to minimize all waste produced
  - Potential benefits:

1. Financial benefits
2. Corporate image
3. Preservation of natural resources

Financial Benefits

- By minimizing hazardous waste, in return it will:
  - Increase production efficiency
  - Reduce costs associated with:
    - purchasing raw materials
    - waste management
  - Eliminate the generation of hazardous waste
  - Comply fully with EQSWR 2005 regulatory requirements

Financial Benefits

- Cost of waste is not only the cost of waste disposal, but also other costs such as:
  - Handling cost of waste
  - Purchasing cost of wasted raw material
  - Generation cost for the waste material
  - Management cost for time spent on waste material
  - Lost of revenue for what could have been a product instead of waste
  - Potential liabilities due to waste

Financial Benefits

- Effective waste minimization will reduce in:
  - Cost of raw materials
  - Manufacturing cost of material
  - Cost of product
  - Cost of treatment of waste to comply with regulatory requirements
  - Cost of waste disposal
  - Cost of waste transportation
  - Maintenance required work environment

Corporate Image

- Company's policy and practices influence community attitudes
- Community attitudes toward companies:
  - Operate and publicize a thorough pollution prevention program
  - Creates environmentally compatible products
  - Avoids excessive use of material and energy resources

Corporate Image

- Business may also benefit from the positive or "green" image associated with hazardous waste minimizing efforts

A company that values strong corporate stewardship can increase goodwill with shareholders and consumers and further distinguish itself from its competitors

Preservation of Natural Resources

- Minimizing hazardous waste
  - Less air, water and soil pollution associated with extraction, refining and processing of raw materials
  - Reduce emissions of greenhouse gases (GHGs)
- When hazardous wastes are minimized
  - Less energy is needed to extract, transport and process raw materials and to manufacture products

Preservation of Natural Resources

- When energy demand decreases,
  - Fewer fossil fuels are burned and less CO_2 is emitted
  - Emissions of other air pollutants can be reduced
  - Decrease releases of air toxics from waste incineration

CHANGES OF INPUT MATERIALS

CHANGES OF INPUT MATERIAL

- First step of product formulation or production process during:
  - Selection for raw material
  - Selection for chemical
- Replaced with a less hazardous or non-hazardous material
- Reformulating a product to contain less hazardous materials

CHANGES OF INPUT MATERIAL

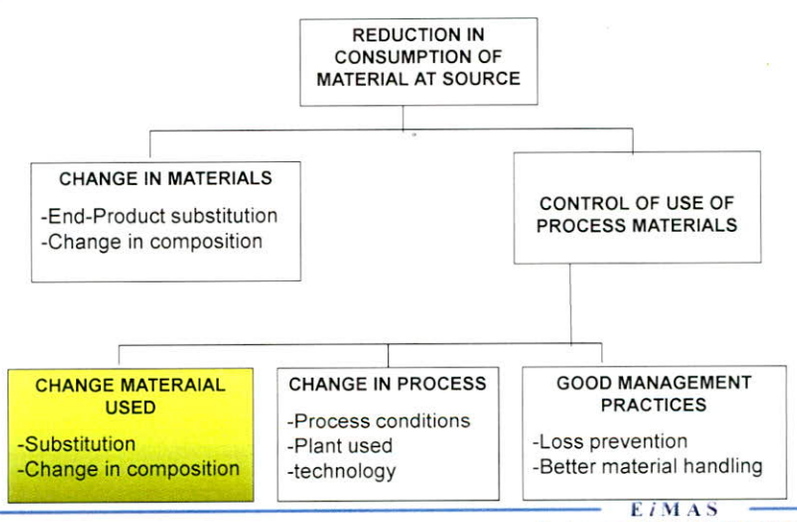
- Examples of material changes

Industry	Material Changes
1. Household appliance	• Eliminate cleaning step by selecting lubricant compatible with next process step
2. Textile	• Reduced phosphorus in wastewater by reducing use of chemicals containing phosphates • Used ultraviolet light instead of biocides in cooling towers • Substituted nonhazardous dye carrier for carrier containing hazardous substances • Substituted solvent-based adhesive system with water-based acrylic latex system • Reuses rinse water as bleach bath

CHANGES OF INPUT MATERIAL

Industry	Material Changes
3. Aerospace	• Replaced cyanide cadmium plating bath with a non-cyanide bath
4. Ink manufacture	• Removed cadmium from product
5. Metal coating	• Eliminated VOC emissions by switching from traditional solvent-based painting to powder coating operation
6. Chemical manufacture	• Replaced 1,1,1 trichloroethane with isopropyl alchohol as process reaction medium
7. Yacht manufacture	• High solids paint and catalyst batches previously mixed prior to application resulted in disposal of large quantities of unused paint in the spray gun resulting in no excess waste paint

Raw Material Selection



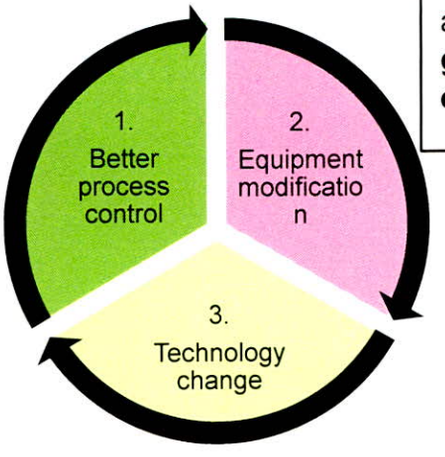
IMPROVEMENT OF OPERATING PRACTICES

IMPROVEMENT OF OPERATING PRACTICES

- Significantly reduce waste generation at source
- Most cost-effective waste reduction techniques
- Practices:
  - Process change
  - Procedural change
  - Good house-keeping

Process Change

- Can be applied by:



To run the processes at **higher efficiency** and with **lower waste generation and emissions**

Process Change

1. Better process control	• Modifications of the working procedures • Machine-operating instructions • Process record keeping
2. Equipment modification	• Addition of measuring and controlling devices
3. Technology change	• Replacement of the technology processing sequence and/or synthesis route • Installing more efficient equipment • Modification existing equipment

Process Change

- Highly efficiency systems will:
  - Reduce number of rejected or off-specification products
  - Reduce amount of material that must be reworked or discarded
  - Higher productivity
  - Reduced raw material costs
  - Lower labour costs
  - Reduced waste management costs

Process Change

Process	Equipment or product modification
Parts cleaning	• Enclose all solvent cleaning units • Use refrigerated freeboard on vapour degrease units • Improve part draining before and after cleaning • Use mechanical cleaning devices • Use plastic bead blasting
Surface finishing	• Prolong process bath life by removing contaminants • Redesign part racks to reduce dragout • Reuse rinse water • Install spray or fog nozzle rinse systems • Properly design and operate all rinse tanks • Install dragout recovery tanks • Install rinse water flow-control valves • Install rip racks and drain boards

Process Change

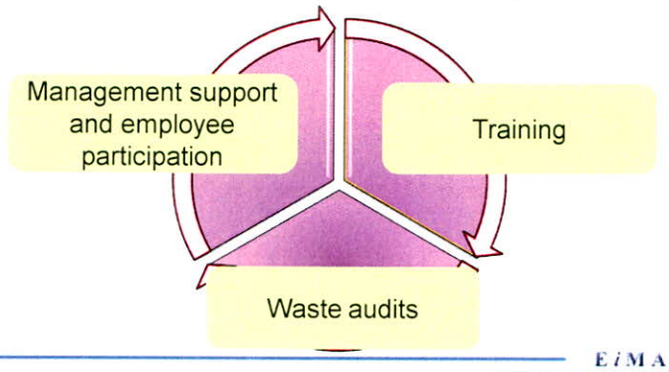
Process	Equipment or product modification
Surface coating	• Use airless air-assisted spray guns • Use electrostatic spray-coating system • Control coating viscosity with heat units • Use high solids coatings • Use powder coating systems
Equipment cleaning	• Use high-pressure rinse system • Use shorter feed lines to minimize cleaning and cleaning waste • Use mechanical wipers • Use countercurrent rinse sequence • Reuse spent rinse water • Use compressed gas to blow out lines

Process Change

Process	Equipment or product modification
Preventing spills/leaks	• Use bellow-sealed valves • Install spill basins or dikes • Use seal-less pumps • Maximize use of welded pipe joints • Install splash guards and drip boards • Install overflow control devices

Procedural Change

- Monitor and reduce generation of hazardous waste
- Elements in procedural change include:



Procedural Change

Management Support and Employee Participation

- Commitment by senior management through policy, communication and resources
- Drafted and adopted formal policy statement
  - Protecting the environment
  - Minimizing or eliminating waste
  - Reuse or recycling materials

Procedural Change

Training

- Formal and on-the-job training
- Includes the company compliance requirements found in
  - Waste management policies
  - Occupational health and safety

Procedural Change

Waste Audits

- Provide systematic and periodic survey on operations designed
  - Identify areas of potential waste reduction
- Useful to analyze:
  - Waste origin
  - Operational problems inherent to its process
  - Areas where improvements can be made

Procedural Change

- Observe, measure and record data and to collect and analyze waste samples
- Applied methodically with support of both operators and administrative staff
- Must aim at waste prevention and reduction
- Must go beyond the end-of-the-pipe treatment

Procedural Change

- 2 audit level:

Regional audit	• Verify problems derived from several industries
On-site audit	• Monitor wastes in each phase of the process and thus locate specific loads for treatment

Procedural Change

- Audit program includes:
  - **I**dentification of hazardous wastes and sources
  - **P**rioritization various waste reduction actions to be undertaken
  - **E**valuation of some technically, economically and ecologically feasible approaches
  - **D**evelopment of an economic comparison of waste minimization and pollution prevention options
  - **E**valuation of their results

Good House-keeping

- System to prevent leakages & spillages through
  - Preventive maintenance schedules
  - Routine equipment inspections

- Most effective and simple first steps
- Relies on:
  - Good common sense
  - Well-written working instructions
  - Supervision
  - Awareness
  - Regular training of workforce

Good House-keeping

- Good housekeeping practices include:

1. Using a **"first in, first out"** inventory system
2. Conduct frequent **inventory checks**
3. Validate **shelf-life** expiration dates
4. Use **raw materials** sparingly and in correct proportions
5. Take care when transferring chemicals to **minimize spills**
6. Keep non-hazardous waste stream **separate** from hazardous waste streams
7. **Segregate** waste according to toxicity
8. **Seal** and contain processes
9. **Inventory** all products and waste, clearly **labeling** and properly **storing**

Module X: Hazardous Waste Minimization TDHW

Good House-keeping

- Material control:
  - Storage of raw materials
  - Products and process waste
  - Transfer of these items within the process and around facility
- Proper material control procedures ensure:
  - Raw material efficiently handled and used
  - Does not become waste

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PRODUCT CHANGES

Product Design

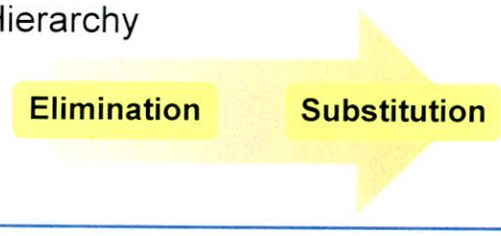
- Reduce amount of components used in the production
  - Saves from waste minimization
  - Later due to it being less complex makes way for recycling
- Product design strategies:

Product Design

Source reduction	• Eliminate unnecessary components • Use minimum amount of material • Avoid unnecessary packaging • Use strong and lightweight materials
Extending the product life	• Identify and eliminate potential weak points in the design • Product is designed for likely misuse as well for the intended use • Design for easy maintenance and repair • Consider classic design
Reusable product	• Product is strong enough to withstand • Cleaning processes meet standards • Design packaging for a number of ways of re-use

Elimination/Reduction of Hazardous Constituents

- Aims:
  - Reduce pollution
  - Prevent damaging effects to the environment
  - Prevent human health problems due to occupational and post-disposal exposure
- Hierarchy



Elimination/Reduction of Hazardous Constituents

Elimination

- Remove the need to use those substances by changing the process or product in which the substances are used

Substitution

- Replacement with one less dangerous

Potential for Waste Minimisation Opportunities in Industries

Example Industries	Operation changes/ Housekeeping	In-process modification	Process modification	Input substitution	End product change
Pharmaceuticals Weapons Robotics Specialty chemicals	+ve	-ve	-ve	-ve	-ve
Rubber Petroleum Commodity Chemicals Paper Products Lumber	+ve	+ve	-ve	-ve	-ve
Steel making Nonferrous metals Textiles	+ve	+ve	+ve	-ve	-ve

Example Industries	Operation changes/ Housekeeping	In-process modification	Process modification	Input substitution	End product change
Electronic components Medical equipment	+ve	+ve	+ve	+ve	-ve
Electroplating Printing	+ve	+ve	+ve	+ve	-ve
Foundries Machine shops	+ve	+ve	-ve	+ve	-ve
Automobiles Appliances Consumer Electronics Paints	+ve	+ve	+ve	+ve	+ve

COMPLIANCE WITH INTERNATIONAL REQUIREMENTS

Basel Convention

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal

- Adopted - March 1989
- Principle - Environmentally sound management" (ESM)
- Protect human health and the environment

Basel Convention

- Basel Convention three-step strategy:

Minimizing the generation of wastes

↓

Treating wastes as near as possible to where they were generated

↓

Reducing international movements of hazardous wastes

Basel Convention

- "Environmentally Sound Management" (ESM)
  - Controlling the storage, transport, treatment, reuse, recycling, recovery and final disposal of wastes
- "Integrated Life-cycle Approach" strategy
  - Provides incentives to companies to monitor and control every step in their production processes

TREATMENT EFFICIENCIES

Design Specifications

- Factors for choosing treatment and/or disposal option:
  - Long-term operation and maintenance aspects
  - Possibilities for final disposal options for the residues

Design Specifications

Example of design specifications:

- Use high pressure water cleaning to replace chemical cleaning
- Use lower pressure steam
- Use squeegees and wipers to recover residual materials prior to rinsing
- Use centrifuge or other methods to remove excess solvent in cleanup rags before laundering
- Clean equipment immediately after use to minimize the amount of solvent needed
- Use cleaning systems that avoid or minimize solvents and clean only when needed
- Inspect equipment, pumps, valves and pipes for leaks
- Plan production schedule to reduce the generation of hazardous waste

Design Specifications

- In products and plant maintenance, consider using low VOC paints and coatings, and improve paint spray equipment and technique to minimize waste
- Maximize dedication of process equipment to reduce cleaning frequency

Technology Applications

- Different wastes require
  - Different treatment technologies
  - Various operating conditions
- Several technologies can be used to achieve the same result

Technology Applications

Suggestion for reducing disposal costs

Waste Type	Suggestion
Flammable Liquids	1. Minimize water content of waste by minimizing any unnecessary dilutions 2. Keep non-halogenated solvents separate from wastes that contain heavy metals, pesticides, cyanides or acute hazardous 3. Keep non-halogenated solvents separate from halogenated solvents 4. Investigate the use of nonflammable or biodegradable alternative solvents 5. Replace solvent based inks in printing operations with soy-based inks 6. Make multiple use of cleaning solutions before disposing of them 7. Substitute non-halogenated solvents in place of halogenated solvents 8. Investigated the use of alternative non-halogenated solvents

Technology Applications

Waste Type	Suggestion
Formalin & Formaldehyde Solutions	1. Minimize the volume of waste generated by eliminating any unnecessary dilution 2. Do not mix with any other waste streams 3. Substitute ethanol or a commercial fixative like Carosafe or Formalternate for formaldehyde in the storage of biological specimens
Oil-based Paints & Solvents	1. Do not contaminate usable paint and always reseal the containers (allows for recycling) 2. Use latex paint 3. Minimize the volume by reducing any unnecessary dilution 4. Minimize inventories of paints. Order only enough to satisfy short-term needs
Unknown Chemicals	1. Prevent generation of unknown wastes/products by keeping all containers labeled 2. Do not let old chemicals and products accumulate, clean out stockpiles of old chemicals and products before they become "unknowns"

Technology Applications

- Other technologies:
  - Purification
  - Substitution
  - Dilution

Purification

- Avoid introduction of inerts or impurities into the production process

Use **deionized rinse water** in electroplating or **oxygen** instead of air in oxychlorination reactors for production of ethylene dichloride

Technology Applications

Substitution

- Replacement of a toxic material with lower toxicity or higher environmental desirability

- Use **phosphates** in place of dichromates as cooling water corrosion inhibitors
- Use **alkaline** cleaners in place of chlorinated solvents for degreasing

Technology Applications

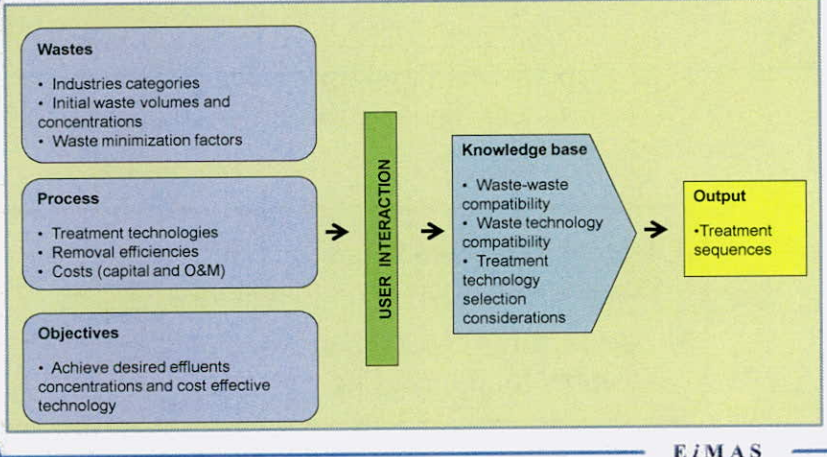
Dilution

- Minor component of input material changes

Use of more dilute plating solutions to minimize drag out (material carried out of one tank into another)

Technology Applications

Framework for technology selection



Operational and Maintenance Procedures

- Operational procedure
  - Make optimum use of raw materials used in the production process
  - Inexpensive to institute
  - Involve little or no capital expenditure
  - Many sources of waste are overlooked because:

"that is just the way the process work"

"that's the way we've always done it"

Operational and Maintenance Procedures

1. Paint manufacturer

Using a series of coarse to fine filters for grit removal

Alternative → only the fine filter was necessary

= Generation of spent filter cartridges was **reduced by 50%**

Operational and Maintenance Procedures

2. Degreasing

Degreasing all parts coming into a facility and then reoiling them to prevent rusting

Alternative → clean only those parts that need further coatings or need to meet a cleanliness specification

Operational and Maintenance Procedures

Other examples of operational changes to reduce hazardous waste

- Reduce raw material and product loss caused by leaks, spills, drag-out and off-spec process solution
- Schedule production to reduce equipment cleaning. E.g. paint manufacturers can make light paint before dark paint so that the vats do not have to be cleaned out between batches
- Inspect component parts before they are processed to reduce the number of rejects
- Consolidate types of equipment or chemicals to reduce quantity and variety of waste
- Improve cleaning procedures to reduce generation of dilute waste. E.g. use dry cleanup techniques, use mechanical wall wipers or squeegees, use compressed gas to clean pipes, increase the time that parts drain
- Segregate product to increase recoverability
- Optimize operational parameters such as temperature, pressure, reaction time, concentration and chemicals to reduce by-product or waste generation
- Develop employee training procedures on waste reduction
- Evaluate the need for each operational step and eliminate those that are unnecessary
- Collect spilled or leaded material for reuse

Operational and Maintenance Procedures

- Maintenance procedure
  - Case study:
    - Poor maintenance resulted 1/4 to 1/2 of its excess waste load
    - Poor maintenance attributed approximately 2/3 of all boiler failures and nearly all unscheduled down time

→ Develop maintenance program

- Help identify potential sources of release and correct the problem before any material is lost

Operational and Maintenance Procedures

- Maintenance program:
  - Include maintenance cost tracking and preventive scheduling and monitoring
  - Developed and followed for each operational step in the production process with special attention given to potential problem points
  - Strict schedule and accurate records on all maintenance activities should be maintained
  - Include predictive maintenance

Operational and Maintenance Procedures

- Maintenance program also produce waste
  - Process materials, rags, scrap parts, oils and cleanup residue
- Reduced waste by
  - Revised operational procedures
  - Equipment modifications
  - Source segregation
  - Material recovery
- Eg.

Before a filter is replaced, all process materials should be drained from the housing, either under gravity or pressure and collected for reuse

Operational and Maintenance Procedures

- Proper operating and maintenance procedures must be established
  - Fully documented and made part of the employee training program
  - Case study (through training):

Printing facility ⇒ 80% waste reduced
Milk processing plant ⇒ 46% waste reduced
Semiconductor manufacturer ⇒ 40% waste reduced
Automotive plant ⇒ 47% waste reduced

Operational and Maintenance Procedures

- Effective training program
  - Included all levels of personnel
  - Goal :

    To make every employee aware of waste generation, its impact on the company and the environment and the ways it can be reduced
  - Prepared written materials
  - Hands-on training
  - Ongoing process with review updates
  - Interaction between employees and supervisors on a regular basis

Operational and Maintenance Procedures

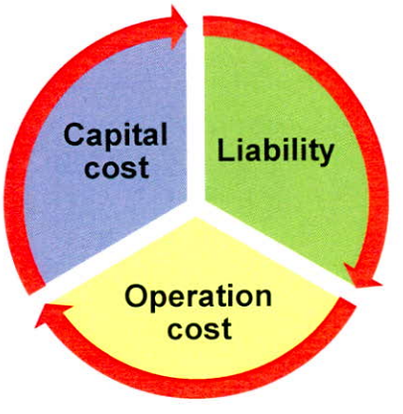
- Approaches to waste reduction training:

Developed a **training video** to introduce waste reduction to the line operators with **simple written** waste reduction procedures for each line operation

CAPITAL AND OPERATING COSTS

Capital and Operating Costs

- 3 financial issues:



Capital and Operating Costs

Capital Cost

- To construct hazardous waste facility
- Cost depends on size and type of treatment process
- Elements on capital cost:
  - Site works
  - Miscellaneous
  - Treatment systems
  - Buildings

Capital and Operating Costs

Operational Cost

- Influenced by:
  - Type of waste
  - Treatment process
  - Ultimate disposal - largest cost and the one that is the least controllable
- Elements on operational cost
  - Personnel
  - Repair and maintenance
  - Chemicals/raw materials
  - Treatment costs per unit waste

Capital and Operating Costs

Liability

- **Financial responsibility**
  - Requirement for obtaining a permit
- **Financial liability**
  - Important business venture if accidents occur
  - Protect financially from accident impacts through:
    - Purchase of insurance
    - Reserve fund

Design Considerations

- General cost should be considered for treatment and disposal planning and design:

Design Considerations

Facility Siting

- Basic principles of facility siting:
  - Defining the maximum potential geographic area
  - Excluding areas that are unsuitable
    - due to physical constraints or environmental or socio-political reasons
  - Selecting several area within the remaining area with favorable characteristics
  - Making a final choice

Design Considerations

- Restrictive siting criteria:
  - Ecological sensitive areas
  - Geologically unstable areas (unstable soils, seismic risk)
  - Flood-plains
  - Highly vulnerable aquifers
  - Excessively steep slopes
  - Prime agricultural land

Design Considerations

Facility Layout

- Depends on size and amounts of different types of wastes
- Major elements:
  - Receipt control (classification and characterization of incoming wastes)
  - Storage for drums, bulk liquids and sludges
  - Treatment process
  - Transport of residuals for offsite disposal and reclaimed materials for reuse and recycling

Design Considerations

Management and Operation Plans

- To guide day-today operations to prevent incidents or accidents
- Requires the cooperative efforts of management and technical personnel during the design and startup phases
- Details and complexity of these plans varies according to the type of activity or facility

Design Considerations

- Essential elements:

- Waste characterization and tracking system
- Site security
- Procedures for safe handling of waste and monitoring of worker health
- Equipment inspection and maintenance program
- Maintenance of operating record
- Employee training
- Incident prevention, preparedness and emergency planning
- Planning for closure

Technology and Equipment

- Cost of site-specific basis:

- Method for collection of hazardous waste
- Treatment facility and supporting ancillary
- Facility layout

Technology and Equipment

Method for collection of hazardous waste

- Collection, manifesting and transport of waste materials to the hazardous waste treatment facilities

Treatment facility and supporting ancillary

- Environmentally sound and cost effective treatment options

Technology and Equipment

- Units at treatment facility include:
  - Waste receiving and unloading
  - Container sampling and processing
  - Containerized waste management
  - Containerized waste storage and loading
  - Inorganic container management
  - Inorganic tank management
  - Organic tank management
  - Organic container management
  - Special projects management
  - Fuels and solvent recovery
  - Aqueous waste management/treatment

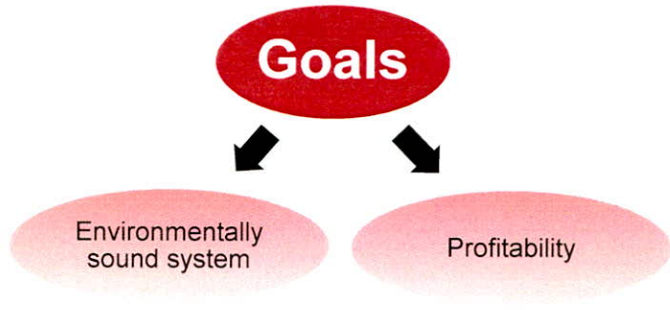
Technology and Equipment

Facility lay-out

- Should include an engineered, preconstructed steel building, built on a poured concrete base
- Portion include:
  - Offices
  - Administrative work area
  - Laboratory
  - Storage area

Infrastructure and Facilities Requirements

- 2 basic goals on developing a hazardous waste treatment facility:



Infrastructure and Facilities Requirements

Environmentally sound system

- Enforcement of the regulations
- Cause a revenue stream to be generated and also dictate the operational and disposal standards for the treatment facility

Profitability

- Driving force for any commercial entity
- Function of operational efficiency and the competitiveness of the product

Human Resource

- Operators, management and staff are the "engine room" of the facility
  - Ensuring profitability is achieved
  - Regulatory requirements are met
- Operational plan must address:

  - Hazardous waste management plan
  - Preparation of an operation & maintenance manual (O&M)
  - Skilled staff
  - Training requirements

Human Resource

- Hazardous Waste Management Plan
  - Addresses health and safety
  - Secured accumulation and storage
  - Recordkeeping and manifesting
  - Materials handling procedures
  - Emergency response plan

Human Resource

- Preparation of an Operation & Maintenance Manual (O&M)

  - Describes operation in detail
  - Establishes maintenance requirements and schedules
  - Detailed technical information on each piece of equipment

Human Resource

- Skilled Staff
  - Depend primarily on the volume of waste treated
  - Would include manager, chemist, operator(s), driver(s) and clerical personnel
  - Strong background in chemistry or chemical engineering
- Training Requirements
  - Combination of both formal and on-the-job training
  - All staff, regardless of position and function
  - Should have a health and safety officer

Operational Consumable

- Features essential for the support of the primary operation include :

  - Laboratories
  - Maintenance workshops
  - Changing rooms for employees
  - Medical facilities
  - Administration and control etc
  - Provision of adequate facilities for waste reception / checking, storage and pre-treatment

Operational Consumable

- Example of chemicals consumed:
  - Solidification plant
    - Cement, lime and sand
  - Physical/chemical treatment plant
    - Ferrous sulphate - reduction of chromate wastes
    - Sodium hypochlorite - oxidation of cyanides
    - Lime and caustic soda - neutralizing pickling acids and other acids
    - Sulphuric acids - neutralizing alkaline wastes

End of Module 3

Thank You

Environment Institute of Malaysia (EiMAS)
Department of Environment

TREATMENT AND DISPOSAL OF HAZARDOUS WASTE

MODULE 3

Options of Hazardous Waste Minimization, Treatment and Disposal

SLIDES (PESERTA)

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TREATMENT AND DISPOSAL OF HAZARDOUS WASTE

MODULE 3:

Options of Hazardous Waste Minimization, Treatment and Disposal

EiMAS
Institut Alam Sekitar Malaysia
Environment Institute of Malaysia

Contents

- Introduction
- Purpose
- Economic Values and Benefits
- Changes of Input Materials
- Improvement of Operating Practices
- Products Changes
- Compliance with International Requirements
- Treatment Efficiencies
- Capital and Operating Costs

Introduction

- Quantities (in tonnes) of scheduled waste generation in Malaysia have been increasing from 2003 to 2009:

2003	– 460,865.74
2004	– 469,584.07
2005	– 548,916.11
2006	– 1,103,457.06
2007	– 1,138,839.491
2008	– 1,304,898.77
2009	– **1,705,308.14**

Introduction

- These scheduled wastes have been managed or handled in the following manners:
  - Sent for off-site recovery
  - Treated on-site
  - Stored on-site
  - Disposed of at secure landfill
  - Exported for recovery

Introduction

- Most industries managing hazardous waste in accordance with control procedures
- Issues confront the authorities:
  - Illegal dumping
  - Illegal dumping
  - New and emerging issues of contaminated land

Purpose

- To provide participants with:
  - Principle elements for the implementation of waste reduction through source reduction program
  - Key elements for developing a successful operational improvements in the hazardous waste minimization strategies
  - Mechanisms for identification of all the relevant elements of capital and operating costs of hazardous waste treatment and disposal

ECONOMIC VALUES AND BENEFITS

Economic Values and Benefits

- Hazardous waste minimization program
  - Goal - to minimize all waste produced
  - Potential benefits:

1. • Financial benefits
2. • Corporate image
3. • Preservation of natural resources

Financial Benefits

- By minimizing hazardous waste, in return it will:
  - Increase production efficiency
  - Reduce costs associated with:
    - purchasing raw materials
    - waste management
  - Eliminate the generation of hazardous waste
  - Comply fully with EQSWR 2005 regulatory requirements

Financial Benefits

- Cost of waste is not only the cost of waste disposal, but also other costs such as:
  - Handling cost of waste
  - Purchasing cost of wasted raw material
  - Generation cost for the waste material
  - Management cost for time spent on waste material
  - Lost of revenue for what could have been a product instead of waste
  - Potential liabilities due to waste

Financial Benefits

- Effective waste minimization will reduce in:
  - Cost of raw materials
  - Manufacturing cost of material
  - Cost of product
  - Cost of treatment of waste to comply with regulatory requirements
  - Cost of waste disposal
  - Cost of waste transportation
  - Maintenance required work environment

Corporate Image

- Company's policy and practices influence community attitudes
- Community attitudes toward companies:
  - Operate and publicize a thorough pollution prevention program
  - Creates environmentally compatible products
  - Avoids excessive use of material and energy resources

Corporate Image

- Business may also benefit from the positive or "green" image associated with hazardous waste minimizing efforts

A company that values strong corporate stewardship can increase goodwill with shareholders and consumers and further distinguish itself from its competitors

Preservation of Natural Resources

- Minimizing hazardous waste
  - Less air, water and soil pollution associated with extraction, refining and processing of raw materials
  - Reduce emissions of greenhouse gases (GHGs)
- When hazardous wastes are minimized
  - Less energy is needed to extract, transport and process raw materials and to manufacture products

Preservation of Natural Resources

- When energy demand decreases,
  - Fewer fossil fuels are burned and less CO_2 is emitted
  - Emissions of other air pollutants can be reduced
  - Decrease releases of air toxics from waste incineration

CHANGES OF INPUT MATERIALS

CHANGES OF INPUT MATERIAL

- First step of product formulation or production process during:
  - Selection for raw material
  - Selection for chemical
- Replaced with a less hazardous or non-hazardous material
- Reformulating a product to contain less hazardous materials

CHANGES OF INPUT MATERIAL

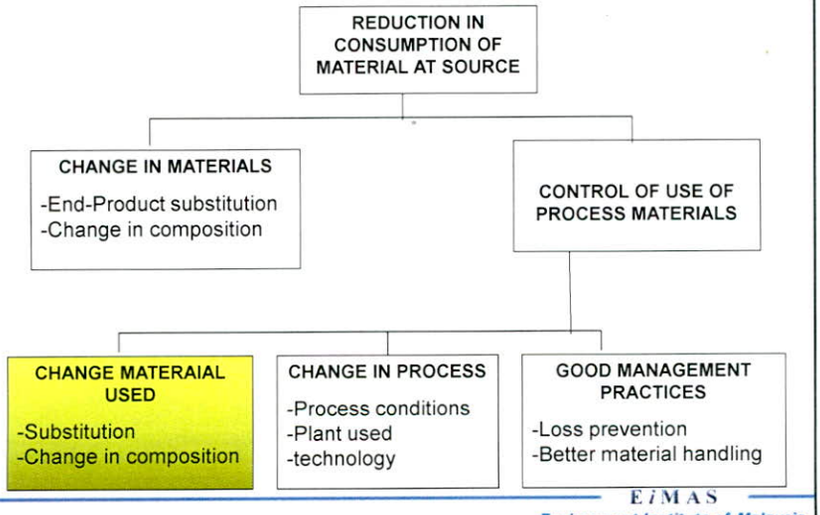
- Examples of material changes

Industry	Material Changes
1. Household appliance	• Eliminate cleaning step by selecting lubricant compatible with next process step
2. Textile	• Reduced phosphorus in wastewater by reducing use of chemicals containing phosphates • Used ultraviolet light instead of biocides in cooling towers • Substituted nonhazardous dye carrier for carrier containing hazardous substances • Substituted solvent-based adhesive system with water-based acrylic latex system • Reuses rinse water as bleach bath

CHANGES OF INPUT MATERIAL

Industry	Material Changes
3. Aerospace	• Replaced cyanide cadmium plating bath with a non-cyanide bath
4. Ink manufacture	• Removed cadmium from product
5. Metal coating	• Eliminated VOC emissions by switching from traditional solvent-based painting to powder coating operation
6. Chemical manufacture	• Replaced 1,1,1 trichloroethane with isopropyl alchohol as process reaction medium
7. Yacht manufacture	• High solids paint and catalyst batches previously mixed prior to application resulted in disposal of large quantities of unused paint in the spray gun resulting in no excess waste paint

Raw Material Selection



Raw Material Selection

- Entails substituting non-hazardous products for hazardous raw materials currently used
- Good purchasing procedures
  - Identify and reduce potential waste
- Look for less or non-toxic and purchase
  - Least toxic and least costly-to-handle
  - Higher-purity raw materials
  - Non-corrosive raw materials

Raw Material Selection

- Guidelines for selection of raw material:

1. Product composition and batch sheets
2. Material application diagrams
3. Material Safety Data Sheet (MSDS)
4. Product and raw material inventory records
5. Operator data logs
6. Operating procedures
7. Production schedules

Chemical Selection

- Evaluate procedures to:
  - Determine whether or not less hazardous chemicals can be used
- If cannot, use substances that can be neutralized or stabilized, either physically or chemically
- A less toxic chemical may:
  - Reduce threats to the environment and human health
  - Also reducing the cost of disposal

Chemical Selection

- Examples of less toxic alternatives:

- **Use enzymatic cleaners, detergents or elbow grease** when cleaning glassware instead of chromium based cleaners (e.g. Chromate)
- **Use quaternary amine detergents** instead of isopropyl alcohol when sterilizing equipment
- **Replace thermal distillation apparatus** with dry solvent purification systems for purifying or drying solvents
- **Use alcohol** as a fixative instead of formaldehyde
- **Use non-halogenated** rather than halogenated solvents when applicable
- **Use digital photography or a digital X-ray machine**

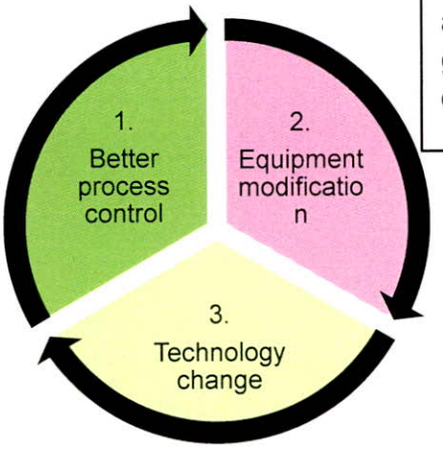
IMPROVEMENT OF OPERATING PRACTICES

IMPROVEMENT OF OPERATING PRACTICES

- Significantly reduce waste generation at source
- Most cost-effective waste reduction techniques
- Practices:
  - Process change
  - Procedural change
  - Good house-keeping

Process Change

- Can be applied by:



To run the processes at **higher efficiency** and with **lower waste generation and emissions**

Process Change

1. Better process control	• Modifications of the working procedures • Machine-operating instructions • Process record keeping
2. Equipment modification	• Addition of measuring and controlling devices
3. Technology change	• Replacement of the technology processing sequence and/or synthesis route • Installing more efficient equipment • Modification existing equipment

Process Change

- Highly efficiency systems will:
  - Reduce number of rejected or off-specification products
  - Reduce amount of material that must be reworked or discarded
  - Higher productivity
  - Reduced raw material costs
  - Lower labour costs
  - Reduced waste management costs

Process Change

Process	Equipment or product modification
Parts cleaning	• Enclose all solvent cleaning units • Use refrigerated freeboard on vapour degrease units • Improve part draining before and after cleaning • Use mechanical cleaning devices • Use plastic bead blasting
Surface finishing	• Prolong process bath life by removing contaminants • Redesign part racks to reduce dragout • Reuse rinse water • Install spray or fog nozzle rinse systems • Properly design and operate all rinse tanks • Install dragout recovery tanks • Install rinse water flow-control valves • Install rip racks and drain boards

Process Change

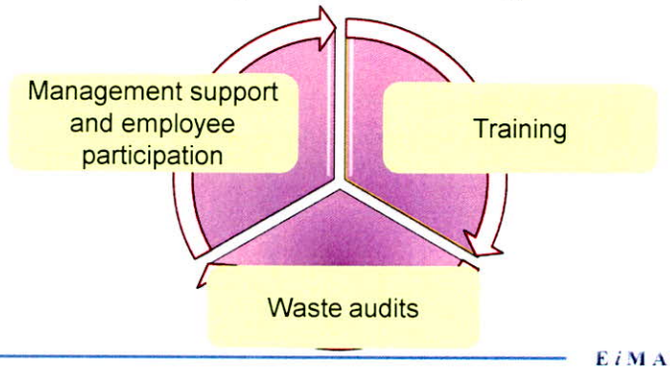
Process	Equipment or product modification
Surface coating	• Use airless air-assisted spray guns • Use electrostatic spray-coating system • Control coating viscosity with heat units • Use high solids coatings • Use powder coating systems
Equipment cleaning	• Use high-pressure rinse system • Use shorter feed lines to minimize cleaning and cleaning waste • Use mechanical wipers • Use countercurrent rinse sequence • Reuse spent rinse water • Use compressed gas to blow out lines

Process Change

Process	Equipment or product modification
Preventing spills/leaks	• Use bellow-sealed valves • Install spill basins or dikes • Use seal-less pumps • Maximize use of welded pipe joints • Install splash guards and drip boards • Install overflow control devices

Procedural Change

- Monitor and reduce generation of hazardous waste
- Elements in procedural change include:



Procedural Change

Management Support and Employee Participation

- Commitment by senior management through policy, communication and resources
- Drafted and adopted formal policy statement
  - Protecting the environment
  - Minimizing or eliminating waste
  - Reuse or recycling materials

Procedural Change

Training

- Formal and on-the-job training
- Includes the company compliance requirements found in
  - Waste management policies
  - Occupational health and safety

Procedural Change

Waste Audits

- Provide systematic and periodic survey on operations designed
  - Identify areas of potential waste reduction
- Useful to analyze:
  - Waste origin
  - Operational problems inherent to its process
  - Areas where improvements can be made

Procedural Change

- Observe, measure and record data and to collect and analyze waste samples
- Applied methodically with support of both operators and administrative staff
- Must aim at waste prevention and reduction
- Must go beyond the end-of-the-pipe treatment

Procedural Change

- 2 audit level:

Regional audit	• Verify problems derived from several industries
On-site audit	• Monitor wastes in each phase of the process and thus locate specific loads for treatment

Procedural Change

- Audit program includes:

- **I**dentification of hazardous wastes and sources
- **P**rioritization various waste reduction actions to be undertaken
- **E**valuation of some technically, economically and ecologically feasible approaches
- **D**evelopment of an economic comparison of waste minimization and pollution prevention options
- **E**valuation of their results

Good House-keeping

- System to prevent leakages & spillages through
  - Preventive maintenance schedules
  - Routine equipment inspections

- Most effective and simple first steps
- Relies on:
  - Good common sense
  - Well-written working instructions
  - Supervision
  - Awareness
  - Regular training of workforce

Good House-keeping

- Good housekeeping practices include:

1. Using a **"first in, first out"** inventory system
2. Conduct frequent **inventory checks**
3. Validate **shelf-life** expiration dates
4. Use **raw materials** sparingly and in correct proportions
5. Take care when transferring chemicals to **minimize spills**
6. Keep non-hazardous waste stream **separate** from hazardous waste streams
7. **Segregate** waste according to toxicity
8. **Seal** and contain processes
9. **Inventory** all products and waste, clearly **labeling** and properly **storing**

Good House-keeping

- Material control:
  - Storage of raw materials
  - Products and process waste
  - Transfer of these items within the process and around facility
- Proper material control procedures ensure:
  - Raw material efficiently handled and used
  - Does not become waste

PRODUCT CHANGES

Product Design

- Reduce amount of components used in the production
  - Saves from waste minimization
  - Later due to it being less complex makes way for recycling
- Product design strategies: