Lecture 2

Waste Minimization and Pollution Prevention

1. General Considerations

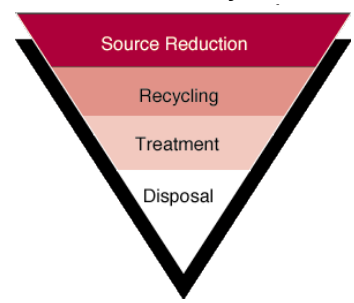
Activities that eliminate or reduce generation of HWs;

- Waste minimization
- Waste reduction
- Source reduction
- Waste diversion
- Pollution prevention
- Recycling and reuse

Waste Minimization

- EPA defines the waste minimization as the reduction of volume or toxicity of waste.
- Waste minimization applies to any management technique or process modification that ultimately reduces the mass or toxicity of waste sent on to treatment and disposal facilities.

EPA's waste management hierarchy



Pollution Prevention

- The term pollution prevention has an evolving definition that includes;
  - Managing chemicals to reduce risk
  - Identifying and estimating all releases
  - Waste minimization

Pollution Prevention

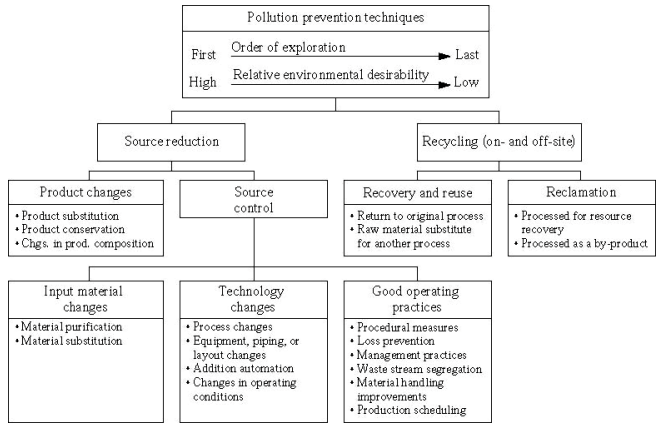


Figure 7.1 Pollutant prevention techniques (LaGrega *et al.*, 2001)

Pollution Prevention

- In the 1940s, paper mills developed a device to recover the fibers and prevent them from becoming a source of pollution.
- This device became so effective and widespread that it is now considered part of the manufacturing process and no credit would be given today to it as a waste minimization technique.
- Because it comes as a standard part of paper manufacturing equipment and is thought of standard operating procedure.

Pollution Prevention

- Today, there are dramatic increases in the cost of disposal, legal and regulatory incentives and public demands that industry simply stop producing HWs.
- The 'cradle-to-grave' concept of HW regulation and associated liabilities causes all industries to develop means and measures for reducing HW generation.

Economic incentives

- A second look at the manufacturing process can identify additional ways that wastes can be reduced, sometimes at little or no cost.

	Product design	Raw materials	Manufacture, sales, and distribution	Packaging	Use	Final disposal
Competitive advantage from:	• Chemical usage • Ease of recycling • Ease of reuse • Ease of disassembly (e.g., modular design) • Size	• Use of renewable resources • Reducing impact from transport	• Pollution prevention, waste minimization • Process hazards management	• Reduced packaging • Vegetable-based inks • Concentrating product	• Aerosol-free cleaning agents • Low-dosage pesticides	• Recycling • PET versus HDPE
	Management and organization		Cross-functional management strategies, integrating environmental expertise into decision-making processes			
	Technologies		Creating new technologies that are environmentally sound			

Figure 7.2 Adding value from an environmental standpoint: competitive advantage (LaGrega *et al.*, 2001)

Legal and regulatory incentives

- A second motivation for conducting waste minimization evaluations is that they are required by law.
- In 1975, the waste hierarchy concept was introduced for the first time into European waste policy.
- It emphasized the importance of waste minimization, protection of environment and human health as priorities.
- In 2008, a new 5-step waste hierarchy (avoidance, reuse, recycling, recovery and disposal) was introduced to Waste Framework Directive (2008/98/EC).

Public demands

- Public no longer tolerates the continued production of HWs.
  - Consumer boycotts of products from companies perceived not to be environmentally responsible
- Opposition to proposed new HW disposal facilities is generated by fears of excessive health risks.
- Another opposition is the perception that industry has no need to prodece HWs in the first place and proposed facility is simply not necessary.

2. Management Strategies

- Outline for minimizing the generation of HW
  - Planning and organization
  - Characterization of waste and losses
  - Development of waste minimization options
  - Technical, regulatory and economic feasibility
  - Implementation (including training)
  - Monitoring and optimization
  - Continued and ongoing evaluation of reaching a "zero" genertion status

Audits

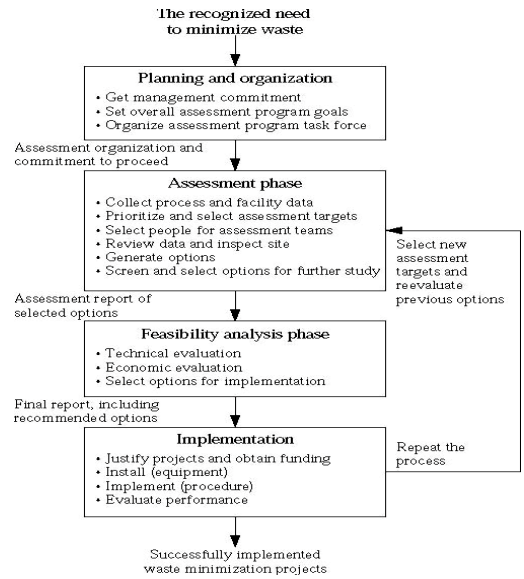
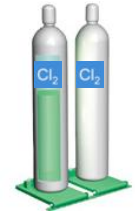


Figure 7.3 EPA's waste minimization assessment procedure (LaGrega *et al.*, 2001)

Methods

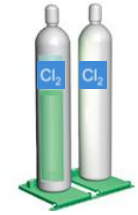
- The simplest waste minimization efforts involve housekeeping changes.
- To reduce HW generation
  - Segregate HWs
  - Sweep the floors prior to washing
  - Train the employees to be sensitive to the implications of their actions
- Only after these relatively inexpensive measures are undertaken should production changes be contemplated.

Example 7-1



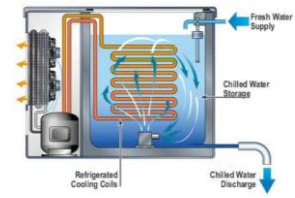
- A downtown office building had large transformers located below the street level.
- Since air cooling was not feasible, groundwater from a well was pumped & treated with Cl_2 to cool transformers.
- The used water was then treated to remove the Cl_2 so it could be discharged to the river.
- For years, environmental engineers processed the necessary extraction and discharge permits and facility personnel maintained the chlorination & dechlorination systems, at an annual cost of app. $ 140.000.

Example 7-1



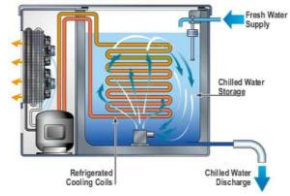
- Cl_2 cylinders were located in a small room below the street that was vented to the street level, near the main intake for the building.
- A new engineer was assigned the routine task of renewing the necessary permits.
- What should he/she do?

Solution 7-1



- This is a true story. Rather than just process the paperwork, the new engineer questioned the need for the permits and having experience with accidental release modeling, found that a release of Cl_2 from one of the cylinders could impact the office building as well as the neighboring area.
- He met with facility maintenance personnel to discuss the feasibility of alternative water treatment systems or the installation of a water chiller.

Solution 7-1

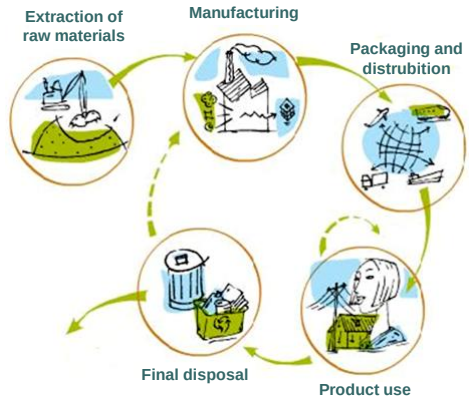


- Through these meetings and follow-up investigations he found that a decade previously, a new computer room was installed in the building and a water chiller was installed to cool the room.
- This chiller was sized to accommodate the cooling needs of the transformers at the time it was installed, but the funds to connect the piping from the chiller to transformers were not appropriated.
- The engineer's simple ability to ask "Why?" ended up eliminating a high-risk scenario and provided significant savings with a rapid payback.

3. Life Cycle Analysis

- One of the more promising systematic approaches for identifying & evaluating opportunities to improve the environmental performance of industrial activity is termed Life Cycle Analysis or Assessment (LCA).
- LCA provides an analytical framework for investigating the entire range of environmental impacts (e.g., air emissions, wastewater, solid & hazardous waste, renewable resources and energy utilization)

Product life cycle



3. Life Cycle Analysis

Table 7.5 The life cycle analysis model (LaGrega *et al.*, 2001)

Phase 1, inventory	**Phase 2, impact analysis**	**Phase 3, improvement analysis**
Organize LCA teams	Assess compliance with company requirements	Assess alternatives for improvement
Determine priorities	Assess risk, where appropriate	
Target products for LCA		
Diagram the LCA		
Determine the usage and generation rates (of raw materials, wastes and energy)		

3. Life Cycle Analysis

- Cascades - Life Cycle Assessment (LCA)
- The Product Life Cycle Approach at RONA
- Sulzer Insights on Managing Life Cycles
- Life Cycle Assessment - It's the only way to drive!

4. Volume Reduction

- Initiate waste minimization investigations by examinig ways to reduce the volume of HW.
- This can be accomplished by modifying production processes, segregation, and reuse.
- Under some regulatory schemes, simply reducing the volume of the waste without an accompanying reduction in toxicity would not be considered “waste minimization”.

Process modification

- Process modifications include changes in:
  - Raw materials
  - Equipment
  - Operating procedures
  - Materials storage
  - End products

Process modification

Raw material substitution:

- In the printing industry, the common practice of using organic solvents for cleaning presses has been replaced with water-based cleaners.
- It was reported that replacing organic solvents with inorganic acids and bases, resulted in the reduction in the emission of huge amounts of hexane.
- Conversion to a higher quality raw material can eliminate the generation of HW where the compound causing the waste to be considered hazardous is due to contamination of raw material.

Process modification

- Any process change needs to be coordinated with production management.
- They must be an integral part of the planning, design, and implementation of any WM efforts.
- Production supervisors must be committed not only to the changes in equipment, but to training staff as to the reasons for the changes.
- Creatively designed waste minimization efforts can fail because of a lack of understanding on the part of production staff as to the need for the changes.

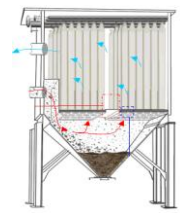
Segregation

- A primary rule of source reduction is to avoid mixing wastes.
- A mixture of a small amount of HW with a larger amount of non-HW creates a large amount of material that must be treated as a HW.
- Another basic rule; don't make it a liquid if it is dry!
- Housekeeping operations as simple as sweeping prior to washing floors can substantially reduce waste volumes.

Segregation

- A volume reduction can be achieved by keeping noncontact cooling water separate from waste streams.
- Many manufacturing facilities are in buildings that were constructed long before waste management was a major concern and there is often a single sewer system for such buildings.
- In such buildings, all aqueous wastes drain to a common sewer, and separating process wastes through the installation of new piping systems is often the only way to properly handle wastes.

Segregation



- Some solid waste streams can be segregated effectively through minor changes in equipment.
- A major source of HW at a number of industries is baghouse dust emanating from air pollution control equipment.
- Common dust collectors were utilized for different production areas, resulting in a mixing of different types of dust and preventing recycling.
- After modifying dust collectors, each compartment serves a single source.

Reuse

- Many materials that are disposed of as HW have a potential to be reclaimed for another application.
- In some instances, contaminated materials may be of adequate quality to serve as a solvent or cleaning material for a less sensitive application.
- In the printing industry, toluene is often used as both a cleaning agent for presses and a thinning agent for the inks, prior to their being placed on the presses.
- If the toluene used for cleaning is limited to cleaning one specific color ink, it may be possible to reuse that toluene to thin the same color ink.

Reuse

- Another source of HWs is raw materials stored past their expiration date.
- Such dates are often established conservatively and it may be possible to reassay and requalify the material for use in production.
- It was suggested that a total evaluatian of specified shelf lives may be appropriate

4. Toxicity Reduction

- A number of waste minimization techniques reduce the concentration of contaminant in a liquid or solid waste stream, without necessarily diminishing the volume of wastes produced.
- It is often possible to lessen the toxic characteristics sufficiently so that the remaining waste is no longer considered a HW.
- Process and equipment modifications, housekeeping practices, material substitution

Process modification

- Powder coating technology has reduced the need for solvent-based paints in many industrial painting applications.
- The process consists of spraying a heat-fusible powder on a metal surface.
- An electrode in the spray gun charges the powder particles.
- The metal to be coated carries an opposing charge and particles are attracted to the metal surface.
- Applying heat to bind the paint to the metal completes the process.

Process modification

- Overspray is collected and recycled.
- In addition to eliminating a HW stream, this process reduces material, labor, and energy costs compared to conventional solvent-based painting.

4. Recycling

- When it is not possible to reduce the volume or toxicity of a waste, it may be possible to recycle it to another process or another plant.
- Other factors being equal, on-site recycling is preferable because shipping HW off-site, even for recycling, carries the liability that the waste might be mishandled.
- Water is in most instances the easiest material to recycle, and this is the first place one should look when evaluating prospects for recycling.

4. Recycling

- Solvent recycling is common practice in many industries, and a wide range of solvents are currently recycled.
- Azeotropic distillation is commonly used to enhance solvent recovery.
- Oil that has become contaminated with hazardous materials may require disposal as a HW.
- Often this material can be recycled rather than shipped for off-site disposal.
- The energy content of spent oil can be reclaimed in many instances, through burning industrial furnaces.

4. Recycling

- A wide range of solid materials, including paper, metals, and plastics, are amenable to recycling.
- The recycling of paper and paperboard has become routine at most industries.
- Scrap metal such as swarf from machining operations is also a common candidate for recycling.
- The recycling of plastics is not as widespread. However, it is a feasible alternative to incineration or land disposal of these materials.

4. Recycling

- While reusing a waste product inside a manufacturing facility is the most desirable form of recycling, it is not always possible to find another department or process that can effectively utilize the waste.
- An alternative is to locate another company that can make use of your waste.
- A waste exchange is a regional clearinghouse for such transactions.
- Waste exchanges maintain computer databases and/or publish periodic lists of wastes available or materials sought by various industries.