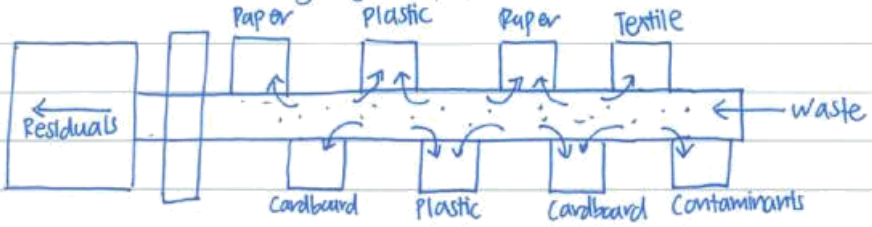
EN3001 17/18

1a. Waste is a misplaced resource as waste are often thrown away when they can be reused - Waste residues can be converted into reusable materials, energy and other products with high value - As the natural resources are limited and depleting, it is necessary to reuse and recycle these materials in order to mitigate waste management problems.

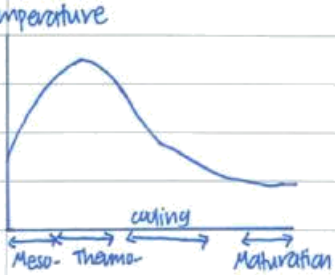
1b. Data are needed to address issues related to:
- National policy setting
- Regional planning of waste management
- Legal aspects
- Administration
- Cost accounting
- Design and operation of facilities
- Environmental assessment

1c. Drop-off centres require residents/businesses to separate recyclable materials at source and bring them to a specified drop-off or collection center. Buy-back centres offer a drop-off program that provides a monetary incentive to participate - Residents are paid for their recyclables either directly or indirectly through a reduction in monthly collection and disposal fees. Such systems can be implemented at the residential areas to encourage residents to recycle. The main reuse and recycling opportunities in Singapore include the reuse of plastic bags and plastic bottles and the recycling of papers.

1d.



1e. The objectives of the composting process is to transform the biodegradable organic materials into a biologically stable product and reduce the volume of waste. It can also destroy pathogens and other unwanted organisms and retain the maximum nutrient.



Mesophilic Phase: Last only a few days
- Explosive growth of bacteria and fungi
- Rapid breakdown of soluble sugar and starches

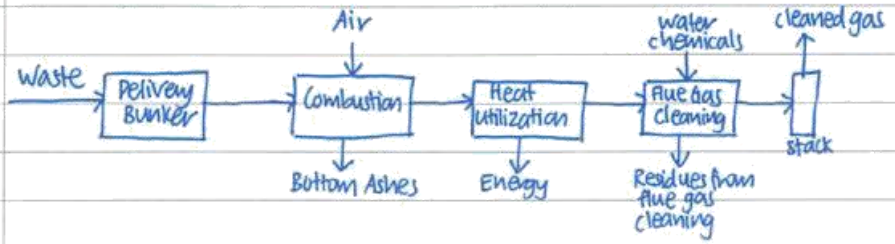
Thermophilic Phase: Last several days to several months
- High heat helps breakdown protein and "tough" plant material
- High temperature kill pathogens

Maturation Phase: Last several months
- Remaining organic material is slowly broken down

2a. Objectives of incineration technology:

- Reduction by volume → Save of landfill space
- Recovery of waste energy → conserve energy resources
- Destruction of contaminants → control emissions

2b.



2c. Requirements for waste incineration:

- Autothermic flammability of waste
- Obtaining the firing temperature
- Sufficient amount of fuel and oxygen provided in combustion chamber

Sources of energy loss:

- Water evaporation
- Radiation
- Hot ash
- stack gases

2d.

Landfill gas
Landfill cover
Leachate collection system
Liner system
Landfill bottom

No, Pulau Semakau landfill is not the same as other traditional landfills as it is a specially engineered landfill to minimize environmental impacts, whereas the other traditional landfills are pure dumping grounds for waste without taking into account the environmental impacts. No, it would not produce methane gas as any leachate produced is processed at a leachate treatment plant.

2e. (1) Incineration plant combined with mechanical and biological treatment to decrease footprint
(2) Material recovery prior to WtE process such as the recovery of ferrous and non-ferrous metals
(3) Low temperature steam taking part in desalination plant.

3a. (1) Hazard Identification: An evaluation of the adverse health effects the agent is capable of causing

(2) Dose-response assessment: Determination of how much of an agent is required to cause a toxic effect and prediction of exposure levels at which risk is likely to be negligible or nonexistent.

(3) Exposure assessment: Determination of how much of an agent people might be exposed to under various conditions

(4) Risk Characterization: An integration to characterize the risks to the exposed population

3b. "PSI" stands for Pollutant Standard Index. It measures concentration of NO_2, SO_2, CO, O_3, PM_{10} and $PM_{2.5}$. It is an indicator of air quality.

3c. Purpose and objectives of the Basel Convention is to control the transboundary movement of hazardous waste. The convention states that "Illegal traffic of hazardous waste is criminal". Each Party shall introduce appropriate national/domestic legislation to prevent and punish illegal traffic. Parties shall cooperate to prevent illegal traffic.

3d(i) In Germany,
MSW generated = 0.95 × 20,000 = 19,000 kg/d

In Singapore,
MSW generated = 1.9 × 20,000 = 38,000 kg/d

(ii) Amount of waste that can be collected by the truck in a week
= 4.5 tonnes × 2 trips/d × 0.75 × 7 d/week
= 47.25 tonnes/week

$$\text{No. of trucks needed in Germany} = \frac{19000\ kg/d \times \frac{1\ ton}{1000\ kg} \times \frac{7\ d}{1\ week}}{6.75\ tonnes/d \times 2}$$
$$= 9.85$$
$$\approx 10$$

$$\text{No. of trucks needed in Singapore} = \frac{38000\ kg/d \times \frac{1\ ton}{1000\ kg} \times \frac{7\ d}{1\ week}}{6.75\ tonnes/d \times 2}$$
$$= 19.7$$
$$\approx 20$$

(iii) $\text{MSW generated in Germany} = \frac{0.84 \times 19000\ kg/d}{280\ kg/m^3} = 57\ m^3/d$

$\text{MSW generated in Singapore} = \frac{0.77 \times 38000\ kg/d}{280\ kg/m^3} = 104.5\ m^3/d$

4a. Heat from combustion = 1000 kg/h × 0.88 × 17000 kJ/kg = 1.496×10^7 kJ/h

Heat due to water evaporation = 1000 kg/h × 0.07 × 2575 kJ/kg = 180,250 kJ/h

Heat lost due to radiation = 0.04 × 1.496×10^7 kJ/h = 598,400 kJ/h

Total amount of ash = Inerts + Unburned organics
= (1000 kg/h × 0.05) + (1000 kg/h × 0.88 × 0.08)
= 120.4 kg/h

Heat lost due to hot ash = 120.4 kg/h × 0.837 × 830 °C = 83,643 kJ/h

Heat lost in the stack gases = $1.496 \times 10^7 - 180250 - 598400 - 83643 = 1.40977 \times 10^7$ kJ/h

Temperature of stack gases = $\frac{1.40977 \times 10^7\ kJ/h}{9000\ kg/h \times 1.0} = 1566\ °C$

4b. Amount of MSW generated = 1.95 kg/capita/d × 200,000 = 390,000 kg/d

Amount of gas production = 390,000 kg/d × 6.2 L/kg = 2418000 L/d

Amount of CH_4 production = 0.55 × 2418000 L/d = 1329900 L/d

Amount of CH_4 recovered = 0.15 × 1329900 L/d = 199485 L/d

Amount of heat that can be generated by CH_4 in a year = $17000\ kJ/m^3 \times \frac{1\ m^3}{1000\ L} \times 199485\ L/d \times \frac{365\ d}{1\ year}$

$= 1.2378 \times 10^9\ kJ/yr$

Peak usage = $1.5 \times 110 \times 10^6\ kJ/yr = 1.65 \times 10^8\ kJ/yr$

No. of homes that can be built = $\frac{1.2378 \times 10^9\ kJ/yr}{1.65 \times 10^8\ kJ/yr} = 7.5$ homes

Tan Kuan Yi