ES 200-S2

Module B : Solid Waste Management and Other Aspects of Environmental Management

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Incineration…..

- **Mass incineration without MSW pre-treatment is regarded as the most reliable and economical option due to:**

✓ **Majority of waste is burned**

✓ **Volume and mass is significantly reduced. The heat of combustion is recovered in a waste heat boiler for steam generation**

✓ **Waste may be objectionable due to the presence of decaying organic matter, but incineration process produces a sterile ash residue**

Incineration

- **Combustible portion of MSW is oxidized with stoichiometric or excess amounts of air at high temperatures (750 - 1000°C).**

- **Incineration can reduce volume by about 80 - 90%.**

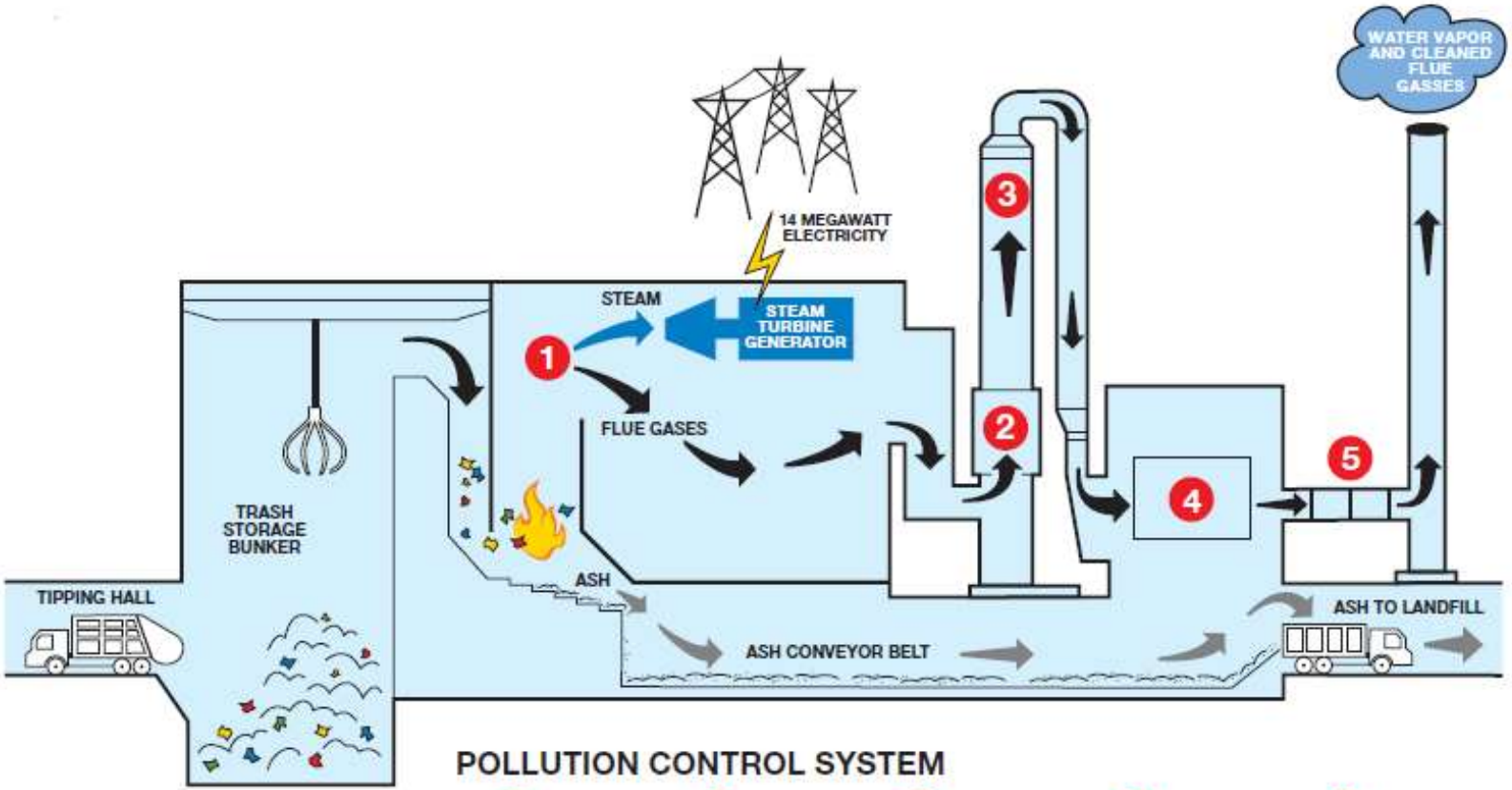
- **In this process, there are three main parts: Incineration, energy recovery and control of air emissions**

- **Major concerns:**

✓ **Bottom and fly ash containing heavy metals**

✓ **Gaseous emissions like SO_X, CO_2, NO_x, dioxins etc.**

Mass Burn Incinerator



POLLUTION CONTROL SYSTEM

1. NITROGEN OXIDE REMOVAL SYSTEM
2. MERCURY & DIOXIN REMOVAL SYSTEM
3. ACID GAS REMOVAL SYSTEM
4. PARTICULATE REMOVAL SYSTEM
5. POLLUTION CONTROL TESTS

Waste-to-Energy

- 90% reduction of trash volume
- Power generation
- Pollution control

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Problems with Traditional Combustion Systems (Huang et al., 2013)

- The existing moving grate system not capable of burning high moisture and low heat value MSW directly.
- High moisture waste should be stored for at least five days for de-watering, before being burned, and the liquid effluent should be treated separately.
- High quality chemical agents, including activated carbon and limestone are essential for reducing dioxin and heavy metal emission.

Advantages and Disadvantages of Incineration Process

Advantages	Disadvantages
Thermal energy recovery with direct heating or power generation	Least suitable for aqueous/high moisture content
Relatively noiseless and odourless	Excessive moisture and inert affects net energy
Low land area requirement	Concern for toxic metals
Can be located within city limits, reducing the cost of transportation	SOx, NOx, chlorinated compounds, HCl

Pyrolysis

- **Thermal processing or destructive distillation of waste in the absence of oxygen (T = 500 – 900°C).**
- **For cellulose, the following expression is suggested as being representative of pyrolysis reaction:**

✓ $3(C_6H_{10}O_5) \rightarrow 8H_2O + C_6H_{10}O + 2CO + 2CO_2 + CH_4 + H_2 + 7C$

- **The system converts solid waste into gaseous, liquid and solid fuels.**

✓ **Gas stream – H_2, CH_4, CO, CO_2 and other gases**

✓ **Liquid fraction – tar or oil stream**

✓ **Char – almost pure carbon and any inert material**

Pyrolysis…..

- The energy content of oil can be as high as 18.2 MJ/kg. Due to poor quality of oil primarily due to high moisture can be reduced to 8 MJ/kg.
- The process requires an external source of heat to drive the endothermic pyrolysis reaction.

Main Operating Parameters For Pyrolysis

(Singh et al., 2011)

Parameter	Conventional pyrolysis	Fast pyrolysis	Flash pyrolysis
Pyrolysis temperature (K)	550 - 900	850 - 1250	1050 – 1300
Heating rate (K/s)	0.1 – 1	10 – 200	> 1000
Particle size (mm)	5 – 50	<1	<0.2
Solids residence time (s)	300 – 3600	0.5 – 10	<0.5

Material Balance for Pyrolysis
(% wt. of waste)

Temperature (°F)	Gases	Liquid fraction	Char
900	12.33	61.08	24.71
1200	18.64	59.18	21.80
1500	23.69	59.67	17.24
1700	24.36	58.70	17.67

Gas composition is the function of temperature.

Composition of pyrolysis gas from MSW (Singh et al., 2011)

Constituent	Amount, Vol%
CO	35.5
CO_2	16.4
CH_4	11.0
H_2	37.1
Calorific value, kcal/Nm^3	~ 14 MJ/m^3

Gasification

- Gasification is a thermal process in which partial combustion of the waste occurs in oxygen – deficient environment.
- The process reduces the volume of solid waste and causes energy recovery.
- The products formed during the process are similar to that formed during pyrolysis.
- The typical composition (by volume) of gas: CO_2 = 10%, CO = 20%, H_2 = 15%, CH_4 = 2% and balance N_2
- The gas contains lesser heating value (~ 6 MJ/m^3) than that emitted during pyrolysis.

Advantages and Disadvantages of Pyrolysis/ Gasification

Advantages	Disadvantages
• Production of fuel gas/oil, which can be used for a variety of applications.	• Net energy recovery may not be sufficient for wastes with excessive moisture.
• Compared to incineration, less atmospheric pollution	• High viscosity of pyrolysis oil may be problematic

RDF Production and its Characteristics

RDF can be defined as the fraction comprising of mainly combustible components of MSW.

Moisture content = 7.2%, VM = 64.6%, Fixed carbon = 6.3%, Ash content = 21.9%, calorific value = 2500 – 3000 Kcal/kg

Possible Energy Recovery Routes for RDF

- **The material can be used as co-fuel in:**
  - **Energy intensive industries (like cement kiln, steel industry etc) with coal and/ or other waste derived materials**
  - **Coal fired power plants**

- **Waste derived fuel can also be utilized as mono-fuel in:**
  - **Dedicated waste incinerators**
  - **Gasification and pyrolysis processes for producing syn gas**

Estimated Potential for MSW to Energy

(11th Planning Commission)

Period	Projected MSW generation (TPD)	Potential for power generation (MWe)
2007	148,000	2550
2012	215,000	3650
2017	304,000	5200

Some Questions

- **How would you suppress the formation of NOx and dioxins & furans formation during incineration.**
- **What is the difference between thermal NOx and fuel NOx.**
- **Based on air requirement, how would you classify thermal processes for waste management.**

Landfilling

- **This is the oldest and most widely used method for waste disposal.**

- **Land disposal may be done in two ways:**
  - ✓**Open dumping**
  - ✓**Sanitary landfilling**

Landfilling……

- **Sanitary landfilling has three key characteristics:**
  - ✓ **Waste is placed in an organized manner.**
    - ➢ **Waste material is spread and compacted.**
    - ➢ **The waste is covered each day with a layer of compacted soil.**
  - ✓ **Provisions for capturing the landfill gas (CH_4 and CO_2 – two major constituents) are made.**
  - ✓ **Proper leachate (wastewater generated from a landfill site) collection system is also present.**

Estimation of Landfill Area

- **Estimate how many hectares of land would be required for a sanitary landfill, under the following conditions:**
  - ✓ Design life of the site = 30 years
  - ✓ MSW generation rate = 25 N/person/day
  - ✓ MSW compacted unit weight = 5 kN/m^3
  - ✓ Average fill depth = 10 m
  - ✓ Community population = 50,000
  - ✓ MSW to cover ratio = 4:1 (20% of volume for cover)

- **Solution**

The quantity of MSW generated per year = 25 x 50000 x 365 = 4.56 x 10^5 kN/yr

The volume of compacted refuse = 4.56 x 10^5/ 5 = 91250 m^3/yr

The additional volume for soil cover = 91250/4 = 22813 m^3/yr

Total required volume = 91250 + 22813 = 114063 m^3/yr

The area required = volume/depth

= 114063/10

= 11406 m^2/yr

Total landfill area required

= 11406 x (30 yrs)/ 10^4 ha

= 34 ha

Solid Waste Management Rules, 2016

Terminology

- **Solid Waste:** Solid or semi-solid domestic waste, sanitary, commercial, institutional, catering and market waste and other non residential wastes, street sweepings, silt removed or collected from the surface drains, horticulture waste, agriculture and dairy waste, treated bio-medical waste excluding industrial waste, bio-medical waste and e-waste, battery waste, radio-active
- **Combustible Waste:** Non-biodegradable, non-recyclable, non-reusable, non-hazardous solid waste with minimum calorific value (C.V.) 1500 kcal/kg excluding chlorinated materials
- **Extended Producer's Responsibility:** Responsibility of producer of packaging products for environmentally sound management till end-of-life of products

Terminology…..

- **Co-processing:** Use of non-biodegradable and non recyclable solid waste having CV > 1500 kcal/kg as raw material or as a source of energy or both to replace or supplement the natural mineral resources and fossil fuels in industrial processes
- **Decentralized processing:** Establishment of dispersed facilities for maximizing the processing of recovery of wastes, closest to the source of generation to minimize transportation
- **Refuse Derived Fuel:** Fuel derived from combustible waste fraction of solid waste in the form of pellets produced by drying, shredding, dehydrating and compacting of solid waste

Duties of Waste Generators

- **Segregate** and store the waste generated in three streams: bio-degradable, non-biodegradable and domestic hazardous wastes and handover these to authorised waste pickers
- **Should not burn or bury** the solid waste on streets, open public spaces or in the drain or water bodies
- All waste generators should pay **user fee** for solid waste management
- To organise a **gathering of more than hundred persons** at any unlicensed place, intimate the local body, at least three working days in advance and ensure segregation at source and handing over of waste
- Every **street vendor** shall keep suitable containers for storage of waste generated during the course of his activity
- All gated communities and institutions with more than 5,000 m^2 area, hotels and restaurants should ensure segregation. The bio-degradable waste shall be processed, treated and disposed off through **composting or bio-methanation** within the premises

Environmental Audit (EA)

- EA are being used as a tool and aid to test the effectiveness of environmental efforts at local level.
- EA is a systematic and independent internal review.
- ISO 14010 – 15 series is related to EA guidelines, which includes General principles, audit procedure, criteria for environmental auditors, Audit programmes, reviews and assessment.

Definition of Environmental Audit (EA) (CPCB, 1993)

- **Environmental auditing is a management tool comprising a systematic, documented, periodic and objective evaluation of how well the management systems are performing with the aim of:**

✓ **Waste prevention and reduction**

✓ **Assessing compliance with regulatory requirements**

✓ **Facilitating control of environmental practices by a company's management and**

✓ **Placing environmental information in the public domain**

Home Assignment

ES – 200 (2017 – 18)

Module: B

Weightage = 8 marks

Problems

1. The development of a new community in a city will certainly lead to the generation of municipal solid waste. List any four questions related to safe disposal of solid waste which should be considered during the planning phase.
2. Suppose an incinerator for municipal solid waste treatment is proposed in the close vicinity of your residence. Currently, insufficient waste segregation is practiced in your city. There plenty agricultural land is available near to the city. In addition, a cement plant is also located close to the city. Assume you oppose such a facility in your area. Give justification for opposing the proposal and suggest the alternative waste management plan.
3. Read the article by Kumar et al. (2009) "Assessment of the status of municipal solid waste management in metro cities, state capitals, class I cities, and class II towns in India: an insight". Summarize specific constraints in implementation of MSWM recommendations for cities located in hilly areas, coastal cities and island cities. *Write summary in your words.*

Home Work Submission date: 31/10/2017 (Tuesday) till 5:00 pm in CESE office (Ground floor)

- **Weightage Factors**
  - **On time : x 1**
  - **Within 7 days (till 7th November) : x 0.7**
  - **By Final exam : x 0.5**
  - ***The assignment MUST be handwritten. You MUST write your roll no., name and date of submission on the top of first page.***
  - ***Most importantly, you MUST keep a photocopy of your assignment (with date, name and roll no.) with you.***