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**GLOBAL HEALTHCARE WASTE PROJECT**

# **MODULE 16: Incineration of Healthcare Waste and the Stockholm Convention Guidelines**



# Module Overview

- Present the principles and basic approaches for healthcare waste treatment
- Describe the basics of incineration and types of incinerators for healthcare waste
- Lay out factors for consideration when selecting waste treatment methods
- Describe the environmental and health impacts of incinerators
- Present the Stockholm Convention guidelines for incinerators
- Describe maintenance and troubleshooting of incinerators and air pollution control devices

# Learning Objectives

- Understand the factors to consider when deciding upon the proper treatment method
- Understand the basics of incineration and its environmental and health impacts
- Be aware of the Stockholm Convention guidelines on incineration
- Learn basic maintenance and troubleshooting of incinerators and air pollution control devices

# Steps in Healthcare Waste Management

- Waste classification
- Waste segregation
- Waste minimization
- Handling and collection
- On-site transport and storage
- Treatment and disposal

# Principles of Waste Treatment

- The main purpose is to reduce the potential hazard posed by healthcare waste in order to protect public health and the environment
- Treatment should be viewed in the context of the waste management hierarchy
- Measures should first be taken to minimize wastes, segregate and reuse non-infectious waste items wherever possible
- After minimization, the remaining waste materials should be treated to reduce the health and environmental hazards, and the residues should be properly disposed of



# Treatment Approaches

- **On-site** – healthcare facility treats its own waste
- **Cluster treatment** – hospital treats its waste plus waste from other health facilities in a small area
- **Central treatment** – dedicated treatment plant collects and treats wastes from many health facilities in an urban center or region



# Processes Used in the Treatment of Healthcare Waste

- Five basic processes are used for the treatment of hazardous healthcare wastes, particularly sharps, infectious and pathological waste:
  - Thermal
  - Chemical
  - Irradiation
  - Biological
  - Mechanical (used to supplement the other processes)

# Thermal Treatment Processes

- Rely on heat to destroy pathogens
- Divided into two types:
  - High-heat thermal systems which involve combustion and/or pyrolysis of healthcare waste (covered in this Module)
  - Low-heat thermal systems also called non-burn or non-incineration treatment technologies (covered in Module 15)

# Incineration

- High temperature (200°C to 1000°C), dry oxidation process that reduces organic and combustible waste to inorganic, incombustible matter, resulting in a significant decrease in overall waste volume
- Organic matter is chemically and physically broken down mainly through the process of combustion

# Incineration

- The basic requirements for incineration to be feasible and affordable are:
  - The heating (calorific) value of the waste is at least 2000 kcal/kg
  - Calorific values are within the regulatory and design standards
  - Content of combustible matter is above 60%
  - Content of non-combustible solids is below 5%
  - Content of non-combustible fine particulates is below 20%
  - Moisture content is below 30%

# Incineration

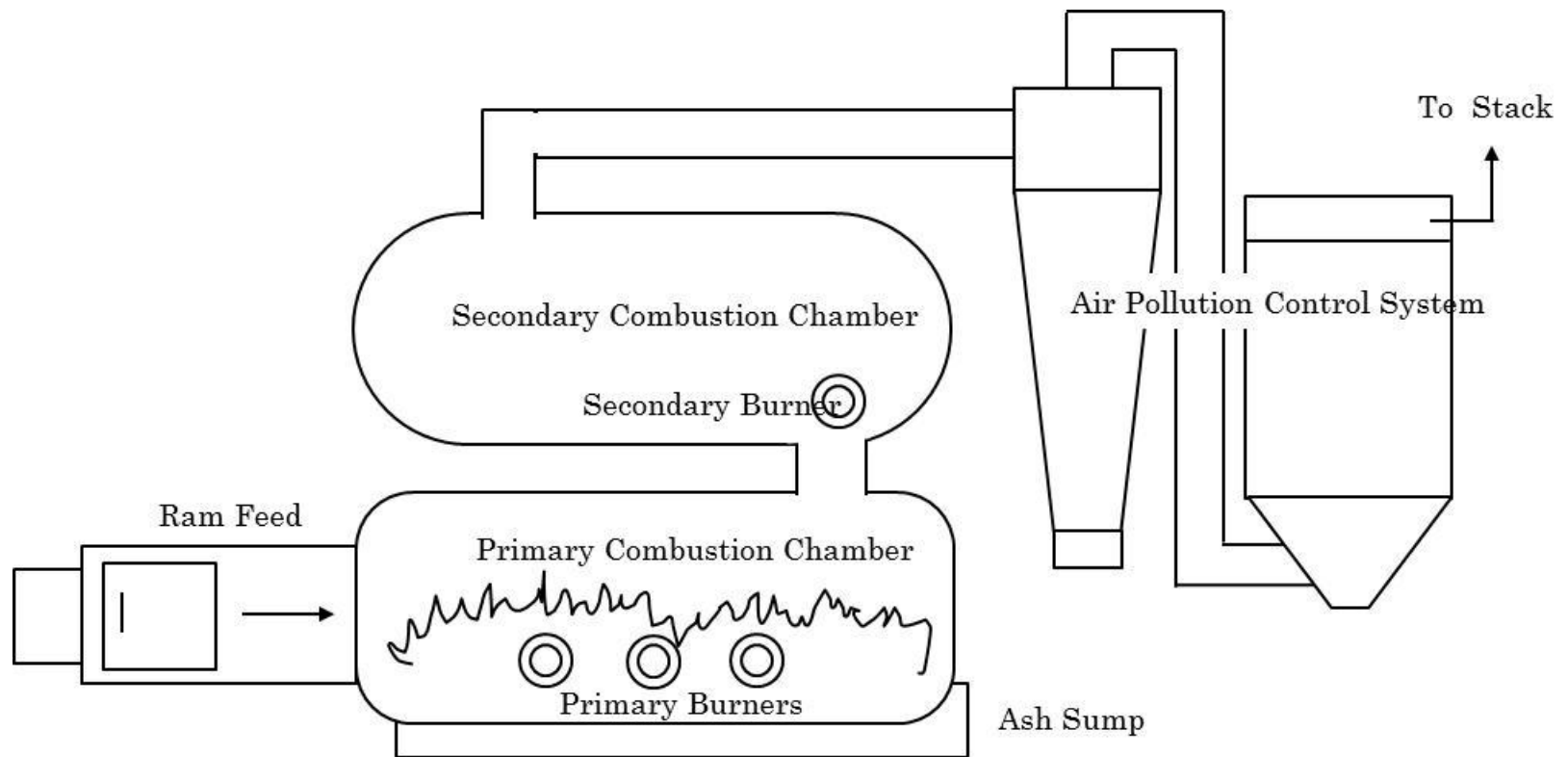
- No pre-treatment will be needed when the following wastes are not present or are kept to an absolute minimum:
  - Pressurized gas containers
  - Large amounts of reactive chemical wastes
  - Silver salts and photographic or radiographic wastes
  - Halogenated materials (such as PVC plastics)
  - Waste containing mercury, cadmium, and other heavy metals
  - Sealed ampoules or vials that might implode during combustion
  - Radioactive materials
  - Pharmaceuticals that are thermally stable in conditions below 1200°C

# Types of Incinerators for Healthcare Waste

- Incineration
  - Range of capacities:
    - ❖ 10 kg/hr to over 20 tonnes per day
  - Historically common types of incinerators:
    - ❖ Dual-chamber incinerators
    - ❖ Multiple-chamber incinerators
    - ❖ Rotary kilns

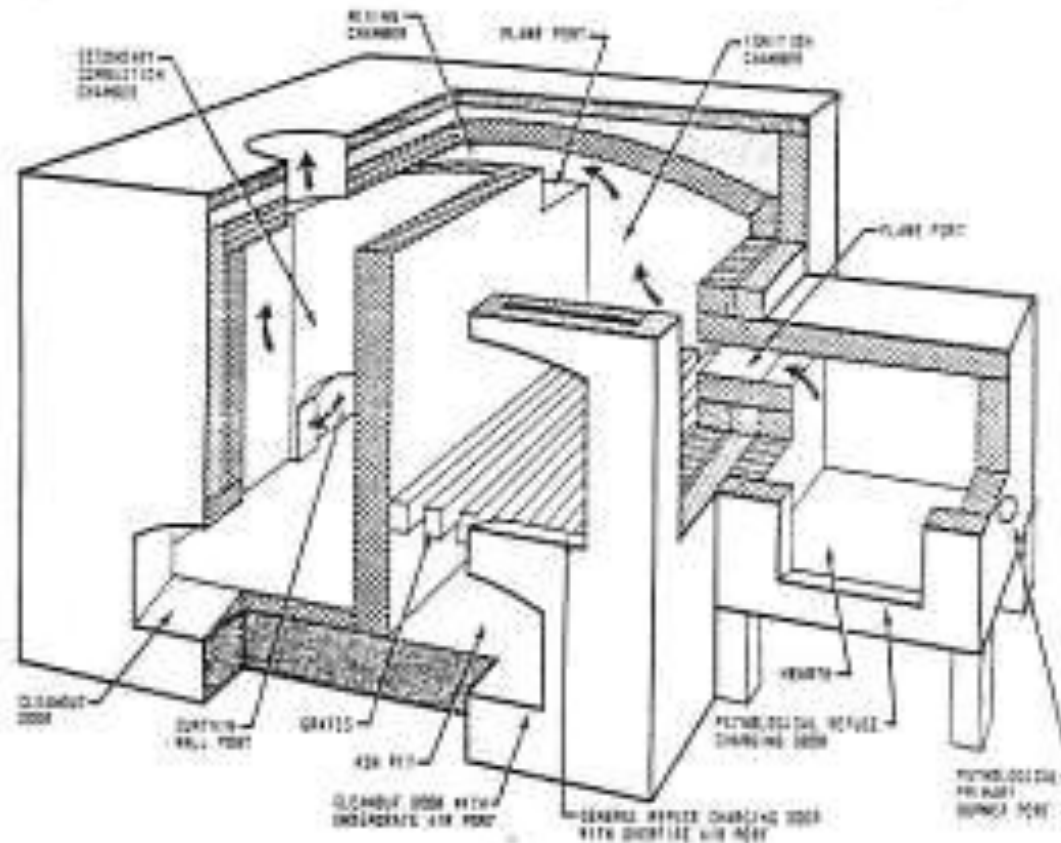
# Types of Incinerators for Healthcare Waste

## – Dual-chamber incinerator



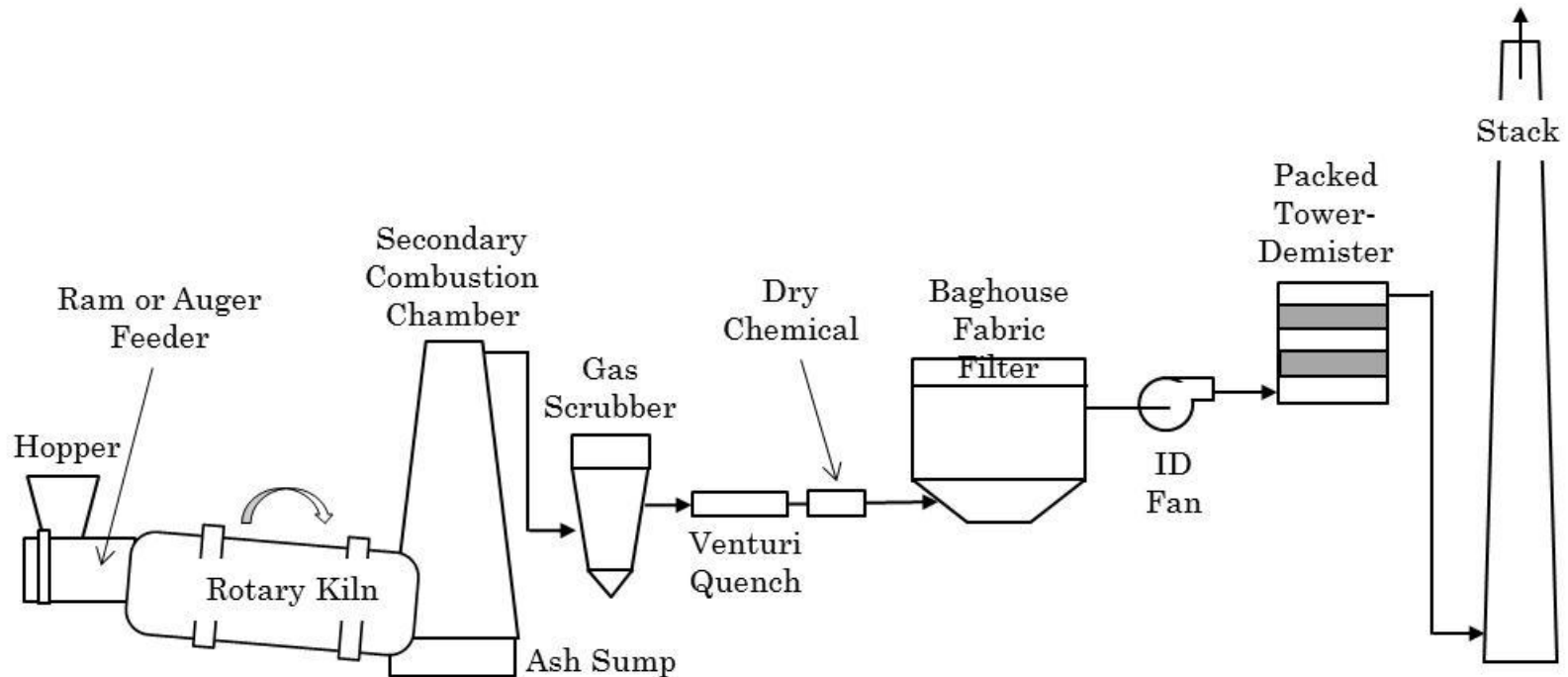
# Types of Incinerators for Healthcare Waste

– Multi-chamber excess air incinerator



# Types of Incinerators for Healthcare Waste

## – Rotary kiln



# Construction and Installation of Incinerators

- Construction of the foundation, enclosure and ventilation
- Construction or assembly of the refractory layers, steel casing, grates, and insulation of the combustion and post-combustion chambers, as well as the refractory-lined channels
- Assembly of the burners, fuel supply systems, air dampers and induced draft fans
- Connection of the electrical controls and air compression system for pneumatic controls
- Addition of the waste charging system, heat recovery boiler if used, and ash sump
- Installation of the flue gas cleaning system and its accessories, including wastewater treatment system, if needed, monitoring sensors and electrical controls
- Construction and connection of the stack or chimney.

# Operation of Incinerators

- General operational procedures
  - Waste charging
  - Combustion
  - Air pollution control
  - Ash removal

# Why Preventive Maintenance is Essential

- Enhances safety by avoiding serious accidents
- Increases the efficiency of the technology
- Ensures that the treatment technology continues to reduce the hazards of healthcare waste
- Extends the life of the technology
- Avoids downtime due to equipment breakdowns
- Saves on the cost of repairs, spare parts, and unscheduled maintenance
- Reduces energy consumption

# Preventive Maintenance

- Healthcare facilities should work with equipment vendors and manufacturers to develop a detailed preventive maintenance schedule
- Technology operators should be trained in simple preventive maintenance
- Maintenance logs should be maintained
- Facility engineers and managers should monitor maintenance procedures



# Maintenance of Incinerators

- Example of a maintenance schedule
  - Hourly: inspect ash removal conveyor and water levels in quench pit
  - Daily: check opacity, oxygen and temperature monitors; clean underfire air ports, ash pit and sump; inspect limit switches and door seals
  - Weekly: clean heat recovery boiler tubes, blower intakes, burner flame rods and sensors, heat recovery induced draft fan; lubricate latches, hinges, hopper door pins, etc.

# Maintenance of Incinerators (cont'd)

- Maintenance schedule (continued)
  - Bi-weekly: check hydraulic fluid, lubricate ash conveyor bearings; clean fuel trains, burners and control panels
  - Monthly: inspect surfaces and refractories, internal ram face, pilot lights; clean secondary chamber floor; lubricate blowers and fans
  - Semi-annual: inspect hot surfaces; clean and lubricate chains

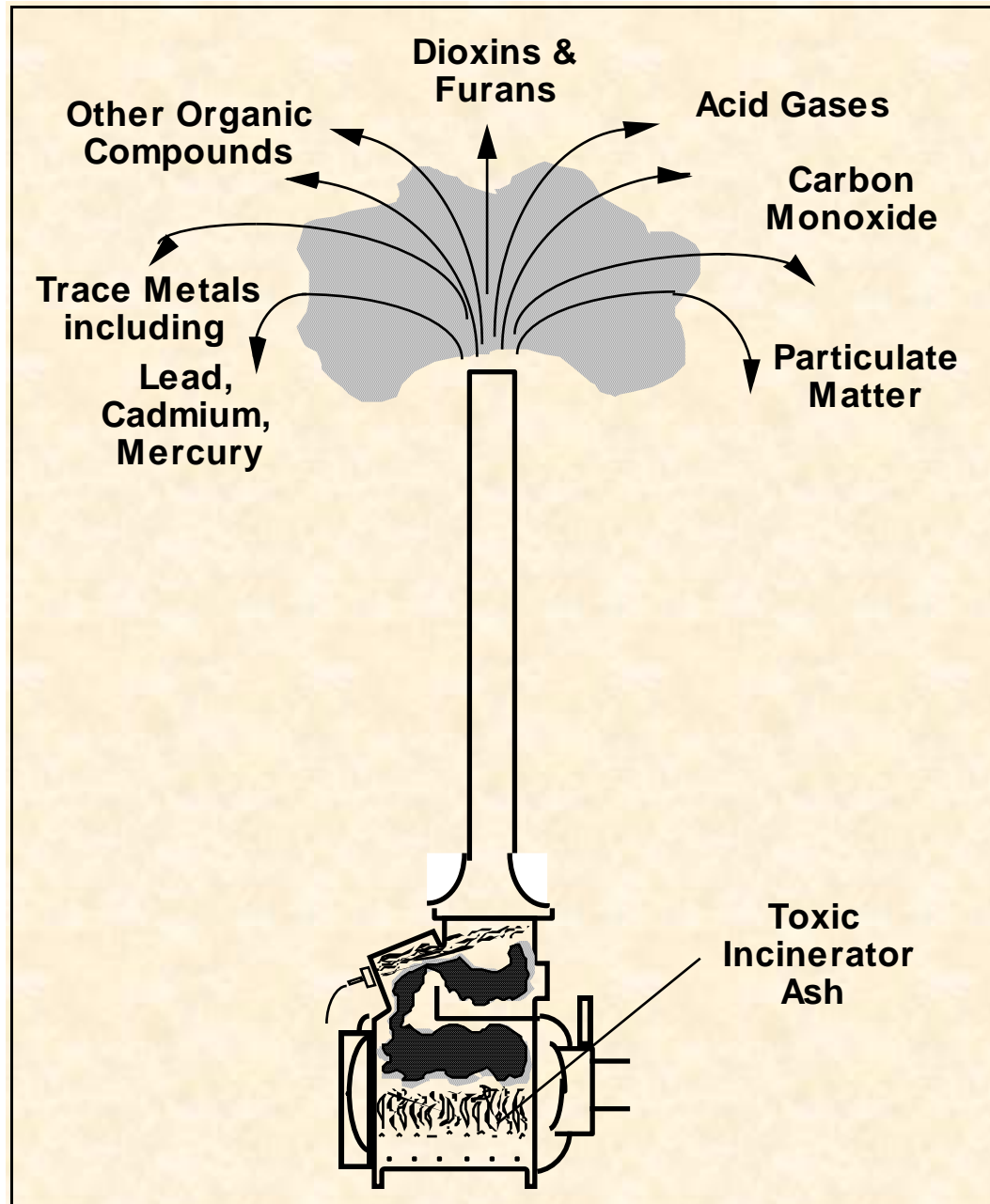
# Factors in the Selection of Treatment Methods

- Types and quantities of waste for treatment and disposal
- Capability of the healthcare facility to handle the waste quantity
- Technological capabilities and requirements
- Availability of treatment options and technologies
- Capacity of system
- Treatment efficiency (microbial inactivation efficacy)
- Occupational health and safety factors
- Environmental releases
- Volume and/or mass reduction
- Installation requirements
- Space available for equipment

# Factors in the Selection of Treatment Methods, cont'd.

- Operation and maintenance requirements
- Infrastructure requirements
- Skills needed for operating the technology
- Location and surroundings of the treatment and disposal sites
- Options available for final disposal
- Public acceptability
- Regulatory requirements
- Capital cost of the equipment
- Operating and maintenance costs of the equipment
- Other costs including costs of shipping, customs duties, installation and commissioning, transport and disposal of residues, and decommissioning

# Air Emissions From a Medical Waste Incinerator



# Pollutants Measured From Medical Waste Incinerators

- Air Emissions
  - trace metals: As, Cd, Cr, Cu, Hg, Mg, Ni, Pb
  - acid gases: HCl, SO<sub>2</sub>, NO<sub>x</sub>
  - dioxins and furans, including 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)
  - other organic compounds: benzene, carbon tetrachloride, chlorophenols, trichloroethylene, toluene, xylenes, trichlorotrifluoroethane, polycyclic aromatic hydrocarbons, vinyl chloride, etc.
  - carbon monoxide
  - particulate matter
  - pathogens (from incinerators with poor combustion)

# Pollutants Measured From Medical Waste Incinerators

- Bottom Ash generally contains:
  - dioxins/furans
  - other organics
  - leachable metals

Bottom ash from medical waste incinerators often fails tests for hazardous constituents (e.g., Toxicity Characteristic Leachate Procedure) and has to be treated as hazardous waste.

# Epidemiological Studies Related to Health Effects of Incineration

STUDY SUBJECTS	CONCLUSIONS REGARDING ADVERSE HEALTH EFFECTS	REFERENCE
Residents living within 10 km of an incinerator, refinery, and waste disposal site	Significant increase in laryngeal cancer in men living with closer proximity to the incinerator and other pollution sources	P. Michelozzi et al., <i>Occup. Environ. Med.</i> , 55, 611-615 (1998)
532 males working at two incinerators from 1962-1992	Significantly higher gastric cancer mortality	E. Rapiti et al., <i>Am. J. Ind. Medicine</i> , 31, 659-661 (1997)
Residents living around an incinerator and other pollution sources	Significant increase in lung cancer related specifically to the incinerator	A. Biggeri et al. <i>Environ. Health Perspect.</i> , 104, 750-754 (1996)
People living within 7.5 km of 72 incinerators	Risks of all cancers and specifically of stomach, colorectal, liver, and lung cancer increased with closer proximity to incinerators	P. Elliott et al., <i>Br. J. Cancer</i> , 73, 702-710 (1996)

# Epidemiological Studies Related to Health Effects of Incineration

STUDY SUBJECTS	CONCLUSIONS REGARDING ADVERSE HEALTH EFFECTS	REFERENCE
10 workers at an old incinerator, 11 workers at a new incinerator	Significantly higher blood levels of dioxins and furans among workers at the old incinerator	A. Schecter et al., <i>Occup. Environ. Medicine</i> , 52, 385-387 (1995)
53 incinerator workers	Significantly higher blood and urine levels of hexachlorobenzene, 2,4/2,5-dichlorophenols, 2,4,5-trichlorophenols, and hydroxypyrene	J. Angerer et al., <i>Int. Arch. Occup. Environ. Health</i> , 64, 266-273 (1992)
37 workers at four incinerator facilities	Significantly higher prevalence of urinary mutagen/promutagen levels	X.F. Ma et al., <i>J. Toxicol. Environ. Health</i> , 37, 483-494 (1992)
104 workers at seven incinerator facilities	Significantly higher prevalence of urinary mutagen and promutagen levels	J.M. Scarlett et al., <i>J. Toxicol. Environ. Health</i> , 31, 11-27 (1990)

# Epidemiological Studies Related to Health Effects of Incineration

STUDY SUBJECTS	CONCLUSIONS REGARDING ADVERSE HEALTH EFFECTS	REFERENCE
86 incinerator workers	High prevalence of hypertension and related proteinuria	E.A. Bresnitz et al., <i>Am. J. Ind. Medicine</i> , 22, 363-378 (1992)
176 incinerator workers employed for more than a year from 1920-1985	Excessive deaths from ischemic heart disease and lung cancer among workers employed for at least 1 year; significant increase in deaths from ischemic heart disease among workers employed for more than 30 years or followed up for more than 40 years	P. Gustavsson, <i>Am. J. Ind. Medicine</i> , 15, 129-137 (1989)
Residents exposed to an incinerator	Reproductive effect: frequency of twinning increased in areas at most risk from incinerator emissions	O.L. Lloyd et al., <i>Br. J. Ind. Medicine</i> , 45, 556-560 (1988)

# Epidemiological Studies Related to Health Effects of Incineration

STUDY SUBJECTS	CONCLUSIONS REGARDING ADVERSE HEALTH EFFECTS	REFERENCE
<b>Residents from 7 to 64 years old living within 5 km of an incinerator and the incinerator workers</b>	<b>Levels of mercury in hair increased with closer proximity to the incinerator during a 10 year period</b>	<b>P. Kurttio et al., <i>Arch. Environ. Health</i>, 48, 243-245 (1998)</b>
<b>122 workers at an industrial incinerator</b>	<b>Higher levels of lead, cadmium, and toluene in the blood, and higher levels of tetrachlorophenols and arsenic in urine among incinerator workers</b>	<b>R. Wrbitzky et al., <i>Int. Arch. Occup. Environ. Health</i>, 68, 13-21 (1995)</b>
<b>56 workers at three incinerators</b>	<b>Significantly higher levels of lead in the blood</b>	<b>R. Malkin et al., <i>Environ. Res.</i>, 59, 265-270 (1992)</b>

# Epidemiological Studies Related to Health Effects of Incineration

<b>STUDY SUBJECTS</b>	<b>CONCLUSIONS REGARDING ADVERSE HEALTH EFFECTS</b>	<b>REFERENCE</b>
<b>Mothers living close to incinerators and crematoriums in Cumbria, north west England, from 1956 to 1993</b>	<b>Increased risk of lethal congenital anomaly, in particular, spina bifida and heart defects around incinerators, and increased risk of stillbirths and anacephalus around crematoriums</b>	<b>T. Drummer, H. Dickinson and L. Parker, <i>Journal of Epidemiological and Community Health</i>, 57, 456-461 (2003)</b>

# Medical Waste Incineration (MWI) is a Major Global Source of Dioxins

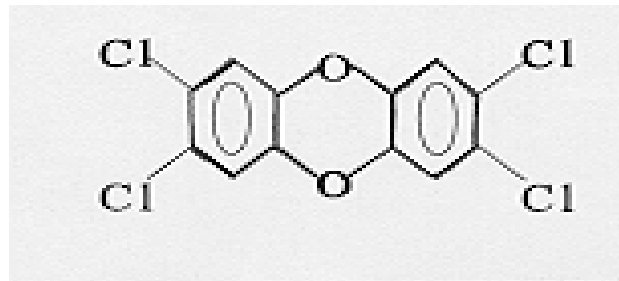
- Europe: 62% of dioxin emissions due to 4 processes, including MWI
- Belgium: MWI accounts for 14% of dioxin emissions
- Denmark: MWI is 3rd or 4th largest dioxin source of 16 process groups
- Thailand:
  - MWI - highest dioxin source by far of 7 sources tested
  - Extremely high dioxin levels in MWI ash and wastewater
  - Thailand's 1,500 incinerators exceed combined total dioxin releases of several European countries
- United States:
  - MWIs – third largest source of dioxins: 17% of total dioxins in 1995
  - Drop in dioxin emissions from MWI in part due to shift to non-incineration methods: 2470 g TEQ/yr in 1987 to 477 g TEQ/yr in 1995
- Canada:
  - MWI - largest dioxin source in Ontario province
  - Drop in dioxin emissions from MWI due to closure of MWIs: 130 g TEQ/yr in 1990 to 25 g TEQ/yr in 1999

# Where are Dioxins Formed in a Medical Waste Incinerator?

- Dioxins are created in cooler sections of the primary chamber and as the gases cool down after the secondary chamber
- Dioxins are found in:
  - Bottom ash or slag
  - Boiler ash
  - Filter cake
  - Wastewater from the wet scrubber
  - Fly ash in the gas exhaust from the stack

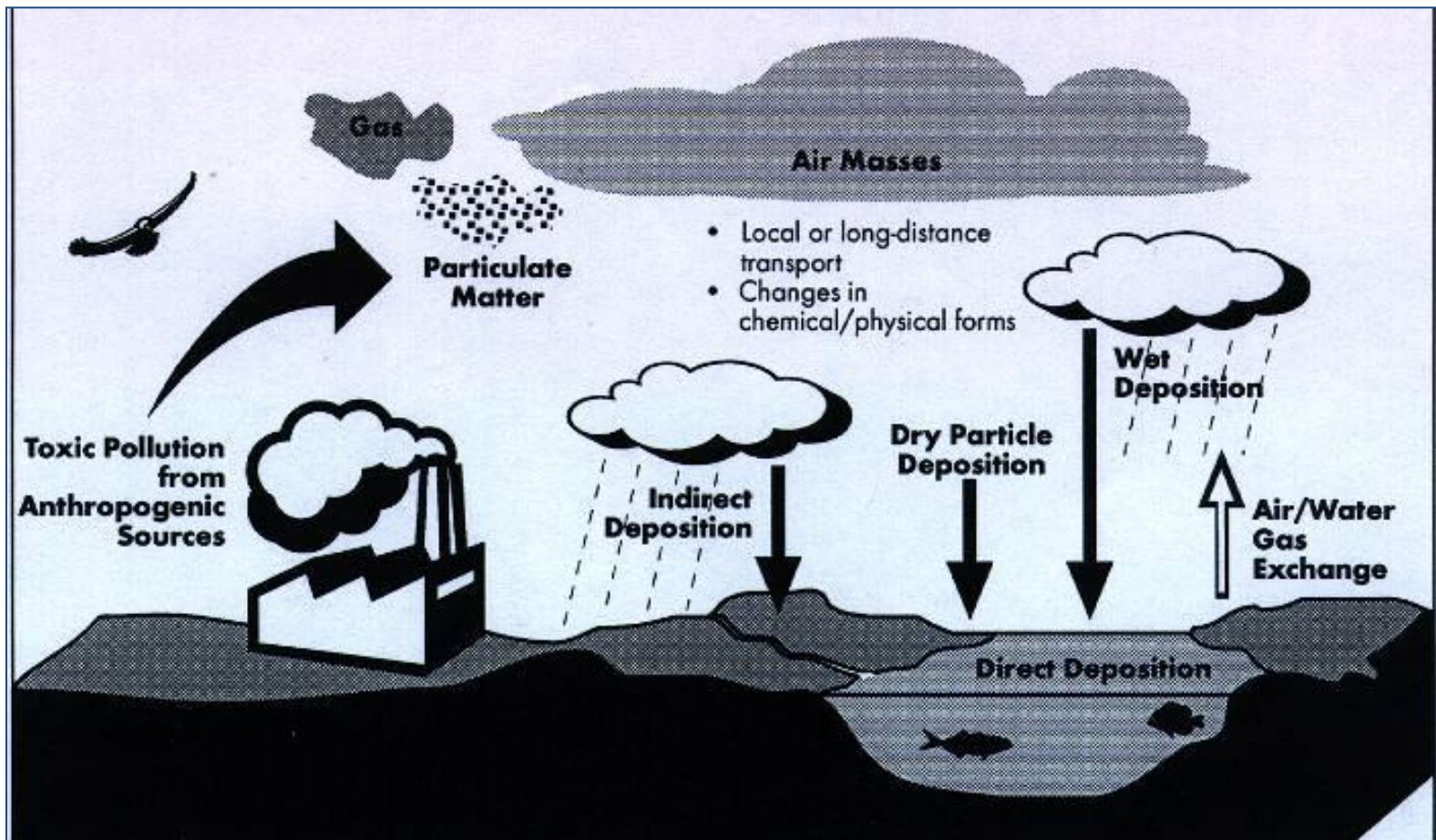
# What are “Dioxins”?

- Short term for polychlorinated dibenzo-p-dioxins and dibenzofurans
- Family of 210 compounds
- Among the most toxic compounds known to humans
  - > The most toxic is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)



# How Far Do Dioxins Travel?

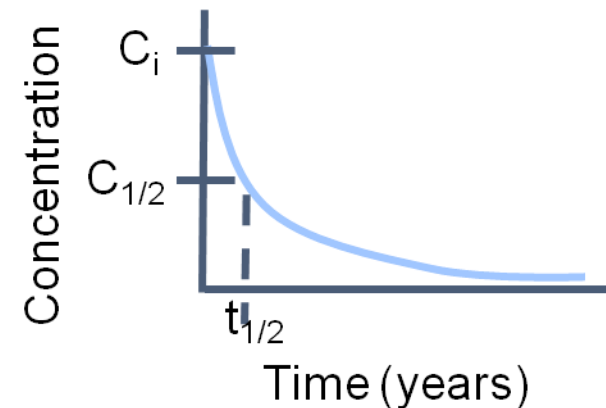
- Dioxins travel long distances in the air (up to hundreds of kilometers)



# How Long do Dioxins Remain in the Environment?

Dioxins are very persistent:

- Environmental half-life  $t_{1/2}$  on surface soil:  
**9 to 15 years**
- Environmental half-life  $t_{1/2}$  in subsurface soil:  
**25 to 100 years**
- Volatilization half-life  $t_{1/2}$  in a body of water:  
**more than 50 years**



# Bioconcentration of Dioxins

- Bioconcentration factors for 2,3,7,8-TCDD
  - Aquatic plants: 200 to 2,100 in 1-50 days
  - Invertebrates: 700 to 7,100 in 1-32 days
  - Fish (carp): 66,000 in 71 days
  - Fish (fathead minnow): 128,000 in 71 days

# Health Effects Associated with Dioxin

- Classified as a known human carcinogen by IARC in 1997
- Cancers linked to dioxins:
  - Chronic lymphocytic leukemia (CLL)
  - Soft-tissue sarcoma
  - Non-Hodgkin's lymphoma
  - Respiratory cancer (of lung and bronchus, larynx, and trachea)
  - Prostate cancer

# Health Effects Associated with Dioxin

- **Developmental Effects**

- Birth defects
- Alteration in reproductive systems
- Impact on child's learning ability and attention
- Changes in sex ratio (fewer male births)



- **Immune System Impacts**

- Suppression of the immune system
- Increased susceptibility to disease

# Health Effects Associated with Dioxin

- **Male Reproductive Effects**
  - Reduced sperm count
  - Abnormal testis
  - Reduced size of genital organs
  - Lower testosterone levels
- **Female Reproductive Effects**
  - Decreased fertility
  - Ovarian dysfunction
  - Endometriosis
  - Hormonal changes

# Health Effects Associated with Dioxin

- Other Health Effects
  - Chloracne
  - Hirsutism
  - Hyperpigmentation
  - Altered fat metabolism
  - Diabetes
  - Nerve system damage
  - Liver, spleen, thymus, and bone marrow damage



# Health Risk Assessment Study

“Assessment of Small-Scale Incinerators for Health Care Waste,” January 2004

<http://uqconnect.net/signfiles/Files/WHOIncinerationReportFeb2004.pdf>

- Study conducted for WHO
- Screening level health risk assessment
- Exposure to dioxin and dioxin-like compounds through inhalation and ingestion

# Health Risk Assessment Study

- Three classes of small-scale incinerators
  - **Best practice**
    - ✓ Engineered design
    - ✓ Properly operated and maintained
    - ✓ Sufficient temperatures and residence time
    - ✓ Has an afterburner and other pollution control
  - **Expected practice**
    - ✓ Improperly designed
    - ✓ Improperly operated or maintained
  - **Worst-case**
    - ✓ No afterburner

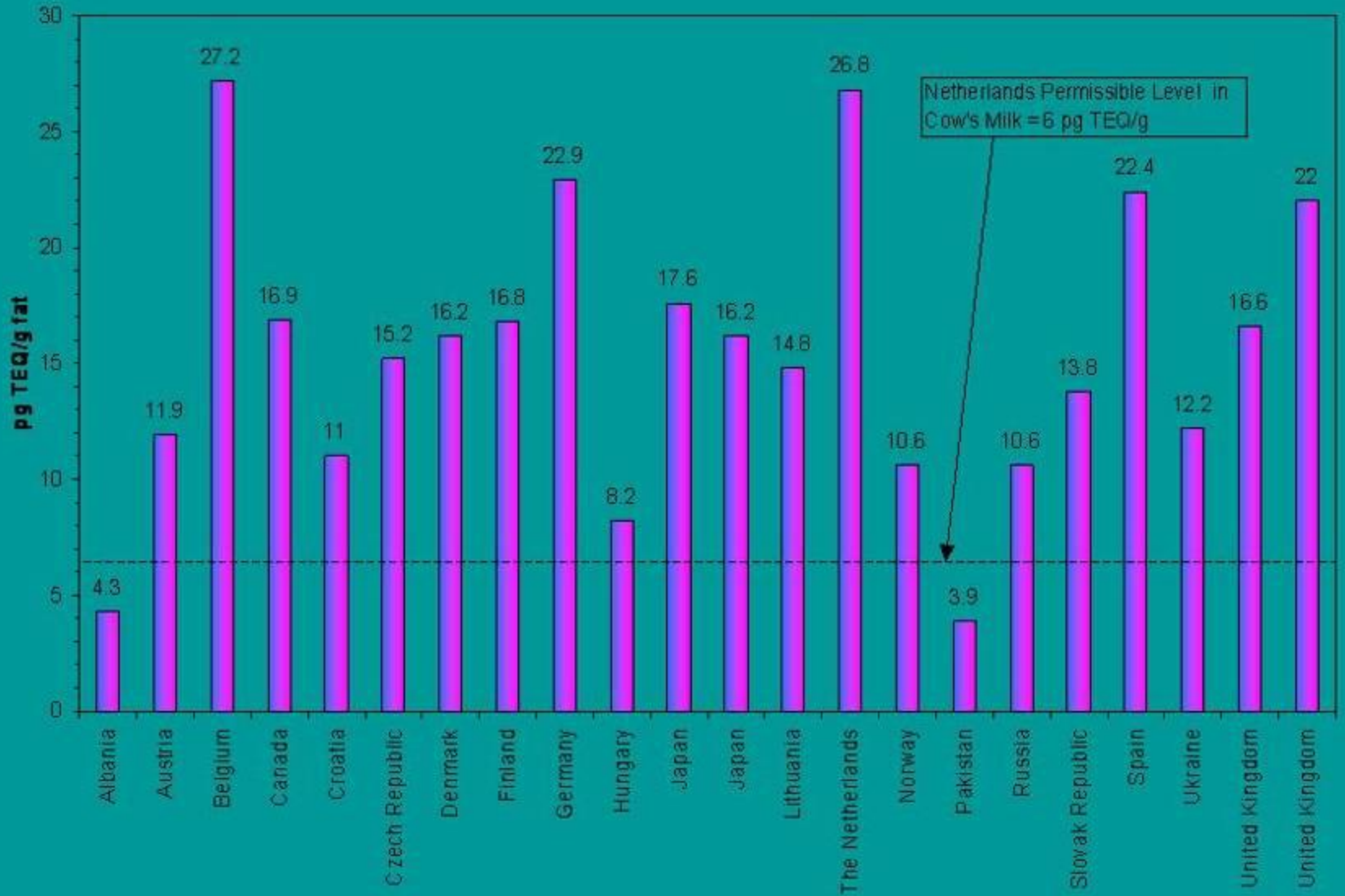
# Health Risk Assessment Study

- Three usage scenarios
  - Low use
    - ✓ 1 hour per month (12 kg waste per week)
  - Medium use
    - ✓ 2 hours per week (24 kg waste per week)
  - High use
    - ✓ 2 hours per day (24 kg waste per day)

# Findings of the Risk Assessment Study

	Compared to WHO ADI	Compared to EPA Cancer Risk
<b>Worst Case: High Use</b>	<b>unacceptable</b>	<b>unacceptable</b>
<b>Worst Case: Medium</b>	<b>unacceptable</b>	<b>unacceptable</b>
<b>Worst Case: Low Use</b>	<b>unacceptable</b>	<b>unacceptable</b>
<b>Expected: High Use</b>	<b>unacceptable</b>	<b>unacceptable</b>
<b>Expected: Medium Use</b>	<b>unacceptable</b>	<b>unacceptable</b>
<b>Expected: Low Use</b>	<b>Acceptable</b>	<b>unacceptable</b>
<b>Best Practice: High Use</b>	<b>Acceptable</b>	<b>unacceptable</b>
<b>Best Practice: Medium</b>	<b>Acceptable</b>	<b>Acceptable</b>
<b>Best Practice: Low Use</b>	<b>Acceptable</b>	<b>Acceptable</b>

### Dioxins in Breast Milk in Selected Countries



Permissible limit in cow's milk (Netherlands): 0.006 picograms/kg milk

# Incineration and the Stockholm Convention

- Most countries have ratified the Stockholm Convention on Persistent Organic Pollutants
- Under Article 5 of the Convention: Countries have to take measures to further reduce releases of dioxins and furans “with the goal of their continuing minimization and, where feasible, ultimate elimination.”
- Annex C of the Convention:
  - **Medical Waste Incinerators** are a major source with “the potential for comparatively high formation and release” of dioxins & furans

# Incineration and the Stockholm Convention

- Incinerator emissions should comply with national standards and be in accordance with the Convention's BAT (best available techniques) and BEP (best environmental practices) if the country has signed the convention



# Best Available Techniques Guidelines under the Stockholm Convention

- On Incinerator Design
  - Single-chamber, drum and brick incinerators are *not* acceptable
  - An incinerator should consist of:
    - Furnace or kiln (primary combustion chamber)
    - Afterburner chamber (secondary chamber)
    - Flue gas cleaning system
    - Wastewater treatment if wet flue gas cleaning is used

# Best Available Techniques Guidelines under the Stockholm Convention

- BAT air emissions performance level:
  - 0.1 nanograms I-TEQ/Normal cubic meter at 11% oxygen
- BAT wastewater performance level for effluents from treatment of gas treatment scrubbers:
  - 0.1 nanograms I-TEQ/liter
- To be achieved by a suitable combination of primary and secondary measures

# Best Available Techniques Guidelines under the Stockholm Convention

- General measures
  - Operation by trained, qualified personnel
  - Use of personal protection equipment
  - Periodic maintenance including cleaning of the combustion chamber and declogging of air flows and fuel burners
  - Auditing and reporting systems
  - Routine inspections of the furnace and air pollution control systems by the regulatory authorities

# Best Available Techniques Guidelines under the Stockholm Convention

- **Primary measures**
  - Introduction of waste at 850°C or higher; automation to avoid introducing waste below 850°C
  - Avoidance of temperatures below 850°C and no cold regions
  - Auxiliary burners
  - Avoidance of starts and stops
  - Control of oxygen input

# Best Available Techniques Guidelines under the Stockholm Convention

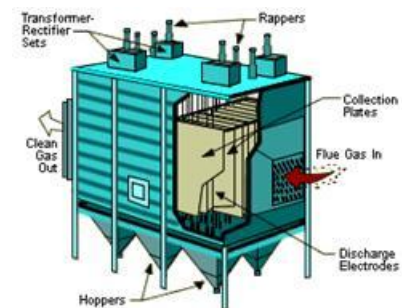
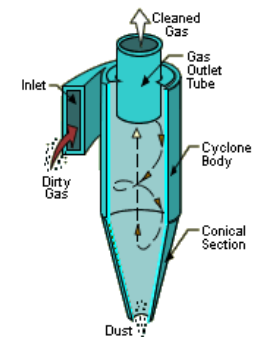
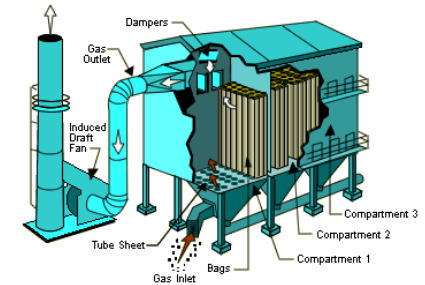
- **Primary measures**
  - Minimum residence time of 2 seconds at 1100°C in the secondary chamber after last addition of air and 6% O<sub>2</sub> by volume (for waste with >1% halogenated substances)
  - High turbulence of exhaust gases and reduction of excess air
  - On-line monitoring for combustion control (T, oxygen, carbon monoxide, dust), and regulation from a central console.

# Best Available Techniques Guidelines under the Stockholm Convention

## • Secondary measures

### – Dedusting

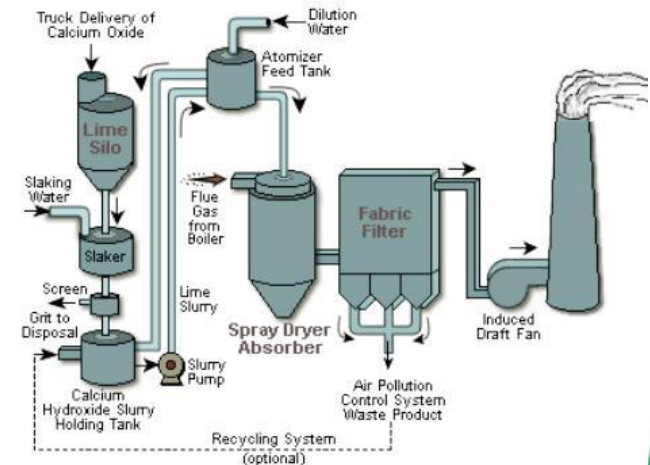
- Fabric filter operating below 260°C
- Ceramic filter used between 800 to 1000°C
- Cyclones for pre-cleaning
- Electrostatic precipitators around 450°C
- High performance adsorption units with activated carbon



# Best Available Techniques Guidelines under the Stockholm Convention

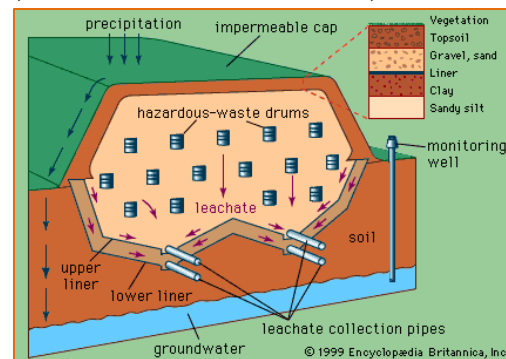
## • Secondary measures

- Techniques for further emission reduction
  - Catalytic oxidation
  - Gas quenching
  - Catalyst-coated fabric filters
  - Different types of wet or dry adsorption systems using mixtures of activated charcoal, coke, lime and limestone solutions



# Best Available Techniques Guidelines under the Stockholm Convention

- **Disposal of Residues** (bottom and fly ash)
  - Ash should be handled, transported (using covered hauling) and disposed of in an environmentally friendly manner
  - Catalytic treatment or vitrification of fabric filter dusts
  - Disposal in safe dedicated landfills (e.g., landfilling in double-walled containers, solidification, or thermal post-treatment)



# Best Available Techniques Guidelines under the Stockholm Convention

- **Monitoring**
  - Routine monitoring of CO, oxygen, particulate matter, HCl, SO<sub>2</sub>, NO<sub>2</sub>, HF, air flows, temperatures, pressure drops, and pH
  - Periodic or semi-continuous measurement of: polychlorinated dioxins and furans

# Examples of Other Environmental Requirements

Pollutant	Units	US EPA emission limits			EU emission limits		
		Small	Medium	Large	Daily average	0.5-hour average	0.5-8 hour average
Particulates	mg/m <sup>3</sup>	50	17	14	10	10, 30	
CO	mg/m <sup>3</sup>	18	1.6	9.8	50	100, 100	
Dioxins/furans	ng TEQ /m <sup>3</sup>	0.0099	0.011	0.027			0.1
HCl	mg/m <sup>3</sup>	17	8.9	5.9	10	10, 60	
SO <sub>2</sub>	mg/m <sup>3</sup>	2.8	2.8	16	50	50, 200	
Mercury	mg/m <sup>3</sup>	0.011	0.0027	0.00099			0.05
Lead	mg/m <sup>3</sup>	0.24	0.014	0.00053			

All reference conditions: 273°K, 101.3kPa, 11% O<sub>2</sub>, dry; Small ≤ 200 lbs/hr, medium > 200 to 500 lbs/hr, and large > 500 lbs/hr.  
 For half hour averages, at least 97% of concentrations must meet the first value and 100% must meet the second value.

# National Regulations Pertaining to Incineration

# Maintenance of Air Pollution Control

- Example of a wet scrubber maintenance schedule
  - Daily: check scrubber pump, liquid lines, fans
  - Weekly: check oil levels and damper air purge
  - Monthly: inspect duct work, fan and motors; clean fan blades and internal housing, pipes and manifolds; check drain chain drive, dampers, spray bars, pressure gauges and main body
  - Semi-annual: check fan, pump, motor, bearings, flow meters, damper drive, seals

# Maintenance of Air Pollution Control

- Example of a baghouse filter maintenance schedule
  - Daily: check stack, pressures, compressed air, damper valves, dust removal system, subsystem operations
  - Weekly: check filter bags, hoppers, and cleaning system
  - Monthly: check shaker mechanism, monitors
  - Quarterly: inspect inlet plenum, gaskets, shaker mechanism
  - Semi-annually: lubricate all motors and fans
  - Annually: check bolts and welds, inspect whole system

# Troubleshooting Incinerators

- **Symptom:** Black smoke from the stack
- **Possible Causes:**
  - Incomplete burning of waste, not enough air, overcharging of waste or volatile material, poor mixing in the secondary chamber, burner failure, primary chamber temperature too high
- **Possible Solutions:**
  - Increase secondary chamber air, decrease underfire or overfire air, ensure secondary chamber temperature is above the minimum, decrease charge rate, check burners, install or check air pollution control system

# Troubleshooting Incinerators

- **Symptom:** Steady white or blue-white smoke from stack
- **Possible Causes:**
  - Aerosols in the stack gas, too much air entering the incinerator, secondary chamber temperature is too low
- **Possible Solutions:**
  - Check secondary chamber burner, ensure that secondary chamber temperature is above 1000°C, decrease underfire air, decrease secondary chamber air, check if waste contains pigments or metallic oxides, install or check air pollution control system

# Troubleshooting Incinerators

- **Symptom:** White smoke or white haze appears a short distance from the stack
- **Possible Causes:**
  - Condensation of hydrochloric acid
- **Possible Solutions:**
  - Reduce amounts of chlorinated materials in the waste, eliminate chlorinated plastics in the hospital, install a scrubber or check the efficiency of the gas scrubber

# Troubleshooting Incinerators

- **Symptom:** Smoke coming out of the primary chamber
- **Possible Causes:**
  - Positive pressure in the primary chamber, too much underfire air, too many highly volatile substances in the waste, problem with the draft damper or induced draft fan, primary chamber temperature too high
- **Possible Solutions:**
  - Check damper or fan operation, decrease underfire air, decrease feed rate, check charging door seals

# Troubleshooting Incinerators

- **Symptom:** Incinerator uses too much fuel
- **Possible Causes:**
  - Not enough heat input from the waste, inconsistent charging, insufficient or poorly distributed underfire air for controlled-air incinerators, too much secondary chamber air, too much air infiltration, fuel leaks, high moisture content in the waste, excessive draft, burning setting too high
- **Possible Solutions:**
  - Charge waste at regular intervals, avoid charging wet waste all at one time, increase underfire air or check air ports for controlled-air incinerators, reduce secondary chamber air, reduce draft, check door seals, check burner settings, check fuel lines and burners

# Troubleshooting Incinerators

- **Symptom:** A lot of combustible materials remaining in the ash (poor ash quality)
- **Possible Causes:**
  - Not enough underfire air; improper waste charging; insufficient burndown time
- **Possible Solutions:**
  - Check underfire air setting and clean underfire ports; charge waste at regular intervals not to exceed the rated capacity of the incinerator, avoid charging all wet waste at one time; allow longer burnout period, maintain primary chamber temperature during burndown

# Troubleshooting Air Pollution Control Devices

- **Symptom:** Corrosion of wet scrubber parts
- **Possible Causes:**
  - Acid build-up in the scrubbing liquid
- **Possible Solutions:**
  - Maintain the pH of the scrubbing liquid, check the system for adding alkali, check pH monitor, perform preventive maintenance on the scrubber

# Troubleshooting Air Pollution Control Devices

- **Symptoms:**
  - Fan vibration, stuck dampers, or poor nozzle spray patten in the wet scrubber
  - Erosion of fans, dampers and duct work (dry components of the wet scrubber)
  - Erosion of scrubber and spray nozzle (wet components of wet scrubbers with recirculating systems)
- **Possible Causes:**
  - Scaling and plugging
  - Droplet carryover due to poor mist eliminator performance
  - Suspended solids in the scrubber liquid
- **Possible Solutions:**
  - Conduct preventive maintenance to clean the wet scrubber, repair the mist eliminator, or purge the system

# Troubleshooting Air Pollution Control Devices

- **Symptoms:**
  - Unusually high pressure readings of the baghouse filter
  - Unusually low pressure readings of the baghouse filter or high opacity
- **Possible Causes:**
  - High resistance to airflow, filter bags not cleaned properly, high condensation at the filter bags
  - Low resistance to airflow, holes in the filter bags, improper bag installation
- **Possible Solutions:**
  - Conduct preventive maintenance, adjust temperatures of the inlet gas and baghouse, check installation of filter bags, check the cleaning system

# Resources

- Guidelines on best available techniques and provisional guidance on best environmental practices, to be posted on the Stockholm Convention website

<http://www.pops.int/>

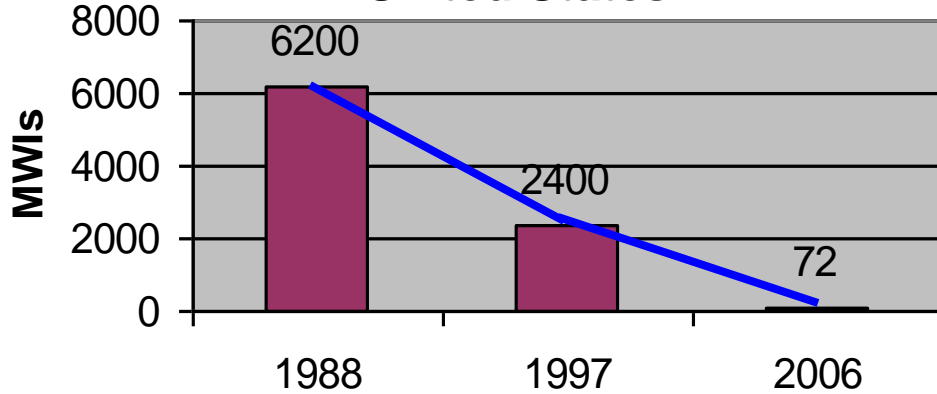
- Reference document on the best available techniques for waste incineration: BAT reference document (BREF), European Commission, 2008; available in the European IPCC Bureau website

[eippcb.jrc.es/pages/FActivities.htm](http://eippcb.jrc.es/pages/FActivities.htm)

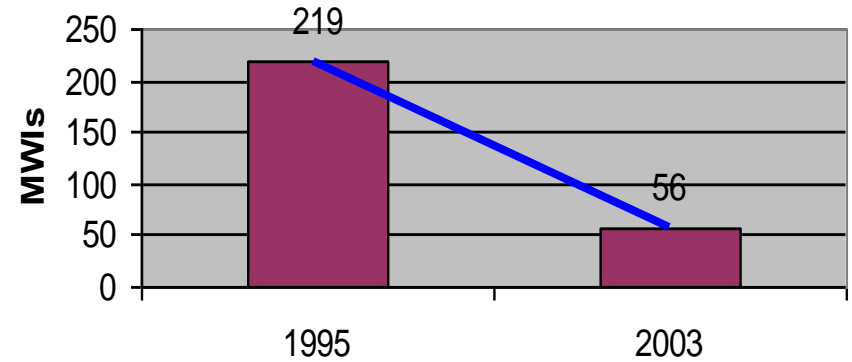
- “Standards of Performance for New Stationary Sources and Emissions Guidelines for Existing Sources: Hospital/Medical/Infectious Waste Incinerators – Final rule amendments,” 40 CFR Part 60, US Environmental Protection Agency, 2011

# Some Trends in Medical Waste Incineration (MWI)

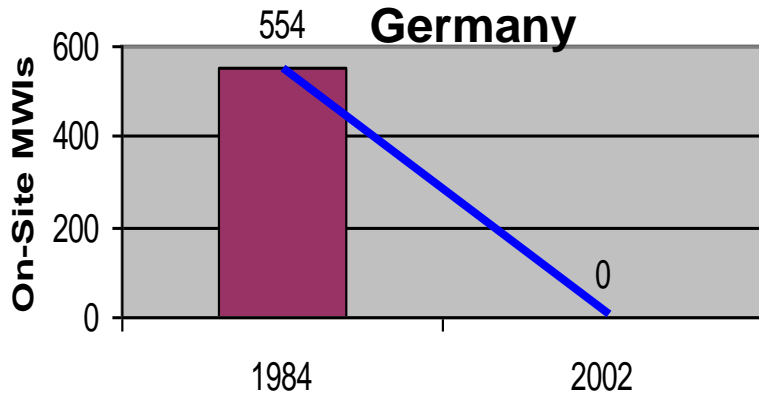
## United States



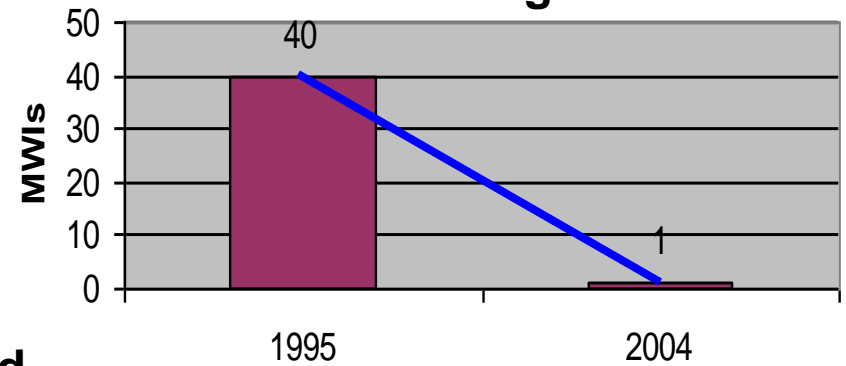
## Canada



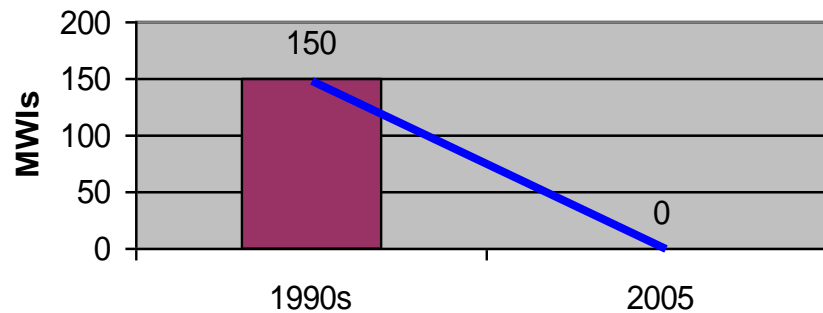
## Germany



## Portugal



## Ireland



# Treatment Technologies That Do Not Generate Dioxins/Furans (covered in Module 15)

- Non-Burn Thermal Technologies
  - Autoclaves
  - Hybrid Steam Systems
  - Microwave Units
  - Frictional Heat Treatment
  - Dry Heat Systems
- Chemical Technologies
  - Alkaline Hydrolysis

# Discussion

- What regulations or policies exist in your country or region regarding treatment and disposal methods?
- What are viable options for disposal of healthcare waste available in your facility or country?
- What are some factors that your facility considers when deciding on a waste treatment method? What do think is important when evaluating which method would be most appropriate?
- Does your facility use incineration, or have they used it as a treatment method in the past? What are some of the cost and benefits of incineration?
- Discuss air emissions and dioxin formation in relation to incinerators.
- Does your incinerator meet the Stockholm Convention guidelines and national regulations?
- What are the barriers to implementing non-incineration treatment and disposal methods?