

Health Impact of Thermal Treatment Facilities

Prof. Wong Tze Wai
Dept. of Community & Family Medicine
School of Public Health
The Chinese University of Hong Kong

What are thermal treatment facilities?

- Thermal treatment with energy recovery is the application of heat under controlled conditions to extract energy from organic wastes. The primary function of thermal treatment is to reduce the volume of municipal solid wastes (MSW), with the recovered energy being a by-product of the treatment process.

Source: Electrical and Mechanical Services Department
website: HK RE Net

http://re.emsd.gov.hk/english/energy/thermal/ther_tec.html

What are thermal treatment facilities?

- Thermal treatment system can be an integral part of an integrated MSW management facility, with a recycling facility to serve as a pre-treatment system. The recycling facility can increase the material recovery percentage and also enhance the overall efficiency of the thermal treatment process.

Source: Electrical and Mechanical Services Department
website: HK RE Net

http://re.emsd.gov.hk/english/energy/thermal/ther_tec.html

What are thermal treatment facilities?

- In a thermal treatment system with energy recovery, MSWs are used to produce heat and gas using various types of technologies such as MSW combustion and MSW gasification.

Source: Electrical and Mechanical Services

Department website: HK RE Net

http://re.emsd.gov.hk/english/energy/thermal/thermal_tec.html

Public Health Reviews of Hazardous Waste Thermal Treatment Technologies

Guidance Manual for Public Health Assessors, Mar 2002

Agency for Toxic Substances and Disease Registry (ATSDR)

- ATSDR's acceptance of any thermal treatment technology in a given situation is contingent on consideration of all remedial alternatives for that site. That is, **each remedial alternative, including thermal treatment, must be evaluated for its potential to affect public health.**

Definitions

- ATSDR considers an incinerator to be any technology where flames contact the waste being treated. The flames destroy the organic contaminants in the waste. On the other hand, ATSDR considers a desorber to be any device using an external heat source to heat the waste material and drive out contaminants.

Principles

- The key public health concern must be to ensure that the facility is operated in a way that prevents or, to the maximum extent practicable, minimizes harmful public exposures.

Principles

- As a matter of general public health policy, ATSDR supports waste minimization, recycling, and reuse as the preferred methods for reducing the volume of hazardous wastes and associated public health hazards. At the same time, the agency recognizes that not all hazardous waste can be eliminated, and that wastes require proper management, monitoring, and disposal.

Emissions of Public Health Concern

- The two categories of emissions of potential public health concern are (i) stack emissions and (ii) fugitive emissions.
 1. Stack Emissions
 - Organics
 - Dioxins and Furans
 - Metals and Halogens

Dioxins and Furans

- Carcinogenic:
- Causes a variety of cancers;
- Associated with many systematic diseases

Metals

- Arsenic, beryllium, cadmium, and chromium are metals sometimes found in wastes and stack emissions that because of their carcinogenicity could be of health concern. Other metals possibly present are antimony, barium, lead, mercury, nickel, selenium, silver, and thallium.

Metals

- Because metals are elements, they cannot be destroyed by incineration or any other treatment technology. They could therefore remain in the bottom ash, be carried into the air pollution control equipment (APCE), and removed as fly ash or in the scrubber liquor, or be emitted in the stack gases.

Fugitive Emissions

- The two primary sources of fugitive emissions at any thermal treatment facility are the waste processing/feed area and the residuals management area

Fugitive emissions

- Fugitive emissions from the waste processing/feed area can be volatilized organics or contaminated particulates. Particulates contain organics and metals blown off waste piles or waste transfer equipment or emitted through cracks in conveyor systems and storage and waste processing buildings.

Fugitive emissions

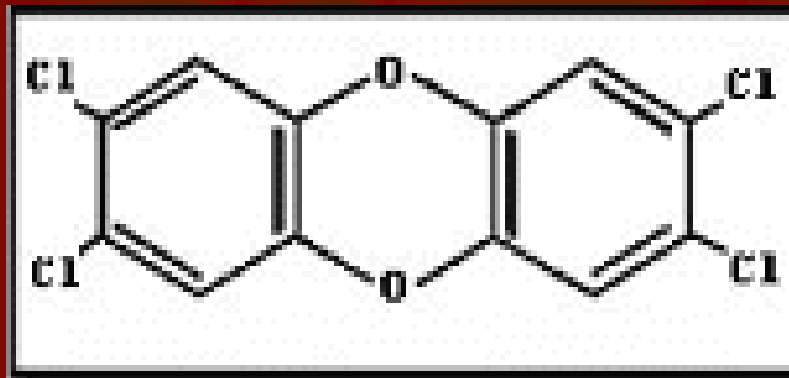
- Fugitive emissions from the solid residuals (fly ash or bottom ash) handling area are generally fine particulate matter that can, if not managed properly, easily become airborne.

Who are exposed to the emissions?

- Stack emissions: a wide geographical coverage, depends on meteorological factors: wind direction, wind speed, air pressure, precipitations, etc. Hence air pollutants can often travel long distances to affect other districts, not necessarily limited to the immediate neighbourhood.
- Fugitive emissions: generally affects the immediate vicinity of the incinerator plant only.

What is Dioxin?

- Not just one substance, "dioxin" usually refers to a complex family of 17 chlorinated organic compounds of highly variable toxicity. Dioxin forms as mixtures of its family member compounds. Some members of the dioxin family are as much as 10,000 times less toxic than the most toxic ones.
- Source:
http://www.dioxinfacts.org/dioxin_health/dioxin_tissues/threshold.html



- "Dioxin" is a shortened version of the technical chemical name given to some of the family member compounds. These compounds contain two oxygen atoms in their chemical structure, hence, "di" refers to "two" and "ox" refers to oxygen.
- Chemical structure of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (the numbers indicate the locations of chlorine atoms in the molecule.)

Where does dioxin come from?

- No one makes dioxin on purpose. Historically, incinerators, the manufacture of certain herbicides, and pulp and paper bleaching were among the largest industrial sources of dioxin.
- Today, USEPA considers "uncontrolled combustion," including open burning of household trash, agricultural burning and landfill fires, to be the largest unaddressed sources of dioxin in the environment, [1] accounting for an estimated 57% of total releases. [2]

Where does dioxin come from?

- Increasingly, natural sources, such as forest fires and composting, are also being recognized as contributors of dioxin to the environment. Because dioxin occurs naturally in the environment, it can never be totally eliminated.

How much dioxin am I exposed to?

- Levels of dioxin in food -- which account for 95 percent of our exposure to dioxin -- have been cut in half over the past seven years. [3] EPA has clearly emphasized that the U.S. food supply is among the safest and most nutritious in the world. [4]
- The World Health Organization sets its Tolerable Daily Intake (TDI) at a range of 1 to 4 pg/kg/bw/day (picograms per kilogram of body weight per day) for adults. A picogram is one-trillionth of a gram. EPA estimates that the average U.S. adult intake is 0.5 to 1 pg/kg body weight per day, clearly within, or below, that range.

How much dioxin am I exposed to?

- People today are exposed to less dioxin than at any time in the recent past. According to EPA, the amount of dioxin in the average person's body has declined by more than 50% since the late 1980s. [\[5\]](#) Studies of levels of dioxin in human breast milk, blood and fat tissue all show significant declines -- with decreases ranging from 50 to 70 percent between 1980 and 1996. [\[6\]](#)

Human Exposure to Dioxin

- According to the U.S. Interagency Working Group on Dioxin, more than 95 percent of human exposure to dioxin originates with the diet. Dioxin accumulates in the fatty components of meat and dairy products and then in human fatty tissue when these foods are consumed. Dioxin is eliminated at a rate determined by the amount of dioxin in the body-the higher the dioxin level in the body, the faster dioxin is eliminated.

Human Exposure to Dioxin

- By following the general public health recommendation of the U.S. Centers for Disease Control and Prevention (CDC) to limit one's intake of fatty foods, it is possible to simultaneously reduce dioxin intake.

Dioxin's Mode of Action

- Cancer is a complex, multi-stage process.
- Scientists have not determined the actual mechanism by which dioxin promotes the development of cancer.
- Probably through a “receptor” in cells, known as AhR* ;

* Certain cells of mammals, such as liver cells, contain a large molecule called an aryl hydrocarbon receptor (AhR), which can be thought of as shaped like a pocket. Some compounds foreign to the body, such as dioxin, fit snugly into this pocket. Once in the pocket, dioxin activates the AhR and the whole unit can travel to the cell nucleus which contains an organism's genes. Once in the nucleus, the unit may either activate or suppress specific genes that control the normal cell life cycle. For example, certain cells may begin to grow preferentially, or other cells may not die appropriately, as normal cells do. It is important to note that gene suppression or activation is not the same as DNA damage.

Effects on Health

- Cancer
- Increase in incidence of cancer in all sites
- Similar for mortality
- Evidence derived from several major cohort studies;
- All are occupational studies: workers in chemical plants, e.g., herbicides.
- Only one study shows no association;

Effects on Health

- No increase in deaths from all cancers among those exposed to environmental contamination;
- A large cohort of 40,000 people exposed to dioxins accidentally released to the atmosphere in 1976 in Seveso, Italy was studied.
- A 15 years follow-up study showed no overall increase in cancer deaths, but there was an increase in deaths from rectal cancers and leukemia in men, and myeloma in women.
- Breast cancer incidence was linked to an increase in blood level of dioxin.

Non-cancer effects:

- Increase in deaths from heart and lung diseases, and diabetes mellitus;
- These include ischemic heart disease and chronic obstructive lung diseases;

Other effects on health:

- Chloracne (a severe form of acne) – well documented among workers exposed to dioxins and dioxin-like compounds;
- Liver damage: Only transient changes in liver enzymes; no evidence for an increase in clinical liver and digestive system diseases;
- Thyroid diseases: conflicting results;

Other possible effects on health

- Endometriosis (a disease involving the lining of the uterus located elsewhere) was more common, but the result was not statistically significant;
- Studies on lipid metabolism: Non-conclusive;
- Some evidence of immuno-suppression in experimental animals and humans (cell-mediated immunity);

Other possible effects on health

- Child development and neurobehavioral studies: Some positive results for PCBs and dioxin-like compounds; insufficient data on dioxins;
- PCBs affect child growth (weight, length and head circumference);

Studies involving residents in Municipal waste incinerator

- No evidence of dioxin toxicity in several studies in the U.S.

Studies on dioxin levels in Hong Kong

- A study on dioxins in breast milk of 316 mothers in Hong Kong was done in 2002.
- The mean dioxin concentration (including PCDDs, PCDFs and dioxin-like PCGs), expressed as TEQs was 12.9 pg/g of fat.

Studies on dioxin levels in Hong Kong

- The median level of PCDD/PCDFs ranks 14th from the top in a WHO study of dioxins in milk in 26 countries – lower than many European countries, but higher than 4 Asia-Pacific countries (Fiji, the Philippines and Australia).
- The median PCB-TEQ ranks 17th from the top, lower than most European countries but higher than 5 Asia-Pacific countries (Fiji, the Philippines, New Zealand and Australia).

Studies on dioxin levels in Hong Kong

- The levels of dioxins in Hong Kong mothers are strongly linked to consumption of fish and age.
- More stringent monitoring of dioxin levels in food is crucial in reducing the overall intake of dioxins into the body.

Other substances that are hazardous to health

- Heavy metals
- Many of the heavy metals are highly toxic;
- Their toxicities are dose-dependent;
- Many metals are toxic to essential organs and systems like the kidney (Hg, Cd), bones (Cd), blood vessels (As), blood (Pb), or cause cancers (Cr, As, Ni)

Other substances that are hazardous to health

- Particulates released into the atmosphere
- Causes a variety of respiratory and cardiovascular diseases;
- Those containing toxic metals cause health problems as explained before;

Conclusion

- Many potential health problems;
- Dose-dependent;
- Control of emission is very important to ensure minimal release into the air (that will effect a wide area beyond the source of emission) and the immediate environment (mainly "fugitive emissions").

Conclusion

- With modern technology of emission control and stringent monitoring of emission, no major environmental health problems caused by incinerators have been reported in developed countries nowadays.

References

- [1] *Questions and Answers About Dioxins*, Interagency Working Group on Dioxin (representatives from the U.S. Environmental Protection Agency, Department of Health and Human Services, Department of Agriculture, Department of Veterans Affairs, Department of Commerce, Department of State, and the White House Office of Science and Technology Policy), October 2004.
- [2] *Draft Dioxin Reassessment*, Part I: Estimating Exposure to Dioxin-Like Compounds, Volume 2: Sources of Dioxin-Like Compounds in the United States, Chapter 1, U.S. Environmental Protection Agency, September 2000.
- [3] *Assessment of the Health Risk of Dioxins: Re-Evaluation of the Tolerable Daily Intake (TDI)*, Executive Summary, World Health Organization, 1998.
- [4] *Questions and Answers About Dioxins* (see citation #1)
- [5] *Draft Dioxin Reassessment*, Environmental Protection Agency, September 2000.
- [6] Pöpke, O., "PCDD/PCDF: Human Background Data for Germany, a 10-Year Experience," *Environmental Health Perspectives* 106: 723-731, 1998. Stanley, J.S., Ayling, R.E., Cramer, P.H., Thornburg, K.R., Remmers, J.C., Breen, J.J., Schwemberger, J., Kang, H.K., and Watanabe, K., "Polychlorinated Dibenzo-p-Dioxin And Dibenzofuran Concentration Levels in Human Adipose Tissue Samples From The Continental United States Collected From 1971 Through 1987," *Chemosphere* 20: 895-901, 1998.