

Part 3. The Terrestrial Environment

Chapter 19.

The Chemistry of Solid Wastes

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19.1 Mixed urban wastes: Landfilling

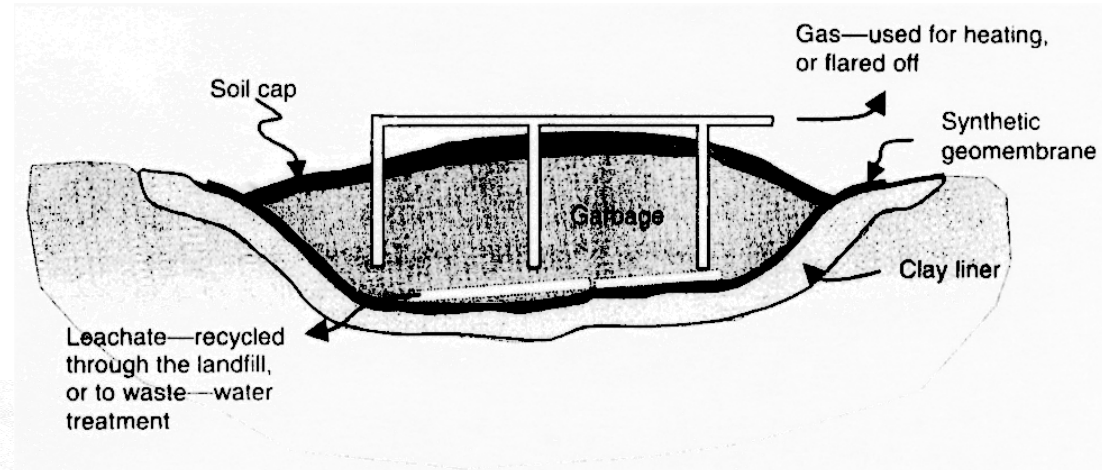


Fig. 19.2 A well designed urban waste disposal site.

- For OM in the landfill, where compact nature of the deposit inhibits air transfer into the bulk mass,

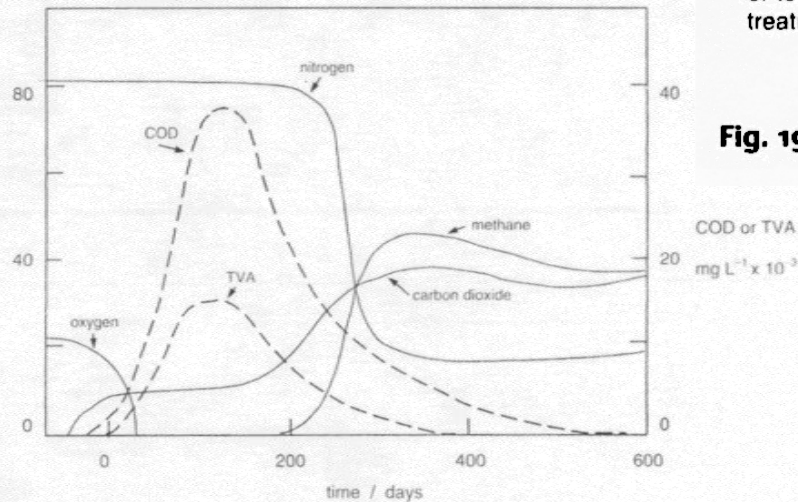
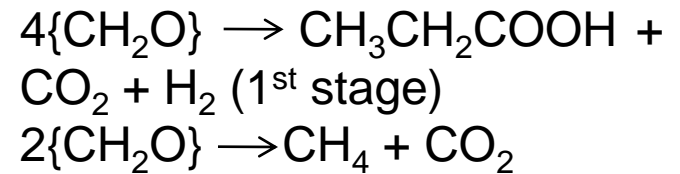


Fig. 19.3 Changes in gas composition(—)and leachate concentration(— —)over a 2 year period in a landfill. COD is chemical oxygen demand and TVA is the total volatile acids and is measured in terms of acetic acid. The total volume of gas evolved from the landfill reaches a maximum at about 380 days. The figure is based on one in Pohland, F. G., J. T. Derien, and S. B. Ghosh, Leachate and gas quality changes during landfill stabilization of municipal refuse, in *Proceedings of the 3rd International Symposium on Anaerobic Digestion*, R. L. Wentworth, ed., Boston, Dynatech, Cambridge, USA: 1983. pp. 185–201.

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19.1 Mixed urban wastes: Incineration

- Attractive features

1) It provides an efficient means for energy recovery from much of the waste, and it is a means of disposal that can be set up in an area immediately adjacent to a population center.

E.g. In a typical landfill, $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$ $\Delta H = -802.3 \text{ kJ}$

So, from 1t of waste, 4500mol (maximum amount of methane recoverable from 1t of waste) $\times 890300\text{J} = 4.0 \times 10^9 \text{ J}$, but

from a direct combustion, $\{\text{CH}_2\text{O}\} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$ $\Delta H = -440 \text{ kJ}$

So, 1t of waste = $1 \times 10^6 / 30 \text{ mol}$,

then $(1 \times 10^6 \times 0.85 \times 440000) / 30 = 1.2 \times 10^{10} \text{ J}$

2) It reduces the volume of waste considerably so that much less land is required for final disposal.

3) It eliminates problems associated with methane generation and leachate that emanate from a landfill site.

- Environmental consequences to consider

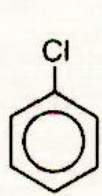
1) massive production of

2) production of

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19.1 Mixed urban wastes: Incineration

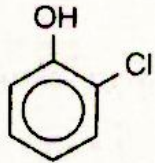
- Polychlorinated organic materials: there are 209 possible congeners



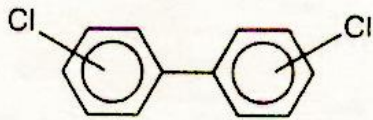
chlorobenzene



1,4-dichlorobenzene

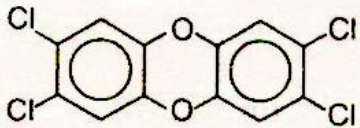


2-chlorophenol



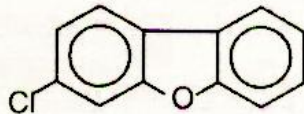
polychlorinated biphenyl

(PCB)



2,3,7,8-tetrachlorodibenzo-*p*-dioxin

(PCDD)



3-chlorodibenzofuran

(PCDF)

- PCDDs and PCDFs: not industrial products as such, but are produced and released in small amounts during combustion of chlorine-containing organic materials such as PVCs.

- Kow of 2,3,7,8-TCDD = 10^6 - 10^7 meaning that it has a tendency to partition into soil, esp. when the soil has a substantial organic content. The same is also true for PAHs.

Fig. 19.4 Some chlorinated organic compounds that have been found in fly ash. A generic formula for PCBs is given. The 2,3,7,8-tetrachlorodibenzo-*p*-dioxin is considered to be a reference compound for dioxins in general.

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19.1 Mixed urban wastes: Incineration

- Specifications for municipal incinerator operations

Total particulates; 11 mg Rm^{-3}

Cd: $7 \text{ } \mu\text{g Rm}^{-3}$ Pb: $76 \text{ } \mu\text{g Rm}^{-3}$

Hg: $56 \text{ } \mu\text{g Rm}^{-3}$ TCDD: 0.14 ng Rm^{-3}

where Rm^{-3} : a reference cubic meter, meaning that the conditions have been normalized to $25 \text{ }^\circ\text{C}$, P^0 , and 11% oxygen.

- To meet the specifications, the followings must be ensured
 - 1) the combustion T should be at least $1100 \text{ }^\circ\text{C}$ and must never fall below $1000 \text{ }^\circ\text{C}$
 - 2) the residence time of gases in the furnace be at least 1 s
 - 3) there be good turbulence
 - 4) oxidizing conditions are maintained by keeping at least 6% residual oxygen after burning