# Hazardous Waste Management

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# Hazardous Waste Management, Hazardous Organic Chemicals

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# Hazardous Waste

- Simply defined, a hazardous waste is a waste with properties that make it dangerous or capable of having a harmful effect on human health or the environment (EPA).
- Hazardous wastes can be in the form of solids, liquids, sludges, or contained gases.
- According to EPA, any waste either toxic, flammable, corrosive or radioactive is hazardous waste.

# Hazardous Waste

- Toxic wastes are poisons, even in very small or trace amounts. They may have acute effects, causing death or violent illness, or they may have chronic effects, slowly causing irreparable harm.
- Some are carcinogenic, causing cancer after many years of exposure.
- Others are mutagenic, causing major biological changes in the offspring of exposed humans and wildlife.

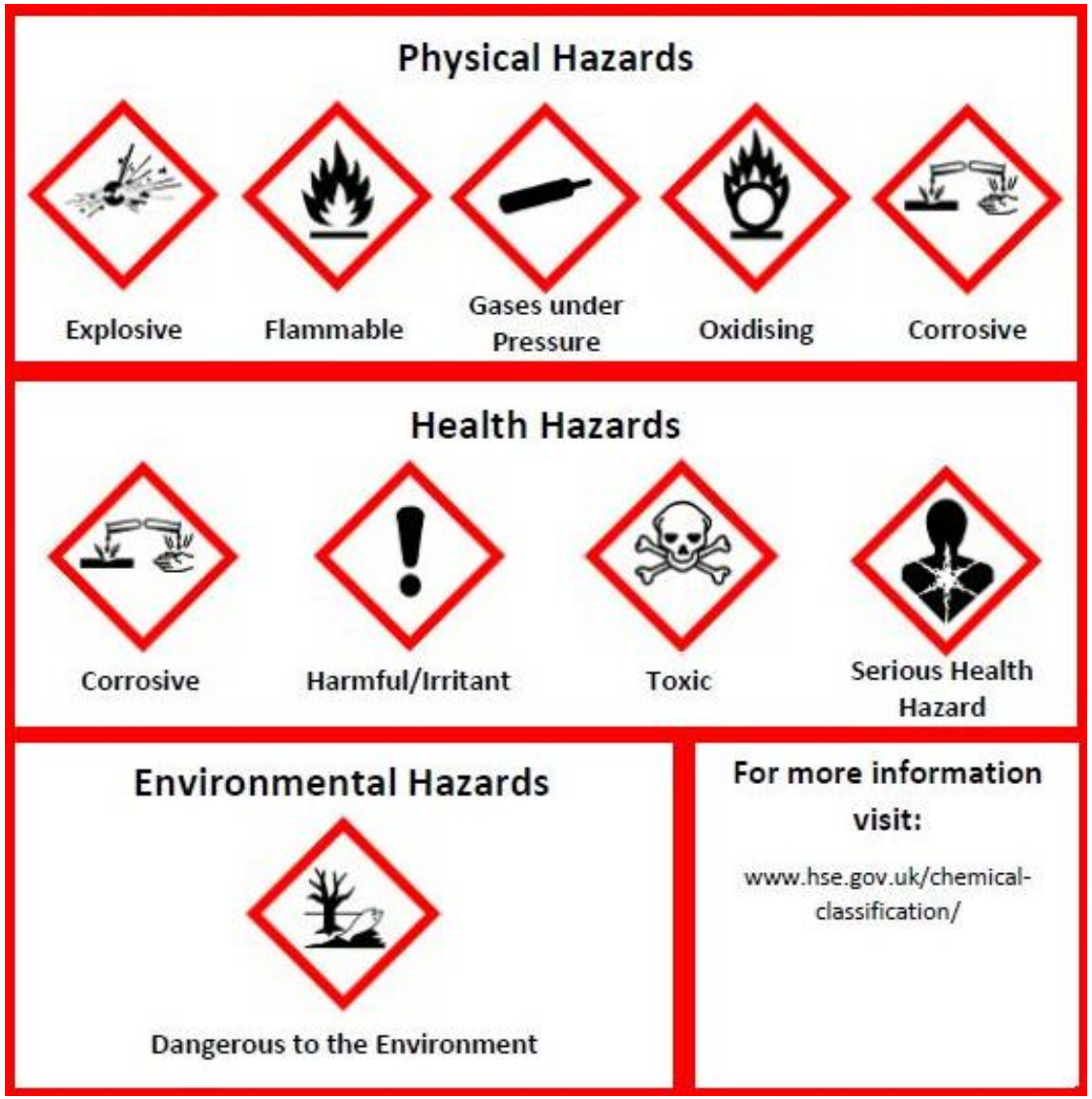
https://www.britannica.com/technology/hazardous-waste-management

# Hazardous Waste

- Reactive wastes are chemically unstable and react violently with air or water. They cause explosions or form toxic vapors.
- Flammable wastes burn at relatively low temperatures and may cause an immediate fire hazard.
- Corrosive wastes include strong acidic or alkaline substances. They destroy solid material and living tissue upon contact, by chemical reaction.

https://www.britannica.com/technology/hazardous-waste-management

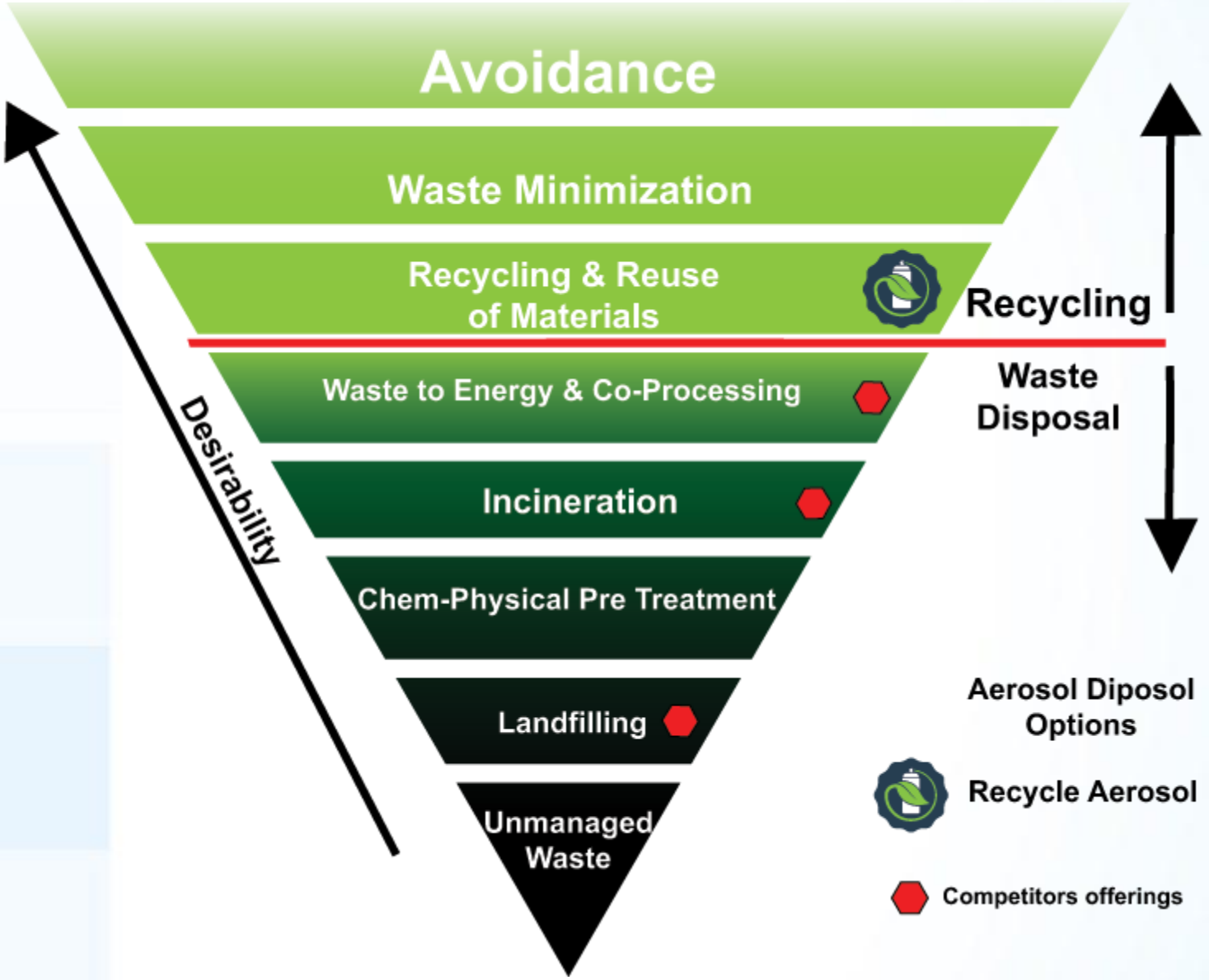
# Hazard Identification




https://sensiblesafetysolutions.co.uk/2152-2/

# Hazardous Waste Management

- The collection, storage, transport, treatment, and ultimate disposal of hazardous waste material that, when improperly handled, can cause substantial harm to human health and safety or to the environment.




http://www.recycleaerosol.com/epa_waste_management_hierarchy/

# Potential Hazard Criteria For Hazardous Wastes

- Waste composition
- Concentration
- Chemical activity
- Waste amount and generation rates
- Fate of waste in environment and exposure rates
- Acute and chronic health effects

# Hazardous Organic Chemicals

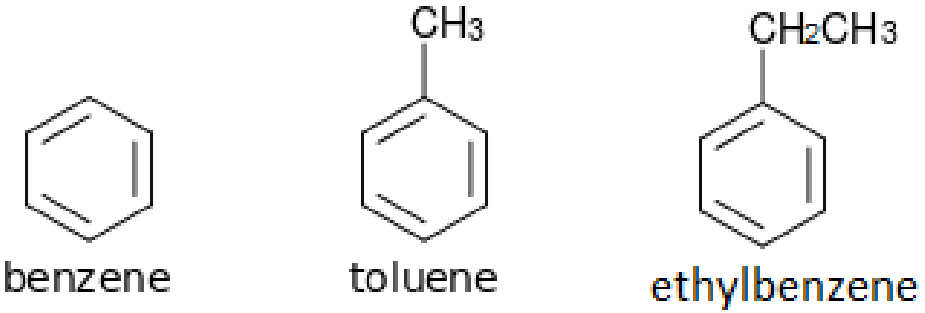
- BTEX compounds
- Polycyclic aromatic hydrocarbons
- PCB
- PCDD & PCDF
- Pesticides

# BTEX Compounds

- Monocyclic aromatic hydrocarbons (based on a single aromatic ring structure) that includes,
  - Benzene ($C_6H_6$)
  - Toluene ($C_7H_8$)
  - Ethylbenzene ($C_8H_{10}$)
  - Xylene (ortho, meta and para) ($C_8H_{10}$)
- collectively known as **BTEX**

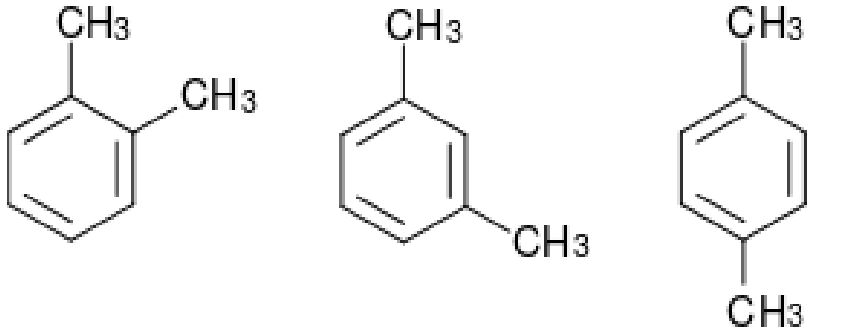
# BTEX

BTE




benzene toluene ethylbenzene

X's




*ortho*-xylene *meta*-xylene *para*-xylene

Gulf Coast Environmental Systems

http://www.gcesystems.com/what-is-btex/

| Benzene | Formula: $C_6H_6$ | CAS#: 71-43-2 | RTECS#: CY1400000 | IDLH: Ca [500 ppm] |
|---|---|---|---|---|
| **Conversion:** 1 ppm = 3.19 mg/m$^3$ | **DOT:** 1114 130 | | | |
| **Synonyms/Trade Names:** Benzol, Phenyl hydride | | | | |

**Exposure Limits:**

**NIOSH REL:** Ca
TWA 0.1 ppm
ST 1 ppm
See Appendix A

**OSHA PEL:** [1910.1028]
TWA 1 ppm
ST 5 ppm
See Appendix F

**Measurement Methods (see Table 1):**
**NIOSH** 1500, 1501, 3700, 3800
**OSHA** 12, 1005

**Physical Description:** Colorless to light-yellow liquid with an aromatic odor. [**Note:** A solid below 42°F.]

**Chemical & Physical Properties:**
**MW:** 78.1
**BP:** 176°F
**Sol:** 0.07%
**Fl.P:** 12°F
**IP:** 9.24 eV
**Sp.Gr:** 0.88
**VP:** 75 mmHg
**FRZ:** 42°F
**UEL:** 7.8%
**LEL:** 1.2%
Class IB Flammable Liquid

**Personal Protection/Sanitation (see Table 2):**
**Skin:** Prevent skin contact
**Eyes:** Prevent eye contact
**Wash skin:** When contam
**Remove:** When wet (flamm)
**Change:** N.R.
**Provide:** Eyewash
Quick drench

**Respirator Recommendations (see Tables 3 and 4):**
**NIOSH**
**¥:** ScbaF:Pd,Pp/SaF:Pd,Pp:AScba
**Escape:** GmFOv/ScbaE

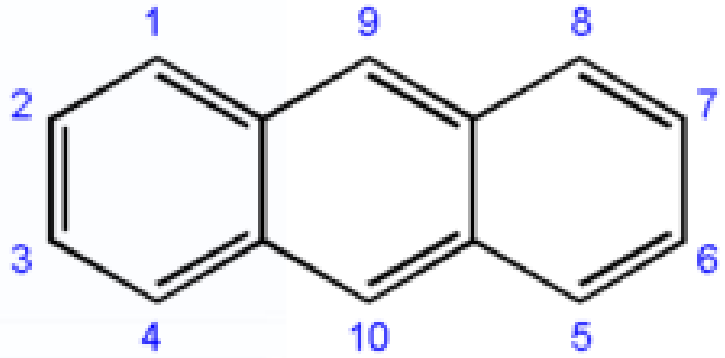
See Appendix E (page 351)

**Incompatibilities and Reactivities:** Strong oxidizers, many fluorides & perchlorates, nitric acid

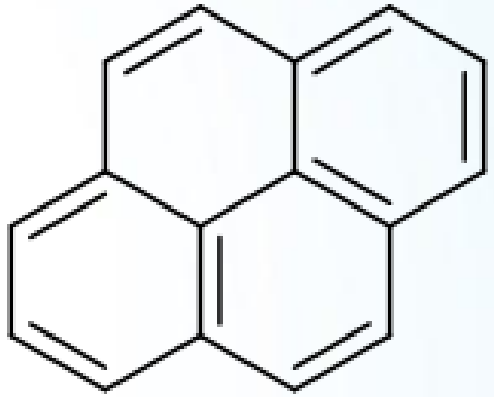
**Exposure Routes, Symptoms, Target Organs (see Table 5):**
**ER:** Inh, Abs, Ing, Con
**SY:** Irrit eyes, skin, nose, resp sys; dizz; head, nau, staggered gait; anor, lass; derm; bone marrow depres; [carc]
**TO:** Eyes, skin, resp sys, blood, CNS, bone marrow [leukemia]

**First Aid (see Table 6):**
**Eye:** Irr immed
**Skin:** Soap wash immed
**Breath:** Resp support
**Swallow:** Medical attention immed

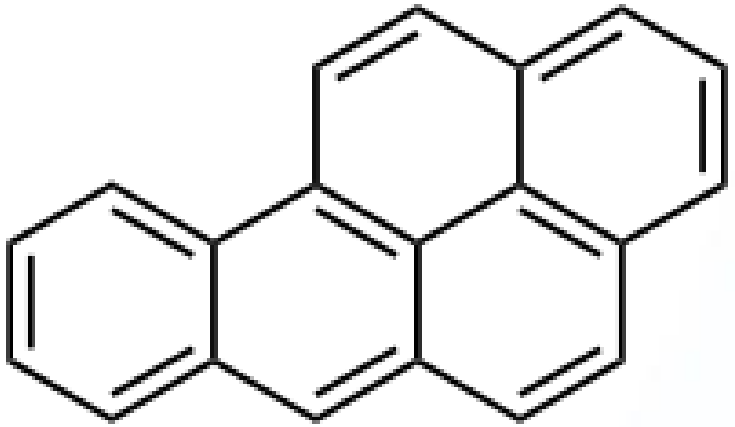
# Polycyclic Aromatic Hydrocarbons (PAH)




**Anthracene**

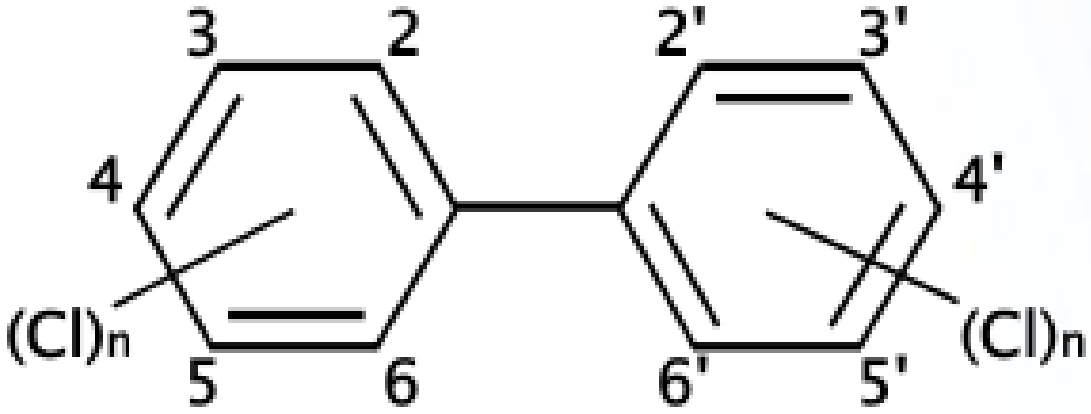


**Pyrene**

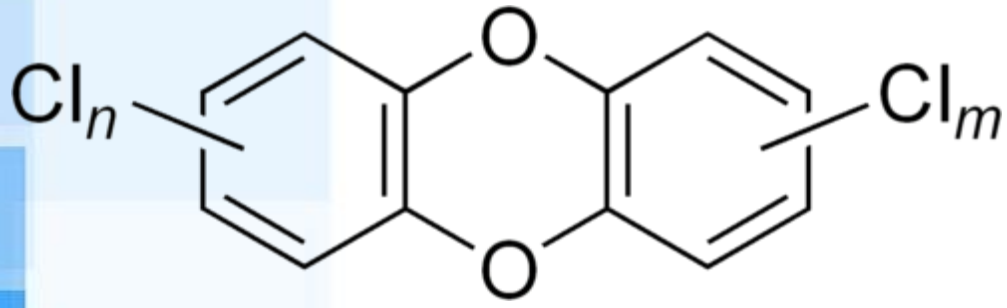


**Benzo[*a*]pyrene**

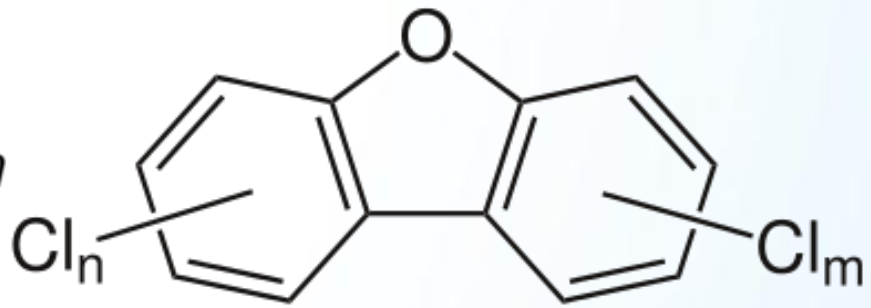
# Chemical Structures of PCB, PCDD, PCDF




**PCB**




**PCDD**




**PCDF**

# PCBs – Poly Chlorinated Biphenyls

- Bio accumulative, persistent compounds.
- Used in transformers and capacitors.
- Banned in 1980's.
- Carcinogenic, teratogenic and mutagenic compounds.
- Theoretically 209 PCB are possible, however 130 exist.

# PCBs – Poly Chlorinated Biphenyls

- They are hydrophobic, with low water solubility, but they have high solubility in most organic solvents, oils, and fats.
- They have low vapor pressures at room temperature.
- PCBs do not easily break down or degrade.
- PCB mixtures are resistant to acids, bases, oxidation, hydrolysis, and temperature change.

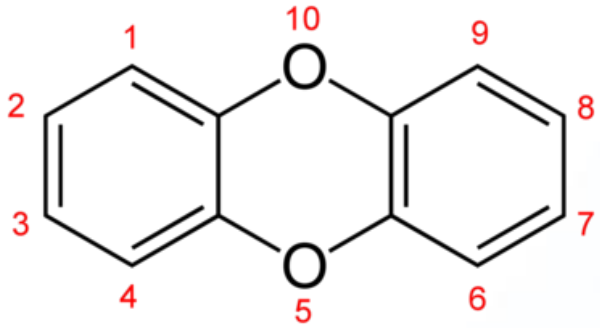
# PCBs – Poly Chlorinated Biphenyls

- At least 1200 °C is required for thermal degradation of PCB.
- Increasing number of Cl atoms make PCB stable, toxicity and viscosity become higher. Biodegradability, chemical degradability and solubility decrease.

- Determination methods:
  - Gas chromatography (GC)
  - Gas chromatography / mass spectrometry (GC/MS)

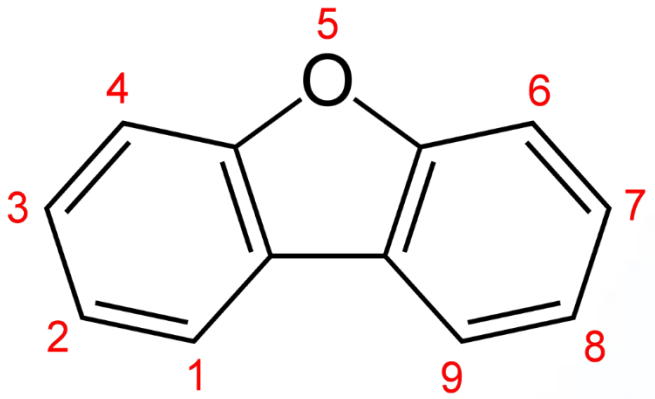
# Polychlorinated dibenzodioxins - PCDD

- Cl atoms make bonds with 1,2,3,4 and 6,7,8,9 numbered carbons.
- 75 PCDD compounds exist.
- Shows bioaccumulation.
- Carcinogenic, teratogenic and mutagenic compounds.
- Causes chloracne, skin disease.



# Polychlorinated dibenzofurans - PCDF

- Carcinogenic, teratogenic and mutagenic compounds.
- Created during the incineration or pyrolysis of PVC, PCB or other organohalogens under 1200 °C.
- PCDD/F are formed in oxygen reach region in incineration process at 250-300 °C.



# Pesticides

- Does not exist naturally.
- Produces chemically in laboratory to control pests.
- Show bio accumulation in fat tissue.
- Toxic.
- Affects liver, brain and kidney in humans.

# Pesticides

| **Group Name** | **Controls** |
|---|---|
| Insecticides | Insect |
| Fungicide | Parasitic fungi |
| Herbicide | Herb |
| Bactericide | Bacteria |
| Rodenticide | Rodantia |

# Hazardous Waste Classification & Physico-chemical Properties

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# Properties of Hazardous Wastes

**Health related:**

- Carcinogen
- Infectious
- Toxic
- Mutagen
- Teratogen

- Radioactive

**Safety related:**

- Explosive
- Reactive
- Corrosive
- Flammable

# NFPA Hazard Rating System

- The NFPA hazard rating system refers to, in part, a safety standard put forth by the National Fire Prevention Association (NFPA).
- The NFPA 704 standard defines the necessary signage and information that needs to be displayed to alert personnel of the type of hazardous materials that are present.
- Each color code (blue, red, and yellow) of the hazard rating system corresponds to a hazard: health, fire, and instability.

https://www.safetysign.com/help/h89/nfpa-hazard-rating

# NFPA Hazard Rating System

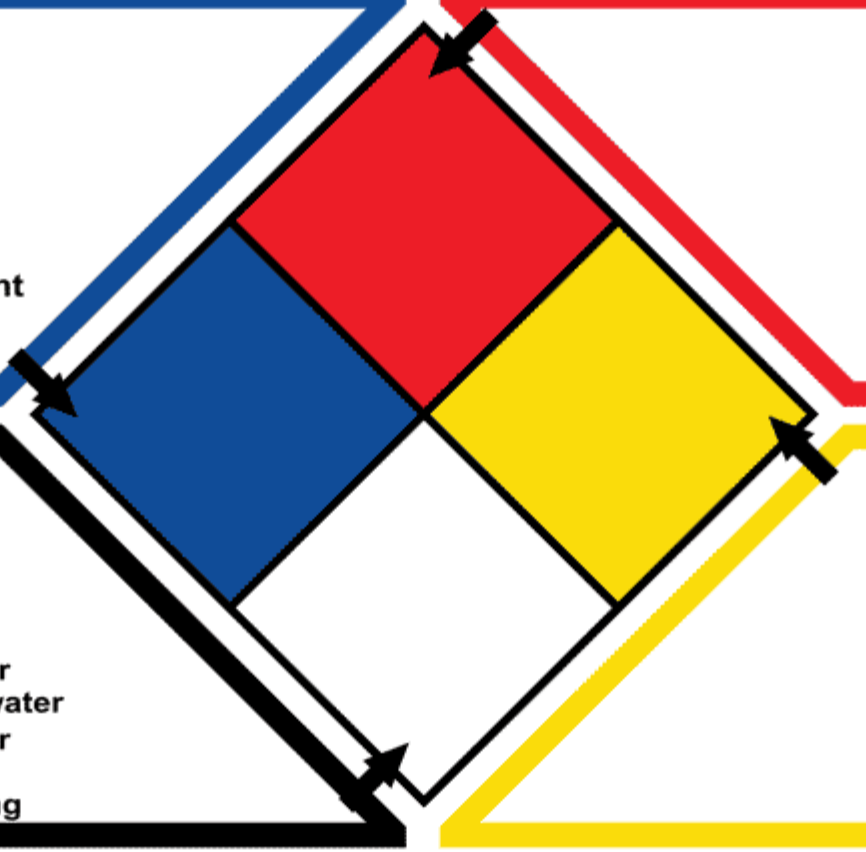


4. Severe Hazard
3. Serious Hazard
2. Moderate Hazard
1. Slight Hazard
0. Minimal Hazard

https://www.safetysign.com/help/h89/nfpa-hazard-rating

https://www.chemsafetypro.com/Topics/USA/NFPA_704_Label_NFPA_Rating.html

# NFPA Rating Explanation Guide



## HEALTH HAZARD

4 = Can be lethal
3 = Can cause serious or permanent injury
2 = Can cause temporary incapacitation or residual injury
1 = Can cause significant irritation
0 = No hazard

## FLAMMABILITY HAZARD

4 = Will vaporize and readily burn at normal temperatures
3 = Can be ignited under almost all ambient temperatures
2 = Must be heated or high ambient temperature to burn
1 = Must be preheated before ignition can occur
0 = Will not burn

## SPECIAL HAZARD

ALK = Alkaline
ACID = Acidic
COR = Corrosive
OX = Oxidizing
= Radioactive
W = Reacts violently or explosively with water
WOX = Reacts violently or explosively with water and oxidizing

## INSTABILITY HAZARD

4 = May explode at normal temperatures and pressures
3 = May explode at high temperature or shock
2 = Violent chemical change at high temperatures or pressures
1 = Normally stable. High temperatures make unstable
0 = Stable

*chart for reference only - For complete specifications consult the NFPA 704 Standard*

# Benzene

Colorless liquid; sweet odor. Irritating to eyes/skin/ respiratory tract. Toxic. Also causes: headache, dizziness, drowsiness. Absorbed through the skin. Chronic: dermatitis, leukemia, bone marrow damage. Carcinogen. Reproductive effects. Flammable.


CAS No. 71-43-2

# Physico-Chemical Properties of Hazardous Wastes

- Used to determine the fate of hazardous waste in an environment. Also, they should be known to select appropriate treatment method for hazardous waste.
- Solubility
- Vapor pressure
- Henry constant
- Octanol/water partitioning coefficient
- Organic carbon partitioning coefficient
- Soil-water partitioning coefficient
- Bioconcentration

# Solubility

- Solubility in water → mg/L or ppm
- Ksp Solubility product
- Inorganic salts have highest solubility in water.
- Some hydrocarbons and halogenated hydrocarbons have lowest solubility in water.
- Solubility < 10 → low
- Solubility > 1000 → high

# Vapor Pressure (Pa)

- (mmHg or atm)
- Pollutants with higher vapor pressure evaporates easily.
- Pa < $10^{-6}$ mmHg → low
- Pa > 0.01 mmHg → high

# Henry Constant ($K_H$)

- Henry's law is used to determine the solubility of a gas in a liquid to form an ideal dilute solution.
- ($atm/mol/m^3$)
- $P_g = K_H \times C$

- $K_H$ : Henry constant ($atm/mol/m^3$)
- $P_g$ : Partial pressure of gas (atm)
- C : mole ratio($mol/m^3$)
- $K_H < 10^{-10}$ → low
- $K_H > 0.01$ → high

# Octanol / Water Partitioning Coefficient (Kow)

- $Kow = C_{octanol} / C_{water}$

- Kow < 500 → low
- Kow > 1000 → high

- Indicates bio accumulation.

# Organic Carbon Partitioning Coefficient (Koc)

- Koc = (mg adsorbed / kg organic carbon) / Cwater
- The soil organic carbon-water partitioning coefficient is the ratio of the mass of a chemical that is adsorbed in the soil per unit mass of organic carbon in the soil per the equilibrium chemical concentration in solution.
- Koc values are useful in predicting the mobility of organic soil contaminants; higher Koc values correlate to less mobile organic chemicals while lower Koc values correlate to more mobile organic chemicals.

- Koc < 1000 → low
- Koc > 10000 → high

# Soil Water Partitioning Coefficient (Kod)

- Kod = (mg adsorbed / kg Soil) / Cwater

- Kod < 10 → low
- Kod > 10000 → high

- Kod = Koc × foc
- Foc : organic carbon fraction

# Bioconcentration (BCF)

- Accumulation of a chemical in an aquatic organism.
- BCF = Cfish / Cwater (mg/kg)

- BCF < 1 → low
- BCF > 10000 → high

# Some Physical and Chemical Properties of BTEX and MTBE

| Compound | Molecular Weight | Solubility ($gl^{-1}$) | Vapour Pressure (mmHg) | Log $K_{oc}$ | Henry's constant $Atm.m^3/mol$ |
|---|---|---|---|---|---|
| Benzene | 78 | 1.78 | 95 | 1.92 | 0.00548 ($25^oC$) |
| Toluene | 92 | 0.52 | 22 | 2.06 | 0.00674 ($25^oC$) |
| Ethylbenzene | 106 | 0.15 | 7 | 1.98 | 0.00868 ($25^oC$) |
| Xylene* | 106 | 0.19 | 10 | - | - |
| MTBE | 88 | 48 | 245 | - | - |

* : Denotes average value for ortho-, meta- and para-xylene

Ref: Suthersan, S.S. 1997 Remediation Engineering CRC, London (http://www.howtomna.com/008%20M3%20BTEX%20reader.htm)