CVL 100: Risk Assessment

Is the chemical released by industry toxic?

- A Hazard is something that has the potential to harm you.

- Risk is is the likelihood of a hazard causing harm.

Examples: Risk of tornadoes, hurricanes, floods, droughts, landslides, forest fires & chemicals released to environment.
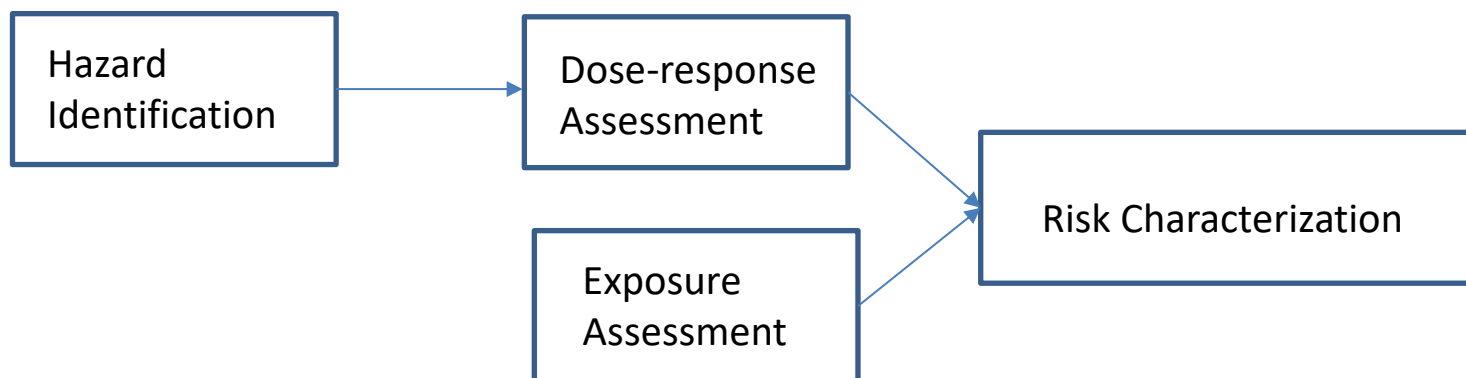
Life time and Annual Risk

- The life time risk of death from all causes is 100%

- If there are 10 million deaths per year, and of these 2500 die with cancer. Assume average life expectancy is 65 years, ignoring age factors

  - What's risk of dying from cancer in a life time?
  - What's annual risk?

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- What's risk of dying from cancer in a life time
- What's annual risk?

- Total deaths per year: 10,00,000
- Cancer deaths per year: 25,000
- Average life expectancy: 65 years
- The annual risk is the proportion of deaths due to cancer out of the total deaths per year.

- $Annual\ risk = \dfrac{cancer\ deaths\ per\ year}{Total\ deaths\ per\ year}$

$$= 2.5 * 10^{-4}$$

- $Life\ time\ risk = 1 - (1 - Annual\ risk)^{Avg\ life\ expectancy}$

$$= \sim 1.6\%$$

Risk Assessment

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│ Hazard          │─────▶│ Dose-response   │
│ Identification  │      │ Assessment      │
└─────────────────┘      └─────────────────┘
                                  │
                                  ▼
                         ┌─────────────────────────┐
                         │ Risk Characterization   │
                         └─────────────────────────┘
                                  ▲
┌─────────────────┐               │
│ Exposure        │───────────────┘
│ Assessment      │
└─────────────────┘
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Steps

- Step 1: Hazard Identification
- Step 2: Dose- response assessment
  - If an adverse risk is present what is the relationship between the **dose** of an agent received by a receptor (organism or ecosystem) and the incidence of an **adverse effect** on that receptor
    - Dose is the mass of chemical received by the exposed individual
    - Receptor is the organism receiving the dose
  - Most of the dose- response assessments are done on animals.
    - Is there any problem with this procedure?

Dose-response curve

NOAEL = No Observed Adverse Effect Level   SF=Slope of the dose-response curve
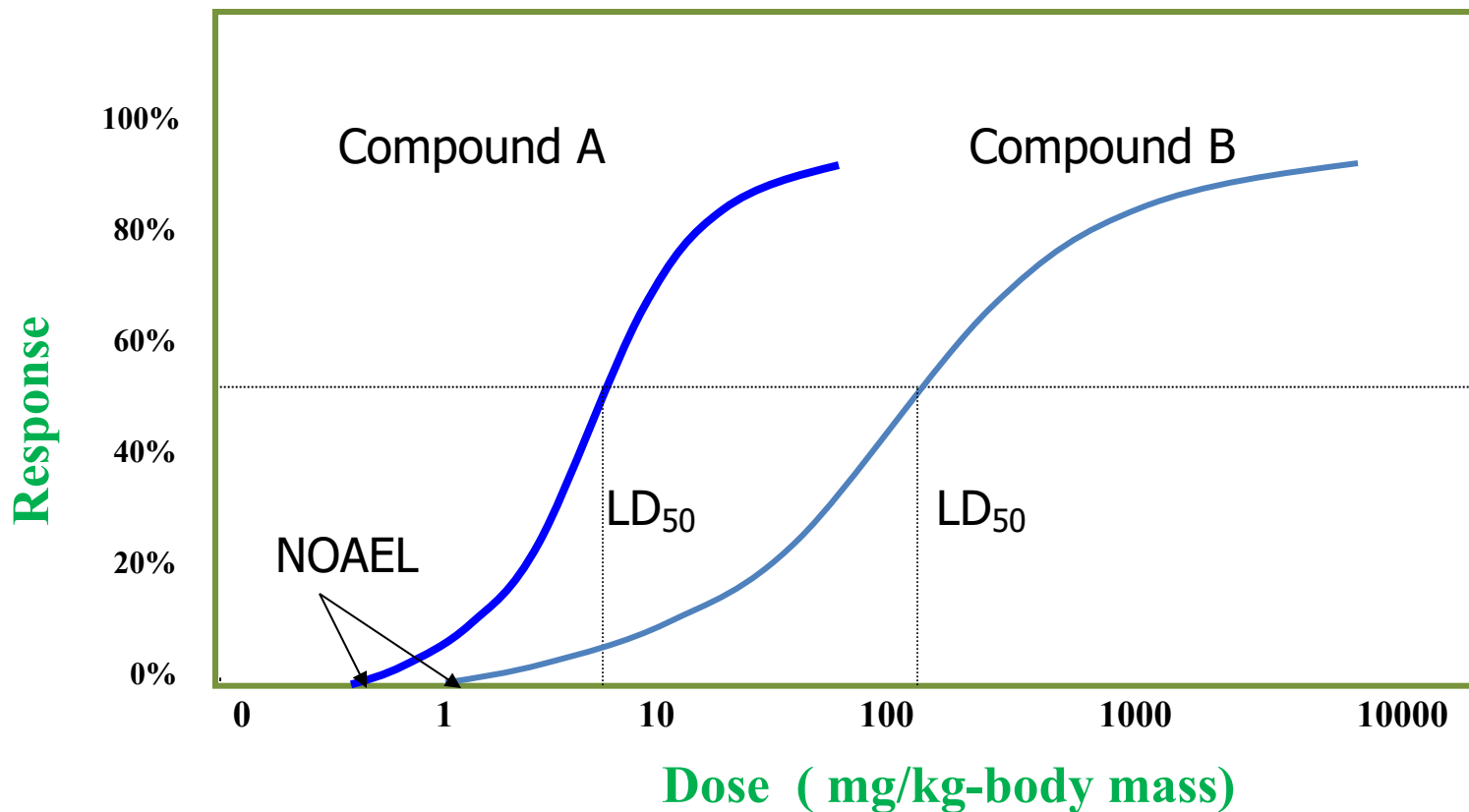
LD = Lethal Dose, LD_{50}=Dose causing 50% mortality

- Step 3: Exposure Pathway
  – Through what pathways are people exposed to a particular chemical.

Media	Pathways
Water	Ingestion, dermal contact, inhalation during shower
Sediment	Ingestion, dermal contact
Air	Inhalation of air borne chemicals and particulate matter
Soil	Incidental ingestion, dermal contact
Food	Ingestion

Exposure Assessment Examples

Ecological Risk

Human Health

Ecological &Human Health

Ingestion in drinking water

$$CDI = \frac{(CW)(IR)(EF)(ED)}{(BW)(AT)}$$

Ingestion while swimming

$$CDI = \frac{(CW)(CR)(ET)(EF)(ED)}{(BW)(AT)}$$

Dermal contact with water

$$AD = \frac{(CW)(SA)(PC)(ET)(EF)(ED)(CF)}{(BW)(AT)}$$

Ingestion of chemicals in soil

$$CDI = \frac{(CS)(IR)(CF)(FI)(EF)(ED)}{(BW)(AT)}$$

Dermal contact with soil

$$AD = \frac{(CS)(CF)(SA)(AF)(ABS)(EF)(ED)}{(BW)(AT)}$$

Inhalation of airborne (vapor phase) chemicals

$$CDI = \frac{(CA)(IR)(ET)(EF)(ED)}{(BW)(AT)}$$

Ingestion of contaminated fruits, vegetables, fish and shellfish

$$CDI = \frac{(CF)(IR)(FI)(EF)(ED)}{(BW)(AT)}$$

where ABS = absorption factor for soil contaminant (unitless)

AD = absorbed dose (in $mg \cdot kg^{-1} \cdot day^{-1}$)

AF = soil-to-skin adherence factor (in $mg \cdot cm^{-2}$)

AT = averaging time (in days)

BW = body weight (in kg)

CA = contaminant concentration in air (in $mg \cdot m^{-3}$)

CDI = chronic daily intake (in $mg \cdot kg^{-1} \cdot day^{-1}$)

CF = volumetric conversion factor for water = $1\ L \cdot 1000\ cm^{-3}$

= conversion factor for soil = $10^{-6}\ kg \cdot mg^{-1}$

CR = contact rate (in $L \cdot h^{-1}$)

CS = chemical concentration in soil (in $mg \cdot kg^{-1}$)

CW = chemical concentration in water (in $mg \cdot L^{-1}$)

ED = exposure duration (in years)

EF = exposure frequency (in $days \cdot year^{-1}$ or $events \cdot year^{-1}$)

ET = exposure time ($h \cdot day^{-1}$ or $h \cdot event^{-1}$)

FI = fraction ingested (unitless)

IR = ingestion rate (in $L \cdot day^{-1}$ or mg soil $\cdot day^{-1}$ or $kg \cdot meal^{-1}$)

= inhalation rate (in $m^3 \cdot h^{-1}$)

PC = chemical-specific dermal permeability constant (in $cm \cdot h^{-1}$)

SA = skin surface area available for contact (in cm^2)

$$Risk = CDI \times SF$$

Example1

A chemical compound 'XX' is in air at concentrations of 10 µg/m³ in a city. A person stays in that city for 60 years. If the inhalation rate is 0.633 m³/h and average body weight is 78 kgs. Estimate the life-time average chronic daily intake of chemical compound 'XX' .

Step I: Identify pathways

1) Inhalation of air

Step II: Use appropriate formula

$$CDI = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT}$$

CA=10 *µg/m³*

IR= *Inhalation Rate= 0.633 m³/h*

ET=Exposure time= 24 h/d

EF=Exposure Frequency= 365 d/y

ED=Exposure duration= 60 y

BW=Body Weight= 78 kgs

AT=Averaging time= 75*365 d

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IR= *Inhalation Rate=0.633 m³/h*

ET=Exposure time=24 h/d

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BW=Body Weight= 78 kgs

AT=Averaging time=75 ×365 d

$$CDI = \frac{10 \times 0.633 \times 24 \times 365 \times 60}{78 \times 75 \times 365}$$

= 1.55814 *μg/kg-d*

=1.55814×10⁻³*mg/kg-d*

If SF=3×10⁻²*kg-d/mg*
Risk=CDI×SF
   = 1.55814×10⁻³*mg/kg-d* × 3×10⁻²*kg-d/mg*
   = 4.67×10⁻⁵

If Risk is less 10⁻⁴, then its fine according to the USEPA

Example 2

- A chemical compound exists in water distributed by a locality. This water is main source for drinking, showering and swimming.
  - Pathways
    - Drinking
    - Showering
    - Swimming: Ingestion and dermal contact
    - Inhalation
  - Formulae
  - Inputs with correct units
  - CDI_{Dri}, CDI_{Show}, CDI_{Swi}, CDI_{Inh}
  - $CDI = CDI_{Dri} + CDI_{Show} + CDI_{Swi} + CDI_{Inh}$
  - $Risk = CDI*SF$