CVL 100: Risk Assessment

Is the chemical released by industry toxic?

- Hazard implies a probability of adverse effects in a particular situation.
- Risk is a measure of the probability.
  - Examples: Risk of tornadoes, hurricanes, floods, droughts, landslides, forest fires & chemicals released to environment.

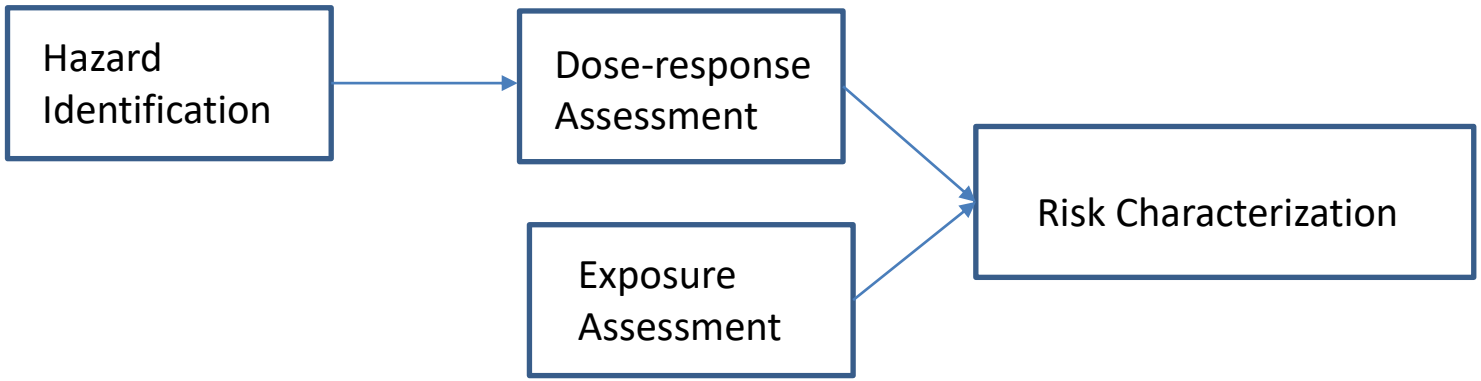
Life time and Annual Risk

- The life time risk of death from all causes is 100%
- If there are 1 million deaths per year, and of these 25000 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?

In 2019

- Population=136,00,00,000
- Deaths=10,00,000
- Deaths due to cancer=1,000
- Lifetime Risk of dying due to cancer=$\frac{1000}{1000000}$=1e-4
- Annual risk (If life expectancy is 70 years)= $\frac{1e-4}{70}$

Risk Assessment

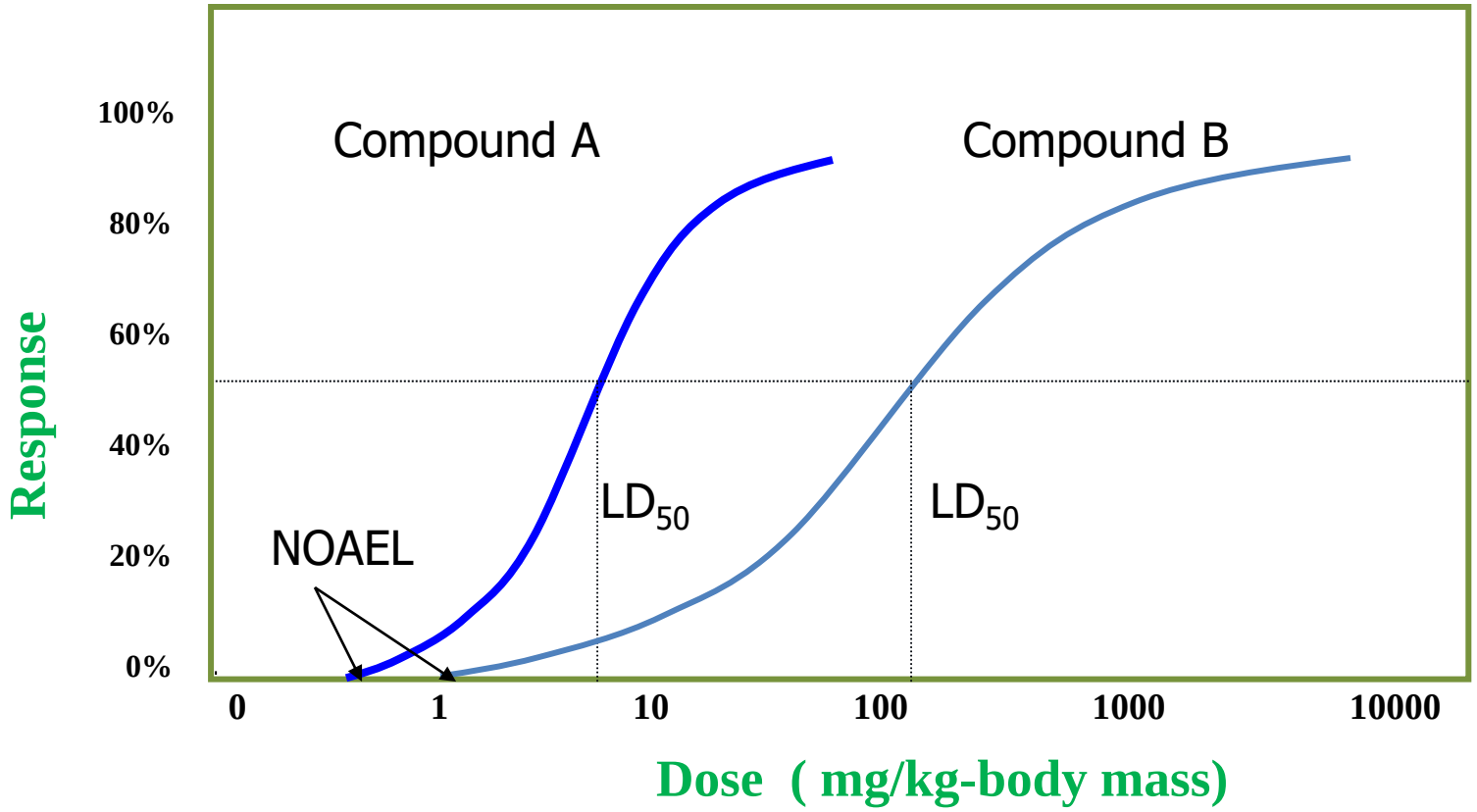


Steps

- 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

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

$$Risk = CDI \times SF$$

where ABS = absorption factor for soil contaminant (unitless)
AD = absorbed dose (in mg · kg^{-1} · day^{-1})
AF = soil-to-skin adherence factor (in mg · cm^{-2})
AT = averaging time (in days)
BW = body weight (in kg)
CA = contaminant concentration in air (in mg · m^{-3})
CDI = chronic daily intake (in mg · kg^{-1} · day^{-1})
CF = volumetric conversion factor for water = 1 L · 1000 cm^{-3}
= conversion factor for soil = 10^{-6} kg · mg^{-1}
CR = contact rate (in L · h^{-1})
CS = chemical concentration in soil (in mg · kg^{-1})
CW = chemical concentration in water (in mg · L^{-1})
ED = exposure duration (in years)
EF = exposure frequency (in days · year^{-1} or events · year^{-1})
ET = exposure time (h · day^{-1} or h · event^{-1})
FI = fraction ingested (unitless)
IR = ingestion rate (in L · day^{-1} or mg soil · day^{-1} or kg · meal^{-1})
= inhalation rate (in m^3 · h^{-1})
PC = chemical-specific dermal permeability constant (in cm · h^{-1})
SA = skin surface area available for contact (in cm^2)

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' .

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

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

= 1.55814 *µg/kg-d*

$=1.55814\times10^{-3}$ *mg/kg-d*

If SF=3×10^{-2} *kg-d/mg*

Risk=CDI×SF

$= 1.55814\times10^{-3}$ *mg/kg-d* $\times\ 3\times10^{-2}$ *kg-d/mg*

$= 4.67\times10^{-5}$

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