M-F1 Toxicology 101: Using Toxicological Information in Emergency Response

Monday 8:00-10:00am

Karen Riveles, Office of Environmental Health Hazard Assessment (OEHHA), CalEPA

March 20, 2023

www.calcupa.org

25th California Unified Program Annual Training Conference
March 20 – 23, 2023

Overview

- Introduction to Toxicology-the basics
- Human Health Risk Assessment and the development of Health Guidance Values
- Application of toxicological information in cleanup decisions during and after a hazardous materials release
- Next Steps and Current Efforts

Introduction
What is Toxicology?

"What is there that is not poison? All things are poison and nothing without poison. Solely the dose determines a thing is not a poison."

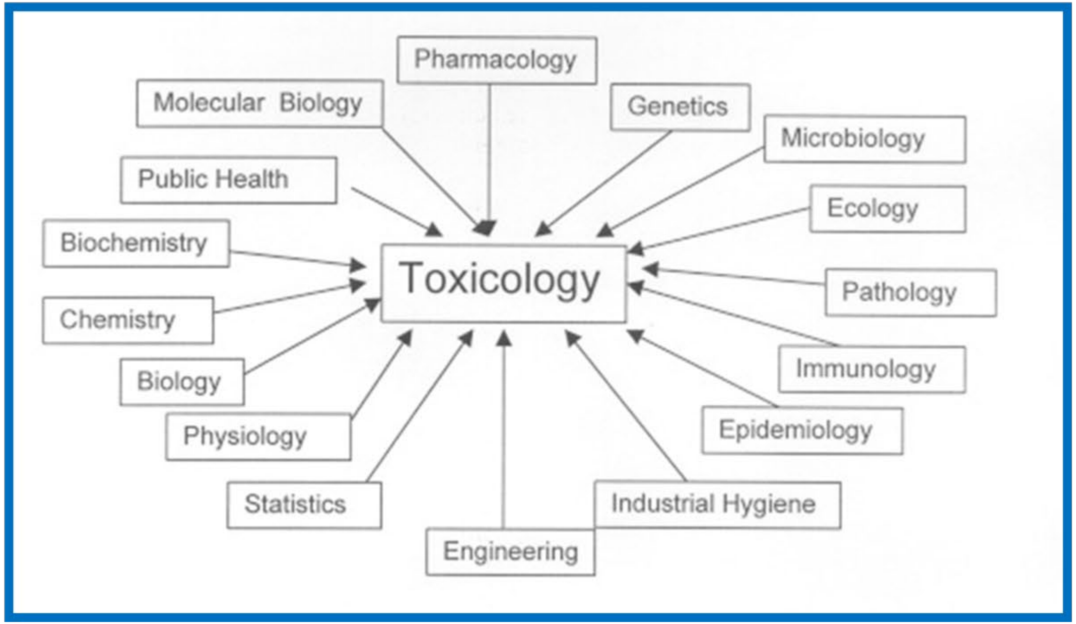
Paracelsus

1500 AD

(from: Philosophia Magna

Brickmann, Cologne, 1567)

Toxicology is Multidisciplinary



Toxicologist: Qualifications, Courses, Universities & Scope - Leverage Edu

Environmental Toxicology

Environmental Toxicology studies the effects of chemicals on man and the environment, it is the combination of toxicology and environmental chemistry

Regulatory Toxicologist:

- Gathers and evaluates existing toxicological information to establish concentration-based standards of "safe" exposure
- Uses body of information to assess risk to human health and the environment

Toxicologists:

May study toxicology by organ system

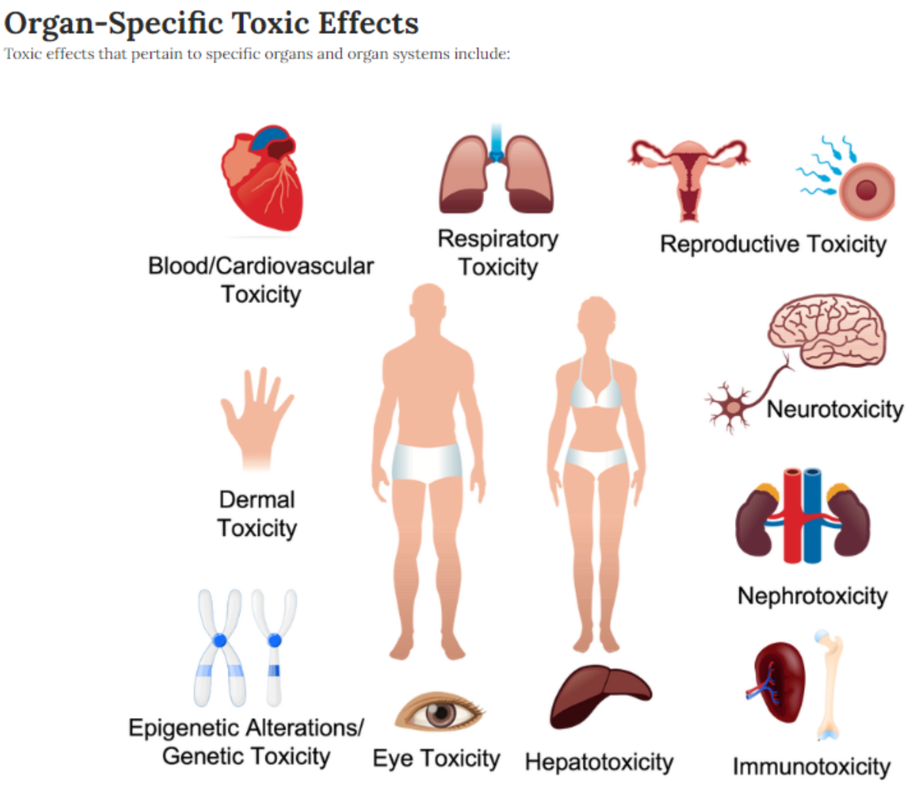


Figure 1. Organ-specific toxic effects pertain to specific organs and organ systems

(Image Source: Adapted from iStock Photos, ©)

[Welcome to ToxTutor - Toxicology MSDT (toxmsdt.com)](toxmsdt.com)

Toxicology Basics

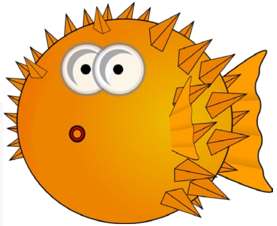
Three elements of toxicology:

1. Toxic agent
2. Biological system
3. Interaction between the toxic agent and the biological system

Toxicant vs. Toxin

Toxicant: <u>Man-made substances</u> producing adverse biological effects

Toxin: Small molecules produced by living organisms, includes poisons and venoms



Exposure to Toxic Substances

1. Route of exposure: How a toxic substance gets in the body

   a. Inhalation

   b. Ingestion

   c. Dermal

   d. Injection

Learn more about Exposure Assessment
Next Class:
M-F2 Introduction to Exposure Assessment
with Case Studies
Monday 10:00-11:45am

CALIFORNIA CUPA FORUM

Exposure to Toxic Substances

2. Duration: Length of exposure
   Often dependent on study parameters

3. Frequency: How often one is exposed over time
   a. Examples: Acute, 8-hour, Chronic
   b. Used for time-adjustment step (more later)

Toxicology Terms: Dose and Effect

These factors determine the "dose" of the chemical:

- The extent of the effect is dependent upon the concentration of the active compound at the site of action over time
  - Some compounds may require bioactivation:
    - Where the parent compounds are converted to reactive metabolites by enzymes in the body

How a chemical enters the body and exerts its toxic effect:

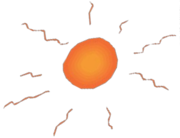
- Toxico-kinetics: Kinetics = movement in body
  - a toxin or poison enters the body and reaches a target tissue/organ/site
  - Absorption, distribution, metabolism, and excretion (ADME)
- Toxico-dynamics:
  - Toxico-dynamics describes what happens to that tissue once the toxicant reaches an effective dose.

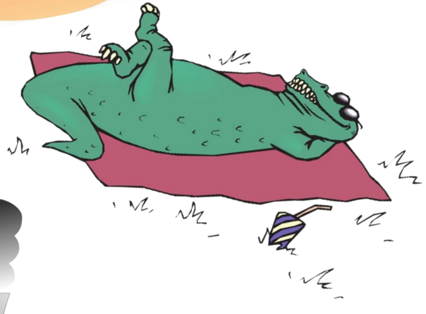
What is Risk?

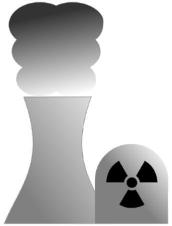
Exposure + Hazard = RISK

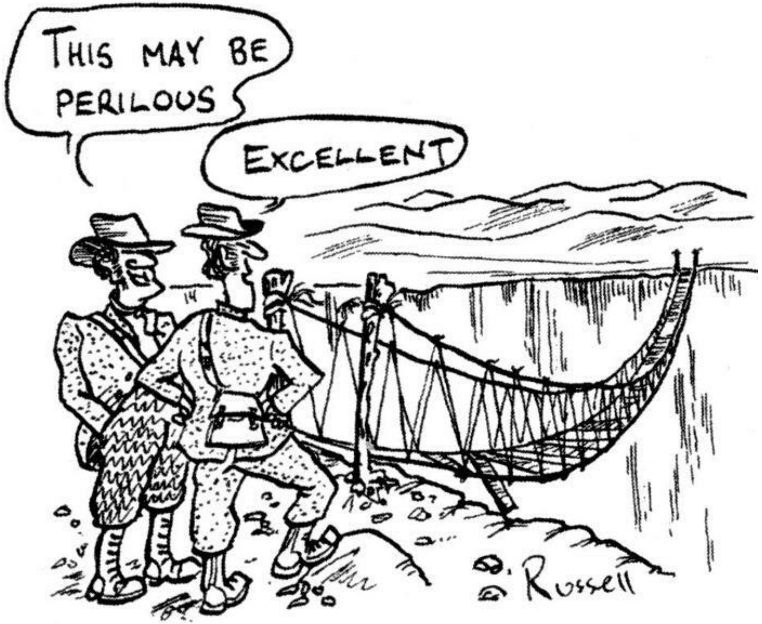
When Fonzie Jumped the Shark on 'Happy Days' | Mental Floss

But what is an acceptable risk? = Risk Perception





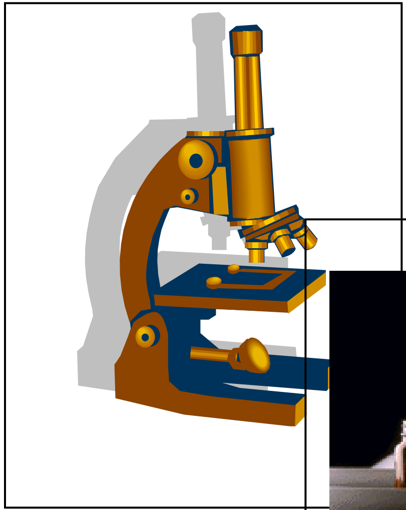




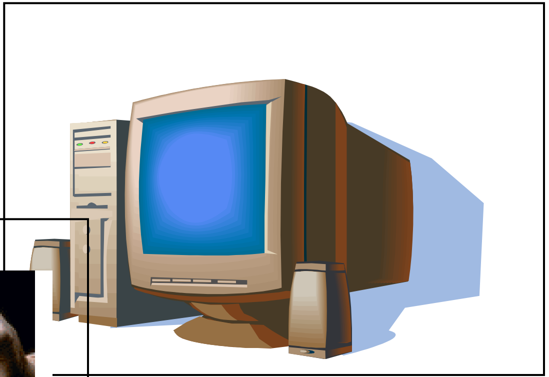
What is Health Risk Assessment?

- The characterization of the potential adverse health effects of human exposures to environmental hazards (NAS 1983)

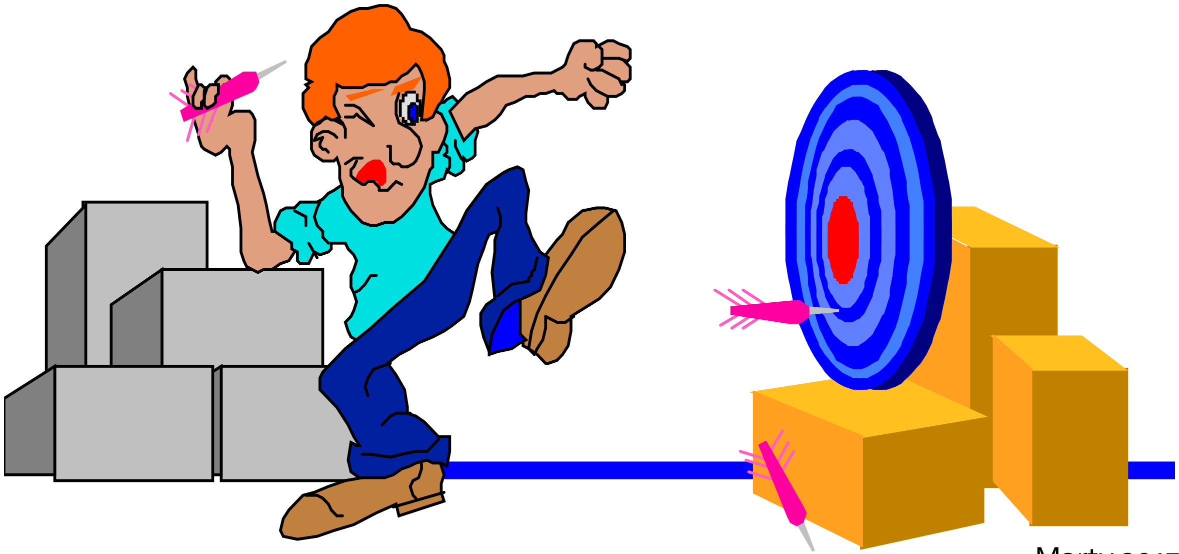
Perceptions of Risk Assessment Process



Marty 2017



Reality of Risk Assessment Process



Marty 2017

Risk Assessment

What data are you using?

What's your key study?

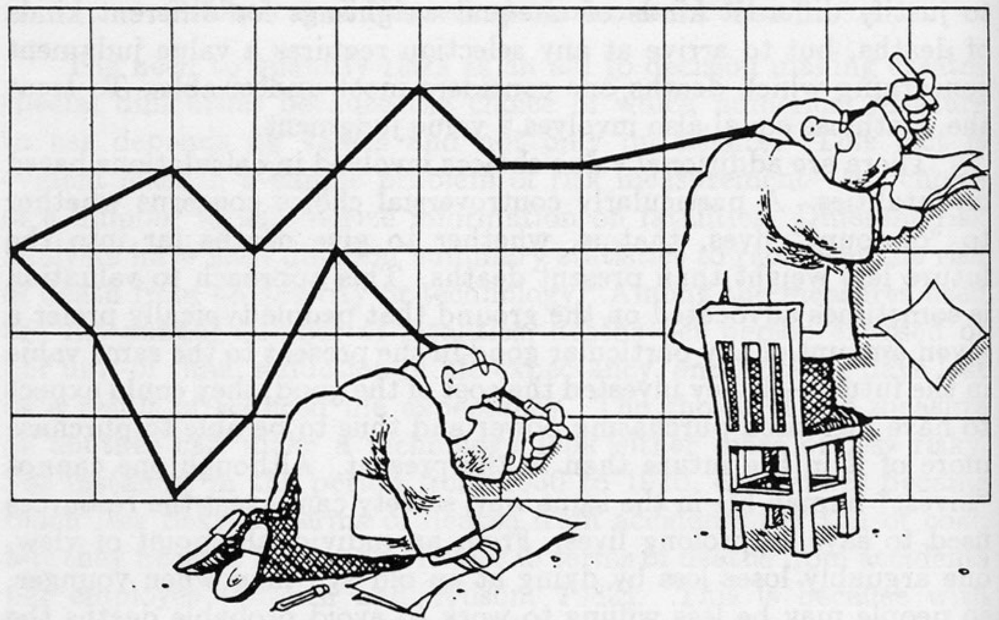


FIGURE 2.3 SOURCE: *National Wildlife Magazine*, August–September, 1984.

CALIFORNIA CUPA FORUM

Why Risk Assessment?

- Is there a problem with exposure to environmental chemical(s)?
- Need to characterize the nature and magnitude of health risks to humans
  - e.g., residents, workers, children
- Typically, only evaluating one chemical at a time

CALIFORNIA CUPA FORUM

Common Types of Human Health Risk Assessment

"Chemical-Specific Risk Assessments"

- **Applies the 4 steps of Risk Assessment to a single chemical**
- **OEHHA performs this type.**

"Site-specific risk assessment"

- **Applies the 4 steps to specific locations or scenarios**
- **US EPA and DTSC, local organizations, OEHHA typically only reviews these types.**

"Ecological Risk Assessment"

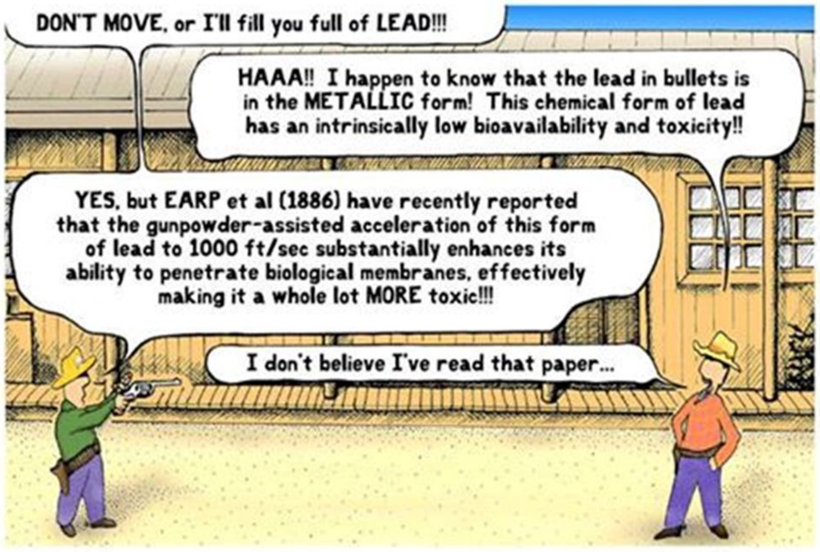
- **Impacts and effects on environmental endpoints**
  - **US EPA, DTSC, CDFW, CEQA-related, local organizations.**

Steps of the Risk Assessment Process

1. Hazard Identification
2. Dose/Response analysis/assessment
3. Exposure assessment
4. Risk characterization

Step 1: Hazard Identification

- The process of determining what adverse effects are caused by exposure to an agent
- Regulatory agencies typically do not conduct experiments to determine types of toxicity, but rather synthesize existing information



ENVIRONMENTAL TOXICOLOGIST IN THE WILD WEST

Hazard Identification

- Gathering and evaluating toxicological information about chemical in question
- What toxicological effects does the chemical cause?
- Is human data available?
- Is animal data adequate to allow extrapolation to possible human effects?

Steps in Hazard Identification

Conduct literature search of chemical (all data types)

↓

Review data to understand health effect caused by the chemical

↓

Use weight of evidence approach to identify toxic effects caused by chemical

↓

Identify critical biological endpoints to focus risk assessment

↓

Feed information into Dose-Response Assessment

CALIFORNIA CUPA FORUM

What Information is used for a Toxicology Review of a Chemical

- Reviewing the Toxicology of chemicals may include:
  - Update of physical and chemical properties
  - Sources, uses, environmental disposition
  - Human health studies (epidemiology, occupational, other)
    - Infants and children
  - Animal studies (acute, subchronic, chronic)
    - Early life-stage
  - Documentation of key studies, points of departure; time or dose adjustments; use of safety/uncertainty factors
  - Review of other relevant toxicological information (reproductive and developmental effects, in vitro studies, new toxicological screening methods

Animal Studies

- Hazard identification and risk assessments have largely relied on data from traditional toxicological studies using animal models
  - High Cost
  - Chronic studies –2 years
  - Test one chemical at a time, sometimes mixtures
  - Slow Process to get data on all chemicals
  - Need to identify most sensitive species

Acute Toxicity Studies

- Can be useful to identify hazards from **high shorter-term exposures**
- Usually have acute animal toxicity studies, a few occupational human studies are available
- Such studies involve airborne exposure to a chemical for short period of time and observation of the animals over a week or two, sometimes longer
- Lethal dose studies (LD50) are not typically used:
    - Endpoint is not most sensitive effect, it's lethality in half the study population.

Types of Toxicological Endpoints - Noncancer

- Typically have toxicity data from animal studies measuring effects on specific organ systems
  - Need to consider all organ systems in hazard identification
- Look across the available database for:
  - Most sensitive effects (occurring at lowest doses)
  - Most sensitive species
  - Specific life-stage (infants, children, adults, elderly)

https://www.searchenginejournal.com/free-data-sources/302601/

Cancer Hazard vs Cancer Risk

Cancer hazard: an agent (e.g., a chemical) that is capable of causing cancer

- Hazard identification
- Not a quantitative risk estimate

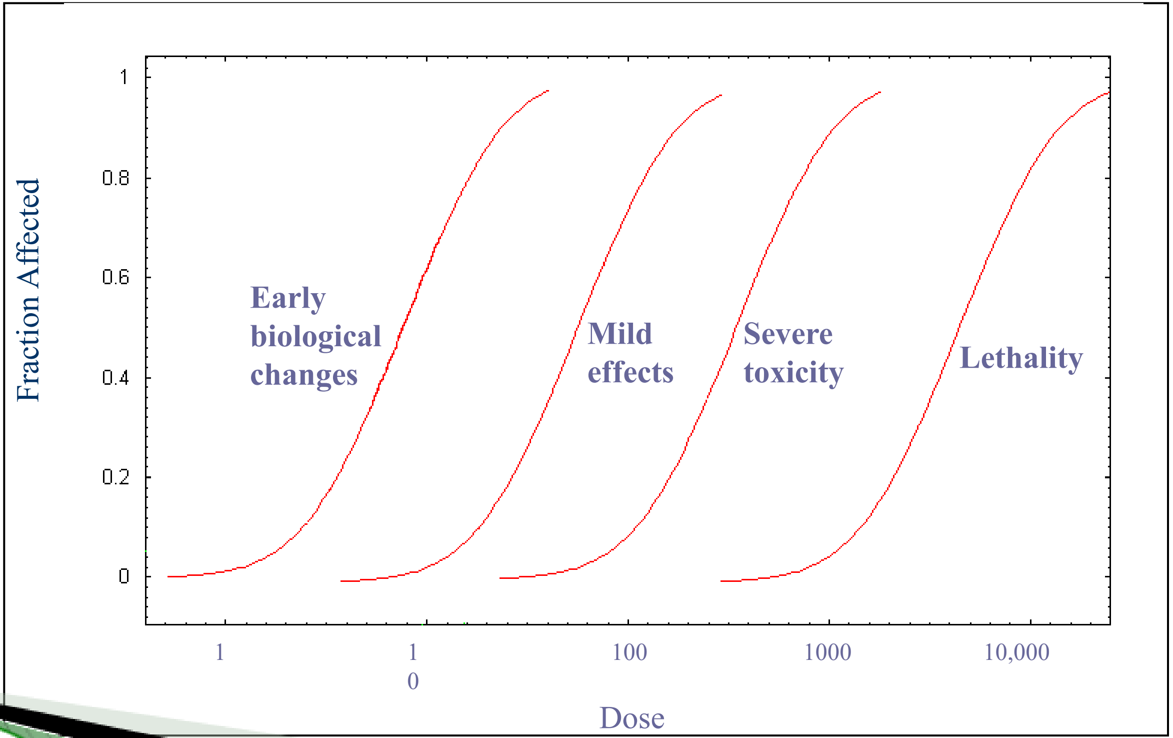
Cancer risk: a quantitative estimate of the risk of carcinogenic effects (cancer) from exposure to a cancer hazard

- Dose-response assessment and exposure assessment combined to get cancer risk

Cancer Hazard Identification at OEHHA
(Office of Environmental Health Hazard Assessment)

Program within OEHHA	Chemicals	Cancer Potency Values
Proposition 65 (Safe Drinking Water and Toxic Enforcement Act of 1986) Program	List of chemicals known to the State of California as causing cancer	No Significant Risk Level (NSRL)
Toxic Air Contaminant Program	Toxic Air Contaminants	Cancer Slope Factors
Drinking Water Contaminant Program	Drinking Water Contaminants	Public Health Goal (PHG)

Multiple effects: Selection of critical effect



A Note About Choosing a Critical Biological Effect:

- Many Risk Assessments look at the <u>most sensitive</u> critical effect
  - Occurring at lowest dose in the most sensitive species

- This may not hold true for chemical evaluation for:
  - Cleanup Goals
  - CalARP
  - Emergency Response
  - Worst-Case-Scenario
  - Off-Site Consequence Analysis

Step 2: Dose-Response Assessment

Intake x Toxicity = Risk

Often must extrapolate from animal studies

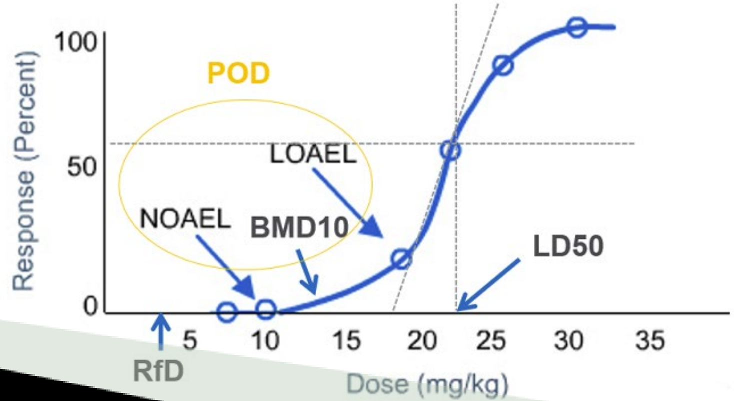
Two important assumptions:

1. Threshold for non-cancer
2. No threshold for cancer

Points of Departure (POD) for Dose-Response Assessment

- The Point of Departure (POD) is the starting point
  - In terms of either an exposure (e.g., mg/m³ of air, mg/L of water) or A dose (e.g., mg/kg-day)
  - From a study to extrapolate to a **Health Guidance Value** (e.g. Reference Dose (RfD) or Concentration)
- Following the Hazard Identification step, you identify best study(ies) and then the **dose** from the study to use as the POD.

•NOAEL: no observed adverse effect level
•LOAEL: lowest observed adverse effect level
•BMD – Benchmark Dose



CALIFORNIA CUPA FORUM

Additional Adjustments

- <u>Study Duration</u>: Generally, use an acute study for acute value and chronic study for chronic value.
  - Chronic exposures <u>not</u> appropriate for acute estimation and vice a versa.
  - Can use a subchronic study for a chronic estimation but then need to use the Subchronic Uncertainty Factor (UFs).

- <u>Dose Adjustment</u>: Change from an administered dose to an internal dose. Account for (Inter) animal to human and (Intra) variation between humans.

- <u>Time Adjustment</u>: Extrapolate from experimental exposure (number of hours and days in the study) to relevant exposure for Health Guidance Value)

Step 3: Exposure Assessment

- The process of quantifying the amount of exposure to an environmental chemical humans receive from a single or multiple media
- Exposures are assessed for:
  - Maximum exposed individual
  - Average population exposure
  - Subsets of the population (sensitive subpopulations)

Learn more about Exposure Assessment Next Class:
M-F2 Introduction to Exposure Assessment with Case Studies: Monday 10:00-11:45am

Step 4: Risk Characterization

The process of combining the first three steps of risk assessment into a coherent picture describing the risks of exposure to the chemical(s) in question

- Combines dose-response and exposure assessment in a quantitative fashion and includes discussion of major uncertainties
    - Interspecies, Intraspecies, Sub-chronic, Data deficiencies, LOAEL
- Can be relatively simple or complex and apply to a single chemical or a specific site
    - e.g., nitrate, a drinking water contaminant that causes methemoglobinemia in infants
    - Multiple chemicals in multiple media emitted from industrial facilities or a contaminated site.

Example: 8-hour OEHHA REL for Mercury

Study	Human workers
Exposure	Inhalation
Expo Dur	8 h/d, 5 d/wk, >13 yr
Crit Effect	Neurobehavior
LOAEL	25 $\mu g/m^3$
NOAEL	n/o
Time adj	18 $\mu g/m^3$ (25*5/7)
HEC	n/a human study
LOAEL UF	10 severe –NOAEL
SubCh UF	1

Subchronic UF	1
Interspecies	
UF A-k	1 default human
UF A-d	1 default human
Intraspecies	
UF H-k	√10 default
UF H-d	10 – dev. neurotox
Cum UF	300
8-Hour	18 $\mu g/m^3$/300
REL	**0.06 $\mu g/m^3$**

Risk Characterization: Noncancer Endpoints Hazard Index Approach

- For air emissions, Modeled Ground Level Concentrations (GLC) in air divided by / REL for appropriate averaging time (acute or chronic). For Example, **Hazard Quotient = [air conc]/REL**
- For other media, e.g., water, soil, and plants, you would calculate HQ and HI using Reference Doses. For example, HQ = Dose/RfD
- **HQ1 + HQ2 +…HQn = Hazard Index**
- When estimating noncancer hazard from a single chemical, HQ = HI

Risk Characterization: Noncancer

- Hazard Index for noncancer effects by target organ.
- Additivity - We assume that the effects on the target organ from different chemicals that induce toxic effects in that organ are additive.
- This has some support from scientific investigations of low doses in animal models
- May not hold true for higher exposures, but overall, appears to be a reasonable assumption.
- Include: Key studies and toxicological endpoints observed, critical effects of chemicals being analyzed, dose-response info, uncertainties, and data gaps. Exposure information: Sources, pathways, susceptible individuals, average and high-end exposures (quantitative).

Risk Characterization for Carcinogens: Cancer Risk

- We use cancer potency factors to estimate cancer risk
- **Cancer Risk = Exposure X Potency**
- Where exposure is in units of concentration or dose (y)
- Potency is in inverse units of concentration or dose (z)
- Risk = y µg/m3 x z (µg/m3)-1
- Estimated cancer risk for given exposures
- To account for increased sensitivity to carcinogens in early life, the lifetime cancer risk is calculated for segments of the lifespan and then added together. Cancer Risk = ∑ [expi x ASFi x CPF]
- ASF is the Age Sensitivity Factor: Where "i" is the age groups 3rd trimester (10), birth to <2 yrs (10), 2 yrs < 16 yrs (3), and 16-70 yrs.

CALIFORNIA CUPA FORUM

Risk Characterization for Carcinogens: Cancer Risk

- When assessing cancer risk for multiple carcinogens, assumption is the risk is additive (regardless of target organ)
- Total Cancer Risk = $CR_1 + CR_2 + \ldots CR_n$
- Commonly done for site-specific risk assessments where you have more than one carcinogen and/or more than one route of exposure.
- Some considerations:
  - Risk values are upper bound estimates for an exposed population.
  - Estimates are believed to be health conservative.
  - Do not predict risk for a specified individual.
  - Risk estimates for multiple carcinogenic exposures usually considered additive.
  - Procedures address risk for whole life: very short-term exposures cannot be evaluated accurately.

Coming up:

- Risk Characterization Calculation Examples
- Risk Characterization vs. Risk Management
- OEHHA's Role in Emergency Role
- Combining Toxicology, Emergency Response, and Cleanup Decisions

BREAK TIME!

Example 1. Let's look at a simple example of a facility emitting 4 chemicals to calculate a noncancer Hazard Index and Cancer Risk

Chemical	Annual average concentration ($\mu g/m^3$)	Chronic REL	Cancer Slope Factor
mercury	0.003	0.03	n/a
manganese	0.045	0.09	n/a
methylene chloride	100	400	1×10^{-6}
benzene	30	60	3×10^{-5}

The risk characterization addresses all the emissions quantified for the facility.
Would assess neurotoxicity from emissions and cancer risk for the carcinogens.

Hazard Index for chronic exposure - nervous system Noncancer

Hazard Quotient (HQ) = annual average exposure/chronic REL

- Mercury HQ = 0.003/0.03 = 0.1
- Manganese HQ = 0.045/0.09 = 0.5
- Methylene chloride = 100/400 = 0.25
- Benzene = 30/60 = 0.5

Chronic **Hazard Index** for neurotoxicity = sum of HQ =

0.1 + 0.5 + 0.25 + 0.5 = 1.35

HI > 1 may indicate need for risk management.

Example 1. Let's look at a simple example of a facility emitting 4 chemicals to calculate a noncancer Hazard Index and Cancer Risk

Chemical	Annual average concentration (μg/m³)	Chronic REL	Cancer Slope Factor
mercury	0.003	0.03	n/a
manganese	0.045	0.09	n/a
methylene chloride	100	400	1×10^{-6}
benzene	30	60	3×10^{-5}

The risk characterization addresses all the emissions quantified for the facility. Would assess neurotoxicity from emissions and cancer risk for the carcinogens.

Example 1. Total Cancer Risk from Facility Emissions

Cancer Risk =

For Methylene chloride

100 ug/m3 x 1 x 10-6 (ug/m3)-1= 1 x 10-4

For Benzene

30 ug/m3 x 3 x 10-5 (ug/m3)-1= 9 x 10-4

Total cancer risk = sum of cancer risk=

(1 x 10-4) + (9 x 10-4) = 1.0 x 10-3

1 excess case of cancer per 1000

Acceptable risk levels are a "societal" decision

"de minimis" risk is thought of as 10-6 (one cancer per million people exposed) above background.

Prop 65 "acceptable risk" is 10-5 or one in 100,000 persons exposed

Regulatory agencies may take action, if feasible, if cancer risk >10-4 to > 10-6, depending on feasibility/cost and program

Example 2. Different target organs and acute and chronic Reference Exposure Levels (RELs)

Chemical	Acute REL (ug/m³)	1 hour max concentration (ug/m³)	Chronic REL (ug/m³)	Annualized average concentration (ug/m³)
Acetaldehyde - respiratory	470	47	140	14
Acrolein - respiratory	2.5	2.5	0.35	0.7
Carbon tetrachloride – liver; developmental	1900	190	40	20
Chloroform – liver; developmental	150	15	300	3

Example 2. Acute vs Chronic by System Hazard Index

Acute HI for respiratory =

1 hr maximum/acute REL

Acetaldehyde HQ = 47/470 = 0.1

Acrolein HQ= 2.5/2.5 = 1

Acute HI for respiratory = 0.1 + 1 = **1.1**

Chronic HI = annual average/chronic REL

Acetaldehyde HQ - 14/140 = 0.1

Acrolein HQ = 0.7/0.35 = 2

Chronic HI for respiratory = 0.1 + 2 = **2.1**

Chronic HI for liver =

Carbon tetrachloride HQ = 190/1900 – 0.1

Chloroform HQ = 15/150 = 0.1

Chronic HI = 0.1 + 0.1 = **0.2**

Acute HI for liver =

Carbon tetrachloride HQ = 20/40 = 0.5

Chloroform HQ = 3/300 = 0.01

Acute HI = 0.5 + 0.01 = **0.51**

HI > 1 may indicate need for risk management.

Example 3. Cancer Risk of Arsenic in Drinking Water

Hazard ID: Arsenic causes lung, bladder and skin cancer in humans from oral and inhalation exposure

Exposure: CA average

2 µg/L in water x 2 L water per day / 70 kg = 0.06 µg/kg - day

Dose-Response: Cancer Slope Factor for Arsenic = **0.0015 (µg/kg-d)-1**

Cancer Risk = 0.06 µg/kg x 0.0015 (µg/kg-day)-1

= 0.00009 = **9 x 10-5 (or, 9 per 100,000 exposed)**

Considering infants and children

Use age-appropriate intake rates

Apply Age Sensitivity Factors to early life exposures

Cancer risk would be about 3-fold higher

Example 4. Cancer Risk of Diesel Exhaust from a Railyard

Hazard ID – diesel engine emissions

Dose-Response – Cancer slope factor = 3×10^{-4} $(\mu g/m^3)^{-1}$

Exposure – upwards of 15 $\mu g/m^3$

Cancer Risk = 15 $\mu g/m^3$ x 3×10^{-4} $(\mu g/m^3)^{-1}$

= **4.5×10^{-3}**

Human data on lung cancer in workers; some uncertainty in exposure assessment for studies

How Do The Risk Characterization Results Get Used?

- Risk managers at federal, state, and local agencies use the results to inform them of actions they need to take
- Various agencies have policies about how much risk is acceptable
- Sometimes can't do much, e.g., for naturally occurring contaminants that are difficult to remove (arsenic is an example) or if background ambient levels high.

Risk Management Overview

- Risk Managers at other regulatory agencies work with risk assessors to identify risks of exposures, either regional or facility (site)-specific
- Identify stakeholders and options for mitigating the risk; can include ascertaining public acceptability
- Determine standard of risk to be met
- Consider costs and feasibility of mitigating risk
  - How much can the emissions or contamination be reduced?
  - Is there a reasonable reduction in risk for the cost?
  - Decide whether and what risk reduction efforts are needed

Office of Environmental Health Hazard Assessment (OEHHA's) Mission

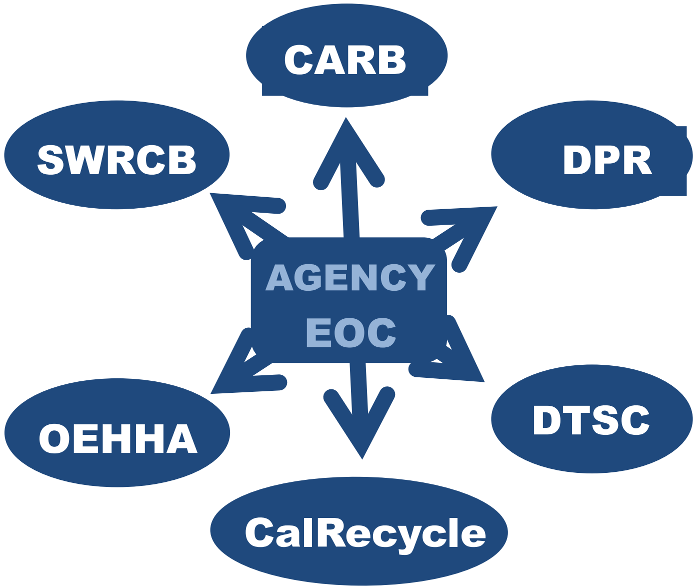
To protect and enhance public health and the environment by scientific evaluation of risks posed by hazardous substances.

In an Emergency OEHHA will assist responders in assessing health effects and characterizing risk to public health and the environment from toxic chemical releases in the environment.

OEHHA works closely with local, state, federal and tribal entities including public health agencies, environmental health departments, CUPAs, and local air districts.

CalEPA's Emergency Response Management Committee (ERMaC)

- OEHHA is a part of the California Environmental Protection Agency (CalEPA).
- ERMaC facilitates interagency coordination for CalEPA, its Boards, Departments, and Offices and partner agencies and leads ESF-10 for CA
  - California Air Resources Board
  - CalRecycle
  - Department of Pesticide Regulation
  - Department of Toxic Substances Control
  - Office of Environmental Health Hazard Assessment
  - State & Regional Water Resources Control Boards (WaterBoards)



Partners:
- CDFW/OSPR
- CDPH
- US EPA
- CalOES
- CDFA

OEHHA's Emergency Functions

- Provides toxicologists, research scientists, and subject matter experts
- Assesses health effects and characterizes risk
- Provides toxicological information, risk assessment and public health recommendations
- Assists in decision making on cleanup goals for public health protection
- Determines human health and environmental impacts of chemicals
- Reviews sampling data and provides recommendations
- Provides seafood safety assessments relating to oil spills and high levels of toxic substances

OEHHA does NOT…

- Have laboratory services
- Provide certifications of clean, safe, or free of health concerns
- Have enforcement activities
- Perform cleanup activities
- We do not perform health assessments; we perform human health risk assessments.
- We can assist with recommendations based on health risk but <u>do not make risk management decisions.</u>

CALIFORNIA CUPA FORUM

Types of Emergencies: Hazmat and Oil Spill

Examples of emergencies that can cause the uncontrolled release of hazardous material:

- Transportation accidents on railways, highways, or waterways
- Destabilization of storage facilities, containers, or infrastructure
  - Accidental Release
  - Natural disasters such as earthquakes, flooding, tornados, hurricanes, and wildfires
- Industrial accidents, fires, and explosions
- Oil spills from marine, pipeline, refinery or storage tank accidents
- Illegal and terrorist activities designed to disperse highly toxic chemicals.
- Contaminated facilities, residences, sites

So many Health Guidance Values, so little time…

MCLs

AEGLS

RELs

TEELS

IDLH

ERPGS

RSLs

CALIFORNIA CUPA FORUM

Emergency Exposure Levels

- Accidents are unpredictable and may release high concentrations of chemicals into the air.
- Emergency exposure levels help emergency responders evaluate the immediate dangers from chemical release.
- May be applied in scenarios in which high concentrations of chemicals are measured or estimated in the air.
- Many Health Guidance Values are not "designed" for emergencies but can still inform us about concentrations at which no health effects are anticipated and include extra protections for sensitive subpopulations.

Using Health Guidance Values during emergency response for decision-making

- Is the Health Guidance Value for acute or chronic health effects
- Does the value represent "no anticipated health effects", "mild-reversible health effects", "severe health effects", immediately dangerous to life and health (lethality)"
- The Health Guidance Value may represent your point of departure, but may need to include:
  - Cost and Feasibility
  - Public Acceptance
  - Level of detection
  - Background levels (e.g. in ambient air)
  - Naturally occurring contaminants or contaminants from other sources

Emergency Exposure Value	Acronym	Developed by
Acute Exposure Guideline Level	AEGL	United States Environmental Protection Agency
Emergency Response Planning Guideline	ERPG	American Industrial Hygiene Association
Immediately Dangerous to Life and Health	IDLH	National Institute of Occupational Safety & Health
Temporary Emergency Exposure Level	TEEL	United States Department of Energy

Emergency Exposure Levels

- **AEGL:**
  - Describe human health effects from once-in-a-lifetime, or rare, exposure to airborne chemicals: 10 mins, 30 mins, 1 hour, 4 hours, or 8 hours.
  - Used by emergency responders when dealing with chemical spills or other catastrophic exposures
- **ERPG**
  - Estimates the concentrations at which most people will begin to experience health effects if they are exposed to a hazardous airborne chemical for 1 hour
- **IDLH:**
  - Characterize high-risk exposure concentrations and conditions and are used as a component of respirator selection criteria (30-min)
- **TEEL:**
  - Designed to predict the response of members of the general public to different concentrations of a chemical during an emergency response incident

Occupational Exposure Limits

May not be suitable for ER

- **Permissible Exposure Limit (PEL)**
  - The maximum amount or concentration of a chemical that a worker may be exposed to under regulations.
- **Threshold Limit Value (TLV)**
  - The airborne concentrations of chemical substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed, day after day, over a **working lifetime**, without adverse effects.

- Defined as the time-weighted average concentration of a contaminant, measured that is considered to be safe for the majority of **healthy workers**, for an 8-hour work shift and a **40-hour work week, and entire work lifetime.**
- Values set to prevent occupational diseases or other adverse effects in workers exposed to hazardous chemicals in the workplace.
- Used to help employers protect the health of workers who may be exposed to chemicals in the working environment.

NIOSH REL Time-Weighted Average (TWA)

A time-weighted average concentration for up to a 10-hour workday during a 40-hour workweek.

Short-term Exposure Limit (STEL)

A 15-minute TWA exposure that should not be exceeded at any time during a workday.

Ceiling Limit (CEIL)

The maximum exposure limit, which cannot be exceeded for any length of time

OEHHA Reference Exposure Levels (RELs)

Documentation: http://oehha.ca.gov/air/allrels.html

Acute 1-hour RELs: The concentration level at or below which, no adverse health effects are anticipated for specified exposure duration. Exposure averaging time for acute RELs is 1 hour. Includes a margin of safety to protect sensitive subpopulations including infants and children.

Health Guidance Values versus Cleanup Values or Goals

- OEHHA develops Health Guidance values for noncancer and cancer risk
- OEHHA does not develop cleanup values but can assist in decision-making with local, State, and Federal agencies "after" a hazardous materials release.
  - The following information on California Human Health Screening Levels is provided for **historical purposes only. For chemical-specific screening levels for use in assessing contaminated sites, please refer to HHRA Note 3 (DTSC HERO)**
  - California Human Health Screening Levels (CHHSLs) are concentrations of chemicals in soil or soil-gas below thresholds of concern for risks to human health—specifically, an excess lifetime cancer risk of one-in-a-million (10-6) and a hazard quotient of 1.0 for non-cancer health effects. The CHHSLs were developed by OEHHA on behalf of the California Environmental Protection Agency, pursuant to Health and Safety Code Section 57008.
  - The CHHSLs have no regulatory effect and are not intended for use by regulatory agencies that have authority to require remediation of contaminated soil.

Health Guidance Values versus Cleanup Values or Goals

[OEHHA Risk Fact Sheet (ca.gov)]

Cancer Risk and Noncancer Hazard Index

Fact Sheet for Contaminated Sites in California

November 2020

Chemical contamination in soil or groundwater has the potential to harm the health of people living or working in or near contaminated areas. This fact sheet explains some terms and processes commonly used to evaluate the health threats that people may face from exposure to the contaminants.

What is cancer risk?

Cancer risk is the likelihood that a person will develop cancer. A person's cancer risk may be increased due to exposure to a chemical contaminant from a site. Cancer risk also depends on other factors, such as a person's diet, lifestyle, and genetic background.

For contaminated sites, the cancer risk estimate describes the extra risk a person may face from exposure to contaminants found at the site. The cancer risk estimate does not include a person's background risk, which is the risk a person faces of developing cancer due to other causes.

The cancer risk is expressed in terms of a person's chance of developing cancer over a lifetime from exposure to a chemical contaminant. If a person is exposed to multiple cancer-causing chemicals from a site, the risk from each chemical is added up to calculate the person's cumulative cancer risk.

According to state and federal guidance on contaminated sites, a cancer risk that is at or below 1 chance in a million (or 1×10^{-6}) is not a public health concern. This means that no more than one person in a population of one million people exposed to the same level of chemical contaminant(s) at the site would develop cancer over a lifetime.

On the other hand, based on this same guidance, a cancer risk above 1 chance in 10,000 (or 1×10^{-4}) is generally unacceptable. This means that more than one person out of 10,000 people with the same exposure would develop cancer over a lifetime. When the risk lies in between these two figures (1×10^{-6} and 1×10^{-4}), state regulators consider a variety of factors at the site to determine whether the risk should be reduced.

What about health impacts other than cancer?

Harmful health effects other than cancer can result from exposures to chemicals from a contaminated site. These effects are evaluated separately from cancer. A noncancer **hazard quotient** signals whether such chronic health effects are likely from exposure to one chemical. If there are exposures to multiple chemicals, the hazard quotient for each chemical is added up to calculate a **hazard index**.

Health Guidance Values versus Cleanup Values or Goals

[OEHHA Risk Fact Sheet (ca.gov)]

When the hazard index or hazard quotient is less than 1, non-cancer health effects are not expected for people exposed to chemicals from the site. When the number is greater than 1, non-cancer health effects are possible, but not certain.

How are the cancer risk and noncancer hazard index calculated?

A **human health risk assessment** is used to evaluate the nature and likelihood of harmful health effects on people who are exposed to contaminants at a site. This process involves four steps:

1. Collecting data: Scientists sample groundwater, soil, and/or air. These samples indicate which chemicals are present, and the locations and amounts of the chemicals.
2. Estimating exposure levels: The data collected in step 1 is used to estimate how much of the chemicals people breathe, ingest, and/or touch. This estimate takes into account the ways that contaminants can move through air, soil, or groundwater. The estimate is also based on how often, how long, and how much people are in contact with the air, soil, or groundwater.
3. Assessing toxicity: State and federal chemical evaluations are used to indicate how much exposure to a chemical it would take to produce a harmful effect. These evaluations are based on findings from laboratory studies of animals, and/or studies of human exposure.
4. Estimating cancer risk and noncancer hazard index: The information from steps 2 and 3 is combined to calculate the cancer risk and hazard index.

The final calculations of cancer risk and noncancer hazard index account for the fact some people are especially sensitive to the health effects of chemicals. These include children, pregnant women, and individuals with health issues.

What happens if the cancer risk or hazard index is too high?

When state regulators determine that an estimated cancer risk or non-cancer hazard index is too high at a particular site, they may require actions to reduce people's exposure to the contaminants. For example, they may require that the contamination be cleaned up. Or, they may require that barriers be installed to keep the chemicals away from people.

Ultimately, what state regulators do depends on several factors at each site. Regulators have to consider how confident they are in the human health risk assessment, and how technologically feasible and costly the different remedies may be.

For more information:

US Environmental Protection Agency (US EPA)
Superfund Risk Assessment

California Environmental Protection Agency
Office of Environmental Health Hazard Assessment (OEHHA)

Cleanup Values or Goals: DTSC Screening Levels (SLs) or US EPA RSLs

https://dtsc.ca.gov/wp-content/uploads/sites/31/2022/02/HHRA-Note-3-Tables-June2020-Revised-May2022A.xlsx?emrc=026890

HHRA Note 3 June 2020-Revised May 2022, Table 1. DTSC-recommended Screening Levels for Soil Analytes	Chemical Abstracts Service Registry Number	Screening Level for Residential Soil (mg/kg), Cancer Endpoint	Reference for Screening Level for Residential Soil, Cancer Endpoint,	Screening Level for Residential Soil (mg/kg), Noncancer Endpoint	Reference for Screening Level for Residential Soil, Noncancer Endpoint	Screening Level for Commercial/ Industrial Soil (mg/kg), Cancer Endpoint	Reference for Screening Level for Commercial/ Industrial Soil, Cancer Endpoint,	Screening Level for Commercial/ Industrial Soil (mg/kg), Noncancer Endpoint	Reference for Screening Level for Commercial/ Industrial Soil, Noncancer Endpoint
1,1,1,2-Tetrachloroethane	630-20-6	2	USEPA	550	DTSC	8.8	USEPA	2700	DTSC
1,1,1-Trichloroethane	71-55-6	--	--	1700	DTSC	--	--	7200	DTSC
1,1,2,2-Tetrachloroethane	79-34-5	0.6	USEPA	700	DTSC	2.7	USEPA	4300	DTSC
1,1,2-Trichloropropane	598-77-6	--	--	170	DTSC	--	--	1100	DTSC
1,1-Dichloroethane	75-34-3	3.6	USEPA	1600	DTSC	16	USEPA	7100	DTSC
1,1-Dichloroethene	75-35-4	--	--	83	DTSC	--	--	350	DTSC
1,2,3-Trichlorobenzene	87-61-6	--	--	40	DTSC	--	--	300	DTSC
1,2,3-Trichloropropane	96-18-4	0.0015	DTSC	4.8	USEPA	0.021	DTSC	21	USEPA

[Human Health Risk Assessment Note 3 -June 2020 revised May 2022 (ca.gov)]

Three Types of Emergencies

Example 1: Unanticipated release into the air from a refinery

Example 2: Illegal use of pesticides sprayed under a residential home

Example 3: Oil spill at a beach causing air, water, and sediment contamination

Example 1: Unanticipated release into the air from a refinery

- Simplistic Example of release of one chemical of concern

  Ammonia

- Reality: hundreds of chemicals can be emitted during an unanticipated release or flaring event from a refinery.
  - https://oehha.ca.gov/air/analysis-refinery-chemical-emissions-and-health-effects
- Use different Health Guidance Values for different reasons
  - Immediate evacuation and shelter-in-place decisions
  - Protection of public health in communities from acute health effects
  - Chronic or Cumulative Impacts

Ammonia

IDLH: 300 ppm (NIOSH, 2022)

AEGLs (Acute Exposure Guideline Levels)

Final AEGLs for Ammonia (7664-41-7)

Exposure Period	AEGL-1	AEGL-2	AEGL-3
10 minutes	30 ppm	220 ppm	2700 ppm
30 minutes	30 ppm	220 ppm	1600 ppm
60 minutes	30 ppm	160 ppm	1100 ppm
4 hours	30 ppm	110 ppm	550 ppm
8 hours	30 ppm	110 ppm	390 ppm

(NAC/NRC, 2022)

ERPGs (Emergency Response Planning Guidelines)

Chemical	ERPG-1	ERPG-2	ERPG-3
Ammonia	25 ppm	150 ppm	1500 ppm

odor should be detectable near ERPG-1. (AIHA, 2020)

PACs (Protective Action Criteria)

Chemical	PAC-1	PAC-2	PAC-3
Ammonia	30 ppm	160 ppm	1100 ppm

LEL = 150000 ppm

Ammonia OEHHA Acute REL 4.5 ppm 1 ppm = 0.71 mg/m3

Ammonia (7664-41-7)	**A**	3200[4]		Respiratory system; eyes
	C	200		Respiratory system

Chronic 0.3 ppm

Example 2: Application of an Illegal Pesticide at a Residence: Cleanup Decisions

- DTSC Residential Screening Levels
- US EPA Screening Levels
- Reference Dose (RfD): CDPR, US EPA
- Soil vapor off-gassing considerations (air)
- Cost and feasibility
- Future use of site
- Access/Exposure
- Removing all items that could absorb chemical

Example 3: Oil Spill: Air, Water, and Sediment

- Public Health Assessment Unit (PHAU)
  - Air Monitoring Subgroup
  - Water and Sediment Subgroup
  - Fisheries Closure Subgroup
- Work in ICS Structure w/ Unified Command
- Work with contractor as well as local government
- Multi-agency workgroups with local, state, and federal representation

- Review Sampling and analysis plan
- Review Analyte lists
- Methodologies and level of detection limitations
- In an emergency, challenging to select criteria for cleanup goals
- Pre-planning is key!
  - DTSC and US EPA Screening Levels
  - Acute Reference Exposure Levels (RELs) are they right for this situation?
  - Values used from other spills in other states?
- Public Acceptance
- Return to Use: Beach Closures

Summary

- Toxicology Basic Elements
- Human Health Risk Assessment
- Risk Characterization
  - Calculating Hazard Index
  - Calculating Cancer Risk
- Health Guidance Values
- Emergency Exposure Levels
- Cleanup Goals
- Public Health Assessment Unit (PHAU)

Conclusions

- Seek out expertise during decision-making
- Form a multi-agency workgroup
- Consult with Local Public Health Officer
- Community Acceptance and Participation
- Protection of Public Health
- Additional monitoring (e.g. in homes)
- Shelter-in-place or Return home recommendations
- Consider a Public Health Assessment Unit (PHAU) in your ICS structure

Monday

Learn more about Exposure Assessment Next Class:
M-F2 Introduction to Exposure Assessment with Case Studies: Monday 10:00-11:45am

Wednesday

Learn more about AB 480 Imminent and Substantial Endangerment-Emergency Closure: **W-M4 : Wednesday 3:00-5:00 pm**

Thursday

Learn more about the Public Health Assessment Unit (PHAU): The CUPA's Role in Public Health Assessment During Oil Spills **TH-I2: 10:00 am to 12:00 pm**

Any Questions?

Karen Riveles

Office of Environmental Health Hazard Assessment (OEHHA), CalEPA

Karen.Riveles@oehha.ca.gov

Thank you!