Chem. Engg.

HWMT (Last xerox)

→ Prof. BCM.

Lecture 28-30

Risk Assessment of Hazardous Waste and Environmental Impact assessment

What is Risk?

- Risk is defined as the probability of suffering harm or loss (measurable e. g. person days lost to accident)
- Risk = (Probability) X(Severity of Consequence)
- Consequence is not a quantifiable matter.

What is Risk Assessment?

Risk assessment is a tool for understanding the health and environmental hazard associated with hazardous waste and can greatly improve the basis upon which to make hazardous waste management decision.

- Risk assessment is an integral part of the hazardous site cleanup process. The Remedial Investigation and Feasibility Study process determines what, if any, action should be taken at a Superfund site. Risk assessment is an important part of the Remedial Investigation, which characterizes the nature and extent of contamination. All Superfund site assessments should comprise two parts, a Human Health Risk Assessment and an Ecological Risk Assessment. The Feasibility Study component develops and evaluates remedial options based on the site-related risks.

- Human Health Risk Assessment
- Human health risk assessors use quantitative models to estimate risks from hazardous waste sites.

- Ecological Risk Assessment
- Ecological risk assessment is a qualitative and/or quantitative appraisal of the actual or potential effects of contaminants from a hazardous waste site on plants and animals other than people and domestic species.

Purpose?

- A) In the hazardous waste field , risk assessment provides information to decision makers as to the consequences of possible action. Important decisions that could use risk estimates include selecting waste treatment/disposal options, remediation contaminated sites, minimizing waste generation, sitting new facilities and developing new products.

Purpose?

- B) Risk assessment plays a major role in the decision making for the remediation of contaminated sites.

- C) Risk assessment helps in site remediation to establish cleanup standars.

Ranking

- Hazardous Waste Site Ranking
- Public Participation in the Decision-Making Process
- Questions and Answers

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why do we rank sites? setting priorities

- The problems exceed our resources
- The US inventory is > 43,000 sites
- Strategic goal: worst sites first

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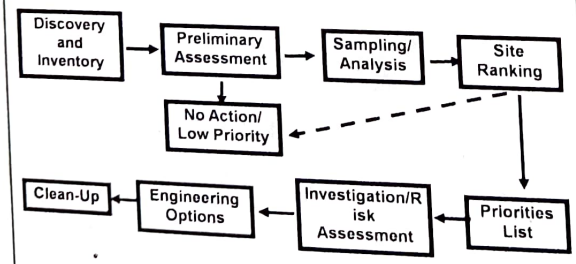
Why Do We Rank Sites?



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Site Ranking: Science and Policy

- Worst is a value judgment
- Values represented in the US Hazard Ranking System
  - Human Health (cancer and non-cancer effects
  - Resources (drinking water, fisheries, etc)
  - Sensitive Environments (national parks, habitats for the endangered species, etc.

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Identifying Hazardous Waste Problems

- **Question 1:** Is a hazardous waste present?
- **Question 2:** Is it mobile?
- **Question 3:** Is there a receptor?

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How to Rank Hazardous Waste Sites

- Identify risk and assign value
- Identify required information
  - Toxicity, quantity, bioaccumulation
  - mobility
  - Receptors (people, environments, resources)
- Identify solution(s)

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Identifying the Risks

- Is there a human health risk?
- Is the environment threatened?
- Is the socio-economic stability of the area threatened?

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Assign Value

- Is there an immediate health risk?
- Is there long-term risk?
- Are the risks acceptable?
- What is the uncertainty?

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Site Assessment

- Step 1: Characterize the hazardous wastes
- Step 2: Consider routes of migration
- Step 3: Evaluate the receptors

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Characterize the Waste

- Identify the waste present
- Confirm the source
- Estimate quantities
- Evaluate chemical properties
  - mobility
  - persistence
  - toxicity
  - biocentration

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Routes of Migration

- Groundwater
- Surface water
- Air
- Direct contact/Soil ingestion

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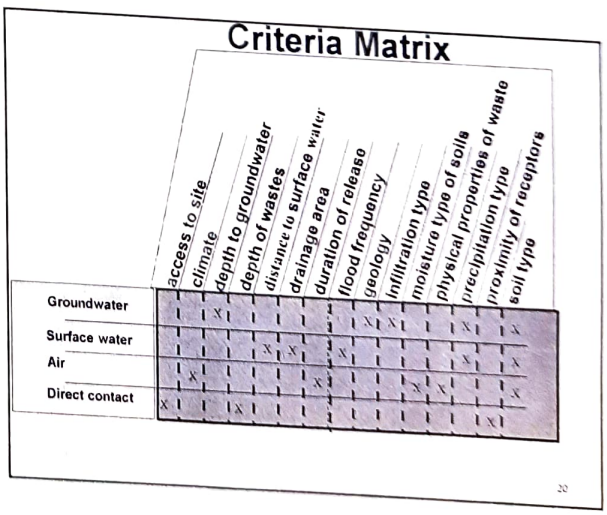
Criteria Matrix



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Other Factors that may Influence Site Ranking

- Costs of cleanup
- Political factors
- Public opinion
- Potential for reuse

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Basic Program Elements for Program Site Ranking

- Inventory
- Review available information
- Sampling and analysis
- Document the findings

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Preliminary Assessment Review Available Information

- Contact local authorities
- Obtain historical information
- Evaluate current conditions
- Consider outside influences
- Evaluate reliability and quality of existing data
- Identify missing information
- Visually inspect the site

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Sampling

- Develop a cost-effective strategy
  - minimum sampling needed to obtain results
  - location of samples
  - type of samples
  - sampling procedures and on-site equipment
- Consider alternative strategies
  - sample existing wells
  - collect wipe samples
  - air monitoring

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Field-Portable Technology Options for Sampling

Technology	Description
Ground-Penetrating Radar	■ Emits pulses of electromagnetic energy into the ground ■ Measures reflection and refraction by subsurface layers and other features ■ Identifies buried objects, for example, unexploded ordnance
Colorimetric Detector Tube	■ Chemical-based indicator ■ Detects and quantifies individual, or classes of compounds ■ Identifies explosives, chlorine, hydrogen sulfide, volatile organic compounds (VOCs)
Mercury Vapor Analyzer	■ Provides real-time measurements of concentrations of mercury in the air
X-ray Fluorescence Analyzer	■ Detects and quantifies individual metals or groups of metals, and lead paint
Portable Gas Chromatography	■ Identifies and quantifies VOCs, SVOCs, dioxins, furans, and pesticides

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Document the Findings

- Create a well-documented report
  - Identify data collection procedures
  - Report significant findings that resulted in ranking decision
- Establish credibility of decision-makers

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ENVIRONMENTAL MANAGEMENT

Comparative Health Risk Assessment is used to set priorities for environmental management.

Risk Assessment	Identify and evaluate risks, set priorities among problems.
Risk Management	Develop and implement solutions for high priority problems

ENVIRONMENTAL RISKS

Environmental damage may have three types of negative effects.

- Public Health--illness, injuries, deaths

Ecological--loss of species and habitat

Quality of Life--economic and social costs

TYPES OF "RISK ASSESSMENT"

Health Risk Assessment:
evaluates the potential public health impacts of an environmental condition

Comparative Health Risk Assessment:
evaluates and compares the potential health impacts of several environmental conditions

Comparative Risk Assessment:
evaluates and compares the potential health, ecological, and quality-of-life impacts of several environmental conditions

COMPARATIVE RISK ASSESSMENT METHODOLOGY

STEPS IN RISK ASSESSMENT

Health risk assessment is quantitative, based on experimental and observational data.

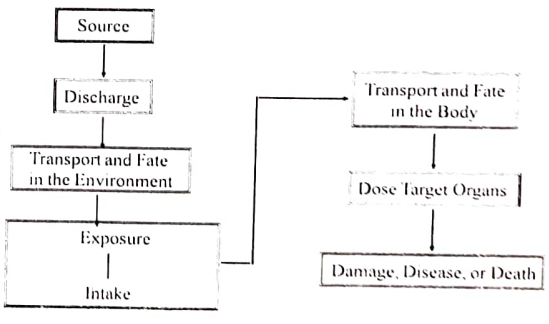
Hazard Identification--
identify health risks associated with exposure

Dose-Response Assessment--
model the relationship between dose and effects

Exposure Assessment--
estimate a group's exposure (amount, duration)

Risk Characterization--
estimate the probability and severity of effects

CONCEPTUAL MODEL LINKING ENVIRONMENTAL CONDITIONS AND HEALTH



CRA METHODOLOGY

Four Phases of Comparative Risk Assessment

- Planning
  - Determine scope of the study
  - Select and organize the team
  - Identify data types and sources
- Data Collection and Analysis
  - Identify and gather data
  - Analyze data to estimate risks
- Priority Setting
  - Interpret and compare risks
  - Debate and agree on priorities
- Reporting
  - Prepare report as input to risk management planning

TECHNICAL ANALYSIS

Identify and evaluate health impacts of many environmental conditions

- water and food
- sanitation, drainage, and wastewater
- ambient and indoor air, gases and particles
- solid and hazardous wastes
- occupational injuries and exposures
- infectious, vector-borne, and pollutant-related diseases

ADAPTING TECHNICAL ANALYSIS FOR CRA IN DEVELOPING COUNTRIES

ISSUE	RESPONSE
Scope includes infectious diseases, outside traditional risk assessment methods	Use health data from clinics and local survey to estimate disease rates
Limited information and many data gaps	Use environmental, health, and qualitative data
Data are not computerized and are aggregated at inappropriate geographic levels	Reorganize information, use assumptions and extrapolation where necessary
Some standard exposure assumptions are inappropriate due to culture or conditions	Adjust assumptions, conduct special studies if possible

PRIORITY SETTING

Categorize each health impact by magnitude and severity

- magnitude -- number of people affected
- severity -- of effect, and importance of group affected

Combine magnitude and severity scores

Compare and categorize environmental problems

- high, medium, and low risk

CRA Risk Ranking

Risk ranking requires judgments based on values

Comparing health effects:

- *acute vs. chronic*
- *disease vs accidents*

Comparing effects among groups:

- *children vs. working adults vs. elderly*
- *poor vs. middle income*
- *voluntarily exposed vs. involuntary exposed*
- *women vs. men*

Hazard Ident. / Risk Assess. Procedure

HAZARD IDENTIFICATION METHODS:

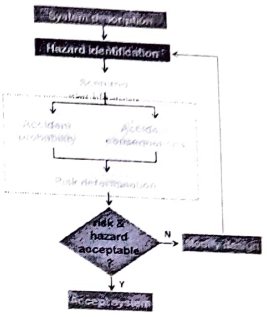
- Process hazard checklist
- Hazard survey: DOW index
- HAZOP hazard & operability study
- Safety review

RISK ASSESSMENT:

- What can go wrong & how ?
- What are the chances ?
- Consequences ?

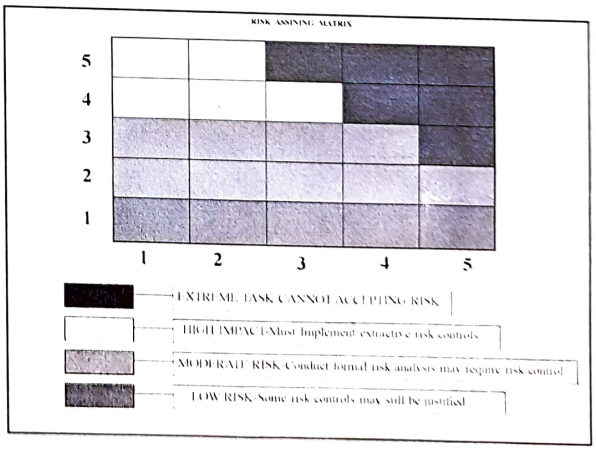
EXTREMES:

- Low probability
- Minimal consequences



RISK ASSESSMENT CRITERIA

Rating	Impact				Frequency
	PEOPLE	COST PERIOD LOSS EQUIP DAMAGE	ENVIRONMENT	PUBLIC IMAGE	
5	Multiple Casualties	Rs 1 Month Total Outage Losses Rs 1 crore	Widespread Permanent Ecological Damage	National & international Attention	Repeatedly during life cycle of System or at least once weekly
4	Single fatality	1 month facility outage losses Rs 50 lacs	Some permanent Ecological damage	Industry wide attention	Several time during lifecycle of system or at least once in quarterly
3	Disabling injury	1 week facility outage losses Rs 10 lacs	Major environmental Releases	Provincial attention	At least once in lic cycle of system typically once yearly
2	Medical Aid injury	1 day facility outage upset losses Rs 10 lacs	Controlled Environment release (within license limits)	Local or community attention	Unlikely to occur during life cycle of system or once in 5 year
1	Minor injury (no loss Lost Aid)	Minor production upset Losses Rs 10,000	Minor spill or Fugitive Emission	Individual Concern	Less than once in more than 10 years



EVENT TREE ANALYSIS

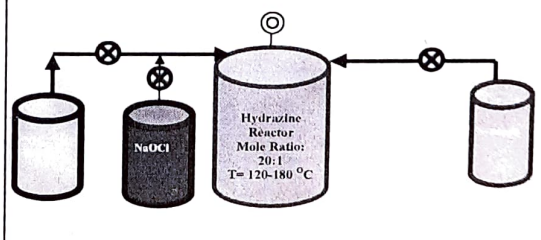
- The technique involves assessment of quantified risk for each dangerous event in terms of frequency. It basically involves to calculate frequency and nature of damage due to consequence events due to typical hazardous properties.

CONSTRUCTION OF EVENT TREE

- **To construct an event tree first step is to develop the hazards into event tree to identify consequences in events it will create i. e. to find out hazard consequences in terms of load damage on identical system. To do so, top event is defined for each question and a probability is given to each branching point. The end events can be gathered in groups according to their consequences to give a risk picture. By constructing this logic through the tree, we can arrive at probabilities for the terminal events. If we multiply the frequency of end event with the frequency of the top event, we arrive at the frequency for each terminal point.**

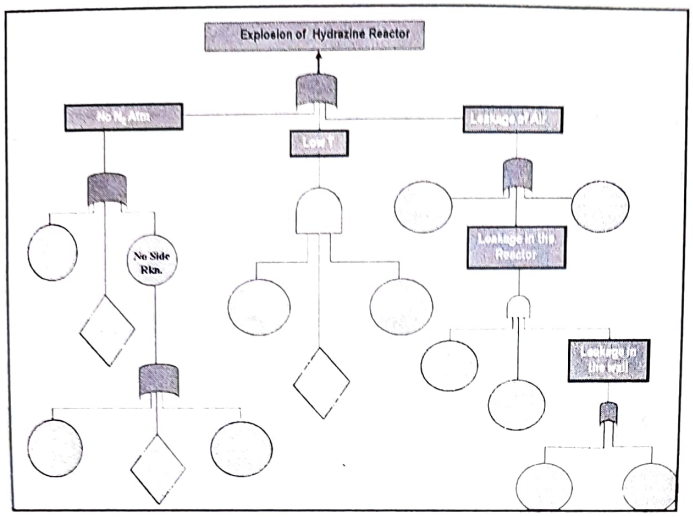
FAULT TREE ANALYSIS

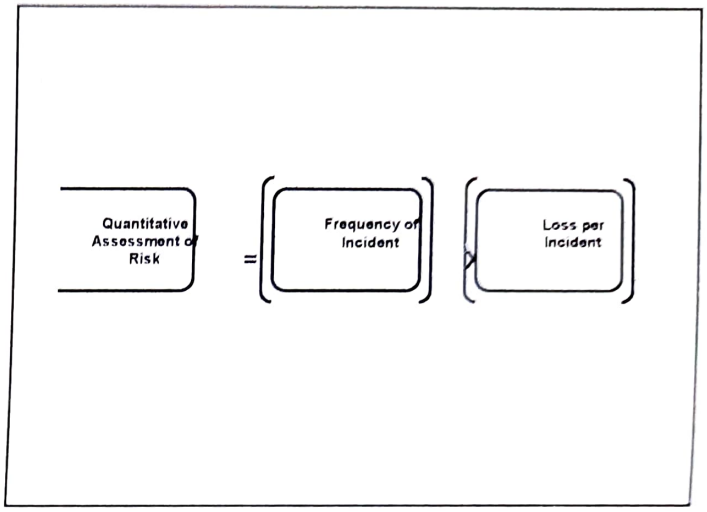
- This technique is used to :
- Determine the reasons of damage due to hazardous waste
- To determine frequency of top event which thereafter is used as initiating event in event tree analysis to find out consequence hazards and load damaging capabilities.



$NH_3 + NaOCl = NH_2Cl + NaOH$
$NH_3 + NH_2Cl + NaOH = N_2H_4 + H_2O$

Hydrazine Reactor System (Rocket Propellant)





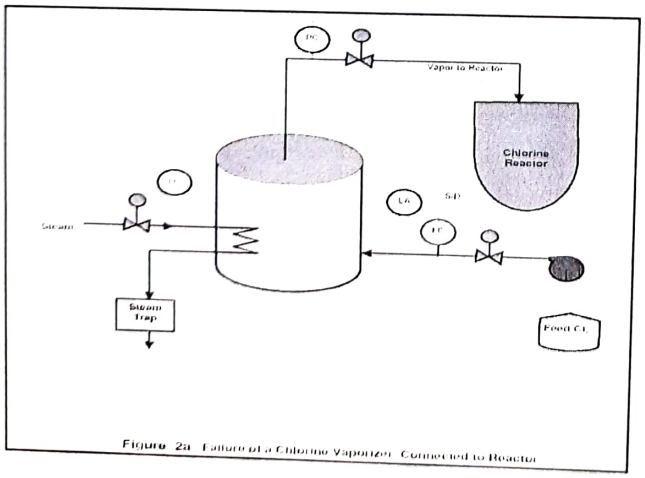


Figure 2a Failure of a Chlorine Vaporizer Connected to Reactor