Bharathidasan University

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Unit- IV Environmental Risk Assessment and Management

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Theories in Environmental Risk Assessment

What is environmental risk assessment (ERA)?

- Qualitative and quantitative valuation of environmental status

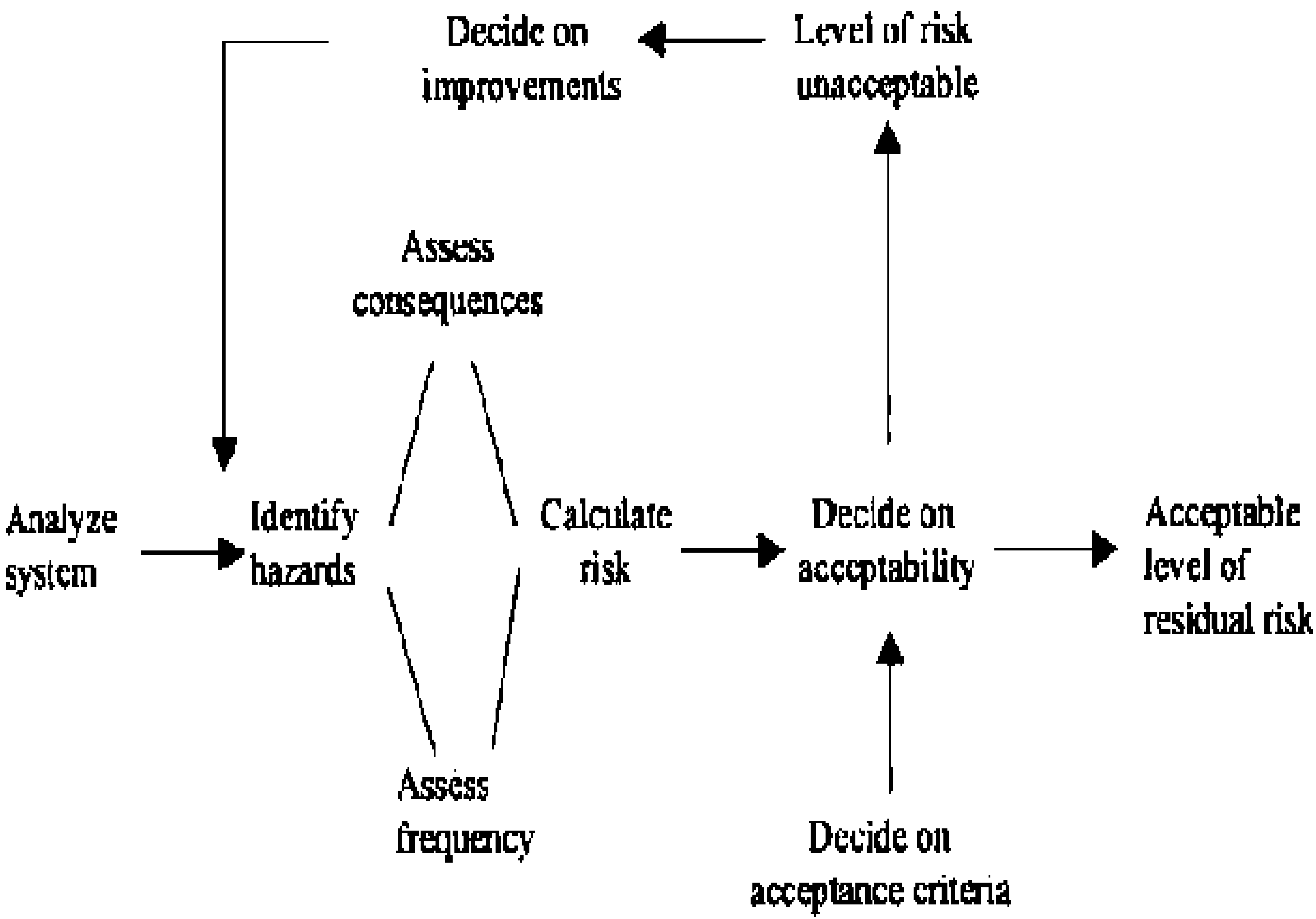
- ERA is comprised of:

1. human health risk assessment;
2. ecological risk assessment.

Systematic approach to risk assessment

- **ERA should be conducted when it is determined that a management action may have consequences to either humans or the environment.**

Systematic Assessments of Risk



Human health risk assessment (HHRA)

Involves:

- **hazard identification;**
- **dose-response assessment;**
- **exposure assessment;**
- **risk characterization.**

Ecological risk assessment (ERA)

- **It is determined the likelihood of the occurrence/non-occurrence of adverse ecological effects as a result of exposure to stressors**

Hazards

- chemicals toxic to humans, animals, and plants;
- materials that are highly flammable or explosive;
- mechanical equipment, the failure of which would endanger persons and property;
- structural failure (e.g., dam or containment vessel);
- natural disasters that exacerbate technological hazards;
- ecosystem damage (e.g., eutrophication, soil erosion).

Examples of information about hazards

- potential release of hazardous chemicals (rate and amount);
- accidental fires and explosions;
- transport and fate of pollutants in the environment;
- dilution-dispersion mechanisms and rates;
- exposure to toxins (who, how many, how much);
- dose-response predictions based on animal tests;
- failure rates of mechanical equipment or structures;
- human behavior (errors by workers, public reaction);
- natural hazards (earthquake, tsunami, typhoon);
- alterations in drainage patterns, water table, vegetation, microclimate.

Uncertainties

- lack of understanding of important cause-effect relationships, lack of scientific theory;
- models that do not correspond to reality;
- weaknesses in available data;
- data gaps;
- toxicological data that are extrapolated;
- natural variation in environmental parameters;
- necessary assumptions on which estimates are based, and the sensitivity of the resulting estimates to changes in the assumptions;
- novelty of the project.

ERA addresses three questions

1. What can go wrong with the project?
2. What is the range of magnitude of these adverse consequences?
3. What can be done and at what cost to reduce unacceptable risk and damage?

The interactive nature of ERA

Purposes in performing ERA

- to learn about the risks
- to reduce the risk

Risk comparison

- Probability of frequency of events causing one or more immediate fatalities.
- Chance of death for an individual within a specified population in each year.
- Number of deaths from lifetime exposure.
- Loss of life expectancy considers the age at which death occurs.
- Deaths per tone of product, or per facility.

Quantitative risk assessments – a possible scenario

- quantity of toxic material in the inventory is hazardous;
- overpressure in the storage tank in combination with failure of the relief valve leading to tank rupture;
- combination of wind speed and atmospheric stability leading to an estimated spatial and temporal distribution of toxic material concentration;
- population distribution based on night-time occurrence.

Risk communication

Psychologists studying risk perception find that fears are heightened beyond what the objective facts would warrant when:

- risks are involuntary or controlled by others;
- the consequences are dread and delayed;
- the benefits and risks are inequitably distributed;
- the proposed project is unfamiliar and involves complex technology;
- basic needs such as clean air, drinking water, or food are threatened.

Risk management:
3 main phases

- Risk analysis and assessment: identification of hazards to people and the environment, the determination of the probability of occurrence of these hazards, and the magnitude of the events.
- Risk limits - entails defining the acceptability of the risk, which can be classified as acceptable or in need of reduction.
- Risk reduction: design and implementation of risk-reducing measures and controls.

Disaster management plan

- details of the specification of equipment and machineries, plot plan, and hazardous areas classifications;
- details of the risk assessment procedure adopted;
- details of the on-site and off-site emergency plan;
- details of the fire extinguishers and foams.

Guidelines for disaster management planning

1. Specification;
2. Plot plan;
3. Hazardous area classification;
4. Diagrams showing all the equipment in position, process and utility valves, instruments, control system, safety valves and other safety devices;
5. Storage of inflammable liquids;
6. Risk assessment.

Hazard analysis: risk assessment of plants

1. Which materials or process streams are flammable or combustible?
2. What is their ignition temperature or what is their ignition energy requirement?
3. How fast will they burn?
4. How much heat can be generated per unit?
5. How much quantity will be available in any one area?
6. Will it explode?

Scope and objectives of risk assessment of industries

(a) To develop a risk hazard checking system.

(b) To rank the plant layout on the hazard potentials.

(c) To re-modify the plant layout and identify safety measures to be undertaken within the industry, so as to minimize the on-site economic damage as well as off-site risks to the society and environment.

(d) To assist the regulatory authorities, planners, and designers to investigate plant accidents and predict the possible consequences for decision-making.

(e) To make decisions on industrial clearance swiftly and on a more rational basis.

Total risk assessment

1. Identification of possible hazardous events.
2. Consequence analysis.
3. Quantitative analysis of system failure probability from their component failure or frequency assessment

Hazard identification procedures

- depends primarily upon two factors: data and organization.

Categories of dispersion model

- Simple "passive" dispersion involves neutral buoyancy and plume rise for heat and momentum. It is used for those phases of gas dispersion dominated by atmospheric turbulence.
- Moment jet dispersion covers high velocity release, when the released gas can be denser or lighter than air, and involves simple horizontal jet models, and complex plume path models.
- Dense vapour cloud dispersion deals with clouds heavier than air, cold clouds, and liquid and vapour clouds.

- Vulnerability model or probit equations have been derived for estimating, from dose relationships, the probability of affecting a certain proportion of the exposed population. These have been based almost exclusively on animal test data. The probit equation is:

$$Pr = At + Bt \ln(C^n te)$$

where Pr = probability function, At, Bt, and n are constants, C is the concentration of pollutant to which exposure is made (in ppm v/v), and te is the duration of exposure to the pollutant, measured in minutes.

Frequency assessment and quantitative analysis

- What is the probability that the system will fail on demand?
- What is the frequency of occurrence of the top event?
- Does a change in the system design improve or reduce the system reliability?

Events involving flammable materials

- (a) major fires with no danger of explosion, with hazards from prolonged high levels of thermal radiation and smoke;
- (b) fire threatening items of plant containing hazardous substances, with hazards from spread of fire, explosion, or release of toxic substances;
- (c) explosion with little or no warning, with hazards from blast wave, flying debris, and high levels of thermal radiation.

Events involving toxic materials

- (a) slow or intermittent release of toxic substances, (from a leaking valve);
- (b) items of plant threatened by fire, with hazards from potential loss of containment;
- (c) rapid release of limited duration, due to plant failure (fracture of pipe, with hazards from a toxic cloud, limited in size, which may quickly disperse);
- (d) massive release of a toxic substance due to failure of a large storage or process vessel, an uncontrollable chemical reaction and failure of safety systems, with the exposure hazard affecting a wide area.

The assessment of possible incidents should produce a report indicating:

(a) the worst events considered;

(b) the route of those worst events;

(c) the timescale to lesser events along the way;

(d) the size of lesser events if their development is halted;

(e) the relative likelihood of events;

(f) the consequences of each event.

Elements tobe included in an on-site emergency plan

- (a) proper alarm and communication mechanisms;
- (b) appointment of personnel, which include:
  (i) the site incident controller who will take care of the area around the incident when the emergency occurs and who will arrange the required rescue operations;
  (ii) a site main controller who will direct operations from the emergency control center after relieving the site incident controller of the responsibility for overall control;
- (c) details of the emergency control centers.

Aspects to be included in an off-site emergency plan

- (i) Organization.
- (ii) Communications.
- (iii) Specialized emergency equipment.
- (iv) Specialized knowledge.
- (v) Voluntary organizations.
- (vi) Chemical information.
- (vii) Meteorological information.
- (viii) Humanitarian arrangements.
- (ix) Public information.
- (x) Assessment.