ENVIRONMENTAL RISK ASSESSMENT

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INTRODUCTION

During the last decade, there has been much public attention and concern about the effects of chemicals, radiation, science, and engineering in general impact on health and living environment. Several scenarios such as the pollutant release at a chemical dump site in Love Canal, New York; Methyl isocyanide exposure in Bhopal, India; Dioxin levels high in Leaf River, Mississippi; and hospital needles found on the beach in Biloxi, Mississippi raise questions about the possibility that similar problems may occur. These include not only sites near the hazardous waste disposal sites and chemical plants, but also from transportation of hazardous chemical and nuclear wastes. "Zero-risk" situations are never attainable and are probably not desirable.

Risk assessment can be defined as the process of assigning magnitudes and probabilities to the adverse effects of human activities and of natural catastrophes. This is a rigorous form of assessment that uses formal quantitative techniques to estimate probabilities of effects on well-defined endpoints, estimates uncertainties, and partitions analysis of risks from decision making, defining significance of risks and choice of actions (Suter 1993). The National Academy of Sciences defines risk assessment as the scientific activity of evaluating the toxic properties of chemicals and their effect on human exposure in order to ascertain both the likelihoods that exposed humans will be adversely affected. Risk assessment is the foundation of environmental decision making, which is a multi-disciplinary project depending on the particular situation to be assessed. The job involves epidemiologists, toxicologists, hydro-geologists, physicians, engineers, environmental chemists, statisticians, meteorologists, and others. Generally, environmental risk assessment is classified into two categories: health risk assessment and ecological risk assessment.

LAWS AND REGULATIONS CONCERNING RISK ASSESSMENT

In 1980, Congress passed the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), commonly know as the Superfund Law, in response to the dangers posed by some abandoned sites' release of hazardous substances into the environment. Basically the CERCLA is a cleanup program. Later reauthorization is known as the Superfund Amendments and Reauthorization Act (SARA 1986). SARA strengthens the Environmental Protection Agency's (EPA) enforcement authority focus on Response Authorities and Cleanup Standards. These have the greatest impact on the Remedial Investigation and Feasibility Study (RI/FS). Another significant milestone is the National Oil and Hazardous Substances Pollution Contingency Plan or National Continency Plan (NCP) (1985, 1988). Under these plans there are certain provisions for both removal and remedial responses. There are seven steps proposed by the NCP remedial response processes. Risk information plays an important role in each step.

1. Site discovery or notification
2. Prelimary assessment and site inspection
3. Establishing priorities for remedial action
4. Remedial investigation feasibility study
5. Selection of remedy
6. Remedial design/remedial action
7. Five-year review

Other regulations which involve environmental risk assessment are Resource Conservation and Recovery Act (RCRA) and Clean Air Act (CAA). Figure 1 shows the role of the human health evaluation in the Superfund remedial process. Figure 2 shows ecological assessment in the RI/FS process and Figure 3 shows the relationship between health and environmental evaluations.

There are several reasons for conducting health risk assessments. From the regulatory point, it provides a process to determine the health implications of environmental pollution and determines the risk associated with new products which are to be introduced into the environment. Development of regulatory standards provides the basis for taking protective action.

Public health and the environment are used to rank risks so that priorities can be set within government agencies for health protection. The Nuclear Regulatory Commission (NRC) sets the allowable limits of radiation. The Food and Drug Administration (FDA) sets limits for pesticides and other chemical residues in food and determines if new

drugs are safe for consumer use. The National Institute of Occupational Safety and Health (NIOSH) sets concentration limits for occupational exposures to biological and chemical agents. The Environmental Protection Agency determines if particular environmental pollutants pose a concern to public health and the environment. From the private business view point, it determines which environmental problems warrant redmediation and which do not. It also determines the health risk associated with particular activities or contaminated sites for liability considerations and determines the relative risk associated with different industrial properties. From economic and social viewpoints, they have limited resources to manage the myriad of environmental problems that exist within our society. Risk assessments can be used to determine solutions which may or may not pose a health concern to society once an environmental problem is defined. Risk assessment methods can be used to determine the risk reduction associated with different methods of intervention, pollution control, and remedial action.

RISK ASSESSMENT PROCESS

This process has been used by toxicologists for a long time and has now been adopted by risk assessors. It includes four major steps as shown in Figure 4.

Step 1

Hazard Identification: The objective of this step is to determine whether the available scientific data describe a casual environmental agent (chemical, biological, or radioactive) and evaluate data on the types of injury to human health or the environment. In humans, the observed injury may have cancer or non-cancer effects. It may also involve characterization of an agent within the body and the interactions with organs and cells. This information was gathered from animal and epidemiological studies.

Problem Formulation: The objectives of this step are to: (1) qualitatively evaluate pollutant release, migration, and fate; and (2) identify the contaminants of ecological concern, and receptors exposure pathway and known effects. This step also selects endpoints of concern and specifies objectives and scope. Ecological effects may include inhabitant kills or other natural effects.

Step 2

Health Exposure Assessment: The objectives of this step are to describe the quantitative relationship between the amount of exposure to substance and the extent of toxic injury or diseases; to compare studies from the known populations in which dose and response occur together; and to identify and characterize exposure in other potentially exposed population.

Ecological Exposure Assessment: This step measures the quantity of release, migration and fate; characterizes receptors; and estimates exposure point concentrations. In this step, investigations develop estimates of current and future contaminant level in affected media. At the same time, information on the species' feeding habits, life history, and habitat preferences are collected. By the completion of these studies, receptors can be identified and investigators can estimate the concentration of contaminants in the media to which the receptors are exposed.

Step 3

Toxicity Assessment: The objective of this step is to use the dose response relationship to establish the quantitative analysis between exposure and response in existing studies in which adverse health or environment effects have been observed. Data are derived from animal studies or from studies in exposed human populations. There may be many different dose-response relationships for a substance if it produces different toxic effects under different conditions of exposure.

Ecological Effects Assessments: The objectives of this step are to do literature reviews, field studies, and toxicity tests, and to link pollutants' concentrations to effects on ecological receptors. From the information collected, one could understand how much toxicant is associated with a given impact.

Step 4

Health Risk Characterization: The objectives of this step are to finalize where important information, data, and the conclusion from each process are examined to describe the expected risk by examining the exposure predictions for real world conditions. Information for this is collected from animals, people, and special test systems.

Ecological Risk Characterization: This is primarily the process of comparing the results of the ecological effect's assessment. It concludes with a risk description, which includes a summary of the risks and uncertainties and interprets the ecological significance of the observed or predicated effects.

CASE STUDY

In the last ten years, about 200 of 1300 superfund sites have been cleaned up. In our state, there are three sites on the Superfund List, out of which one is cleaned with the other two in the final stages. Generally, the site is

contracted to well-known environmental consulting companies to perform the clean up job.

Background Information: The site has been operated by different lumber companies and chemical companies since 1930 until late 1977. The operation was stopped due to an explosion on site. The main products of different operations are wood derivatives, rosin, turpentine oil, tall oil, and pentachlorophenol (PCP) mixed with diesel oil.

Exposure Assessment: According to site information, potential pathways by which human populations could be exposed to under land use conditions are ingestion, inhalation, and dermal absorption. Human population includes workers on sites. All exposed scenarios consider point concentrations for current and future.

Toxicity Assessment: Chemical of potential concerns (CPC) was evaluated first by "Applicable or Relevant Appropriate Requirements" (ARAR), but ARARs are not available for all chemicals in all media and, therefore, risks were qualitatively assessed for human exposures to these chemicals of potential concern at the site. Quantitative risk assessment involves chronic daily intakes (CDI). This is based on the amount of substance taken into the body per unit body weight per unit time (mg/kg/day). A CDI is averaged over a lifetime for a carcinogen and over the period of exposure for a noncarcinogen. These intakes are then combined with reference doses (RfDs) or cancer potency factors to derive estimates of noncarcinogenic hazard or excess lifetime cancer risks, respective to the potential exposed populations. For noncarcinogens, results are presented as the ratio of the intake of each chemical to its RfD and as the hazard index, which is the sum intake of each chemical to its RfD, and as the hazard. A hazard index which is exceeding one indicates that a health hazard might result from such exposure. For carcinogens, the excess lifetime cancer risk was estimated. EPA recommends a superfund site which calculates total carcinogenic risk to individuals resulting from exposure at sites be reduced to zero if possible.

Ecological Assessment: Plant and animal species potentially exposed to chemicals of CPC at the site were identified based on a knowledge of the site and surrounding habitat. Individual species or communities were selected as indicators of potential impacts at the site and exposures of these receptors was quantified. Receptors for which exposure was qualified were terrestrial plants, small mammals, birds, and aquatic life. The available toxicological literature was reviewed to identify exposure concentrations or doses potentially associated with adverse effects in plants and wild life.

CONCLUSION

Risk Assessment is a good tool for decision makers to select the best choice from different alternatives. We also know there are many uncertainties in the assessment process, such as: (a) toxicity data is mostly derived from animal studies, (b) toxicity values generally apply on animal studies at high doses and on humans at low doses, (c) there is no unified mathematical model to predict the fate of pollutant transports. The most important assessment is site specific. Each site differs from all others.

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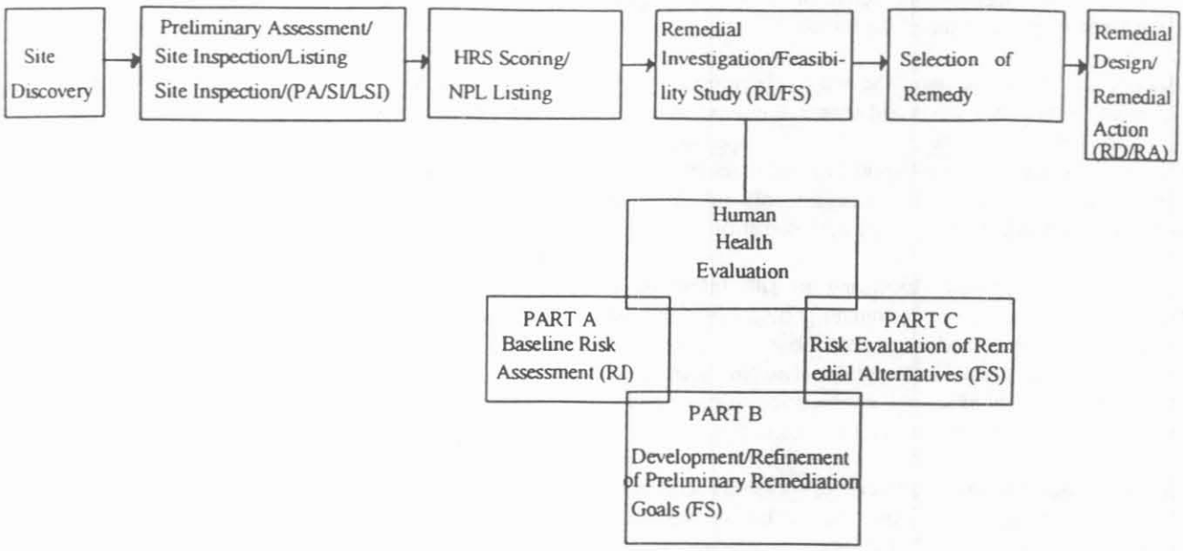

Fig 1. Role of the Human Health Evaluation in the Superfund Remedial Process (Ref EPA/540/1-89/002)

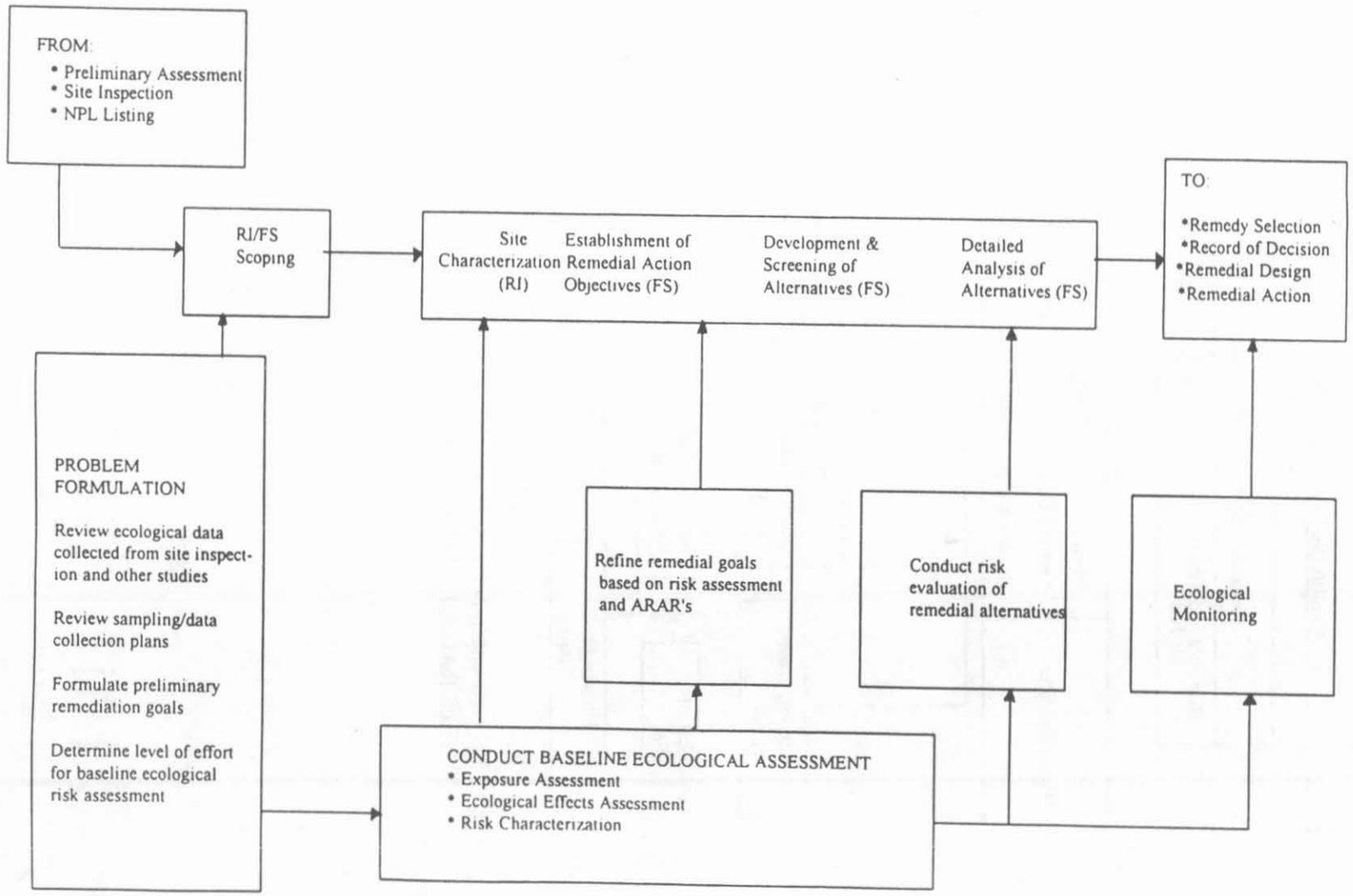

Figure 2. Ecological Assessment in the RI/FS Process

(Ref ECO Update, pec, pp1, Vol.1, No.2)

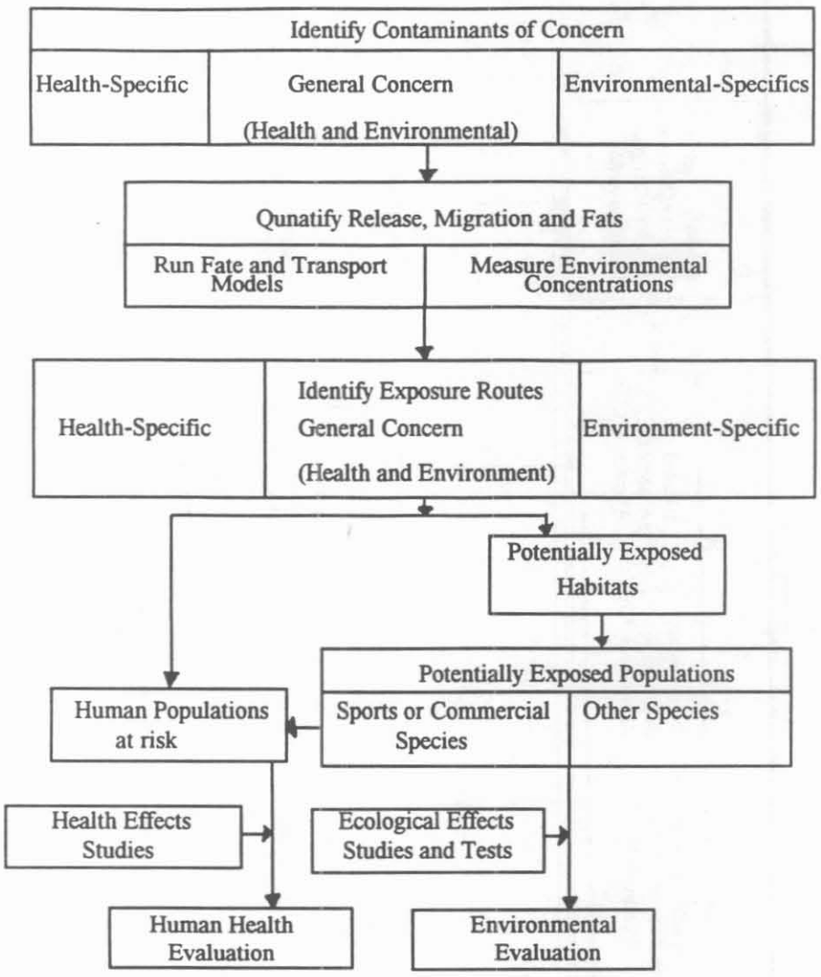

Figure 3. Relationship between Health and Environmental Evaluations. (Ref. RAGS, EPA/540/1-89/001)

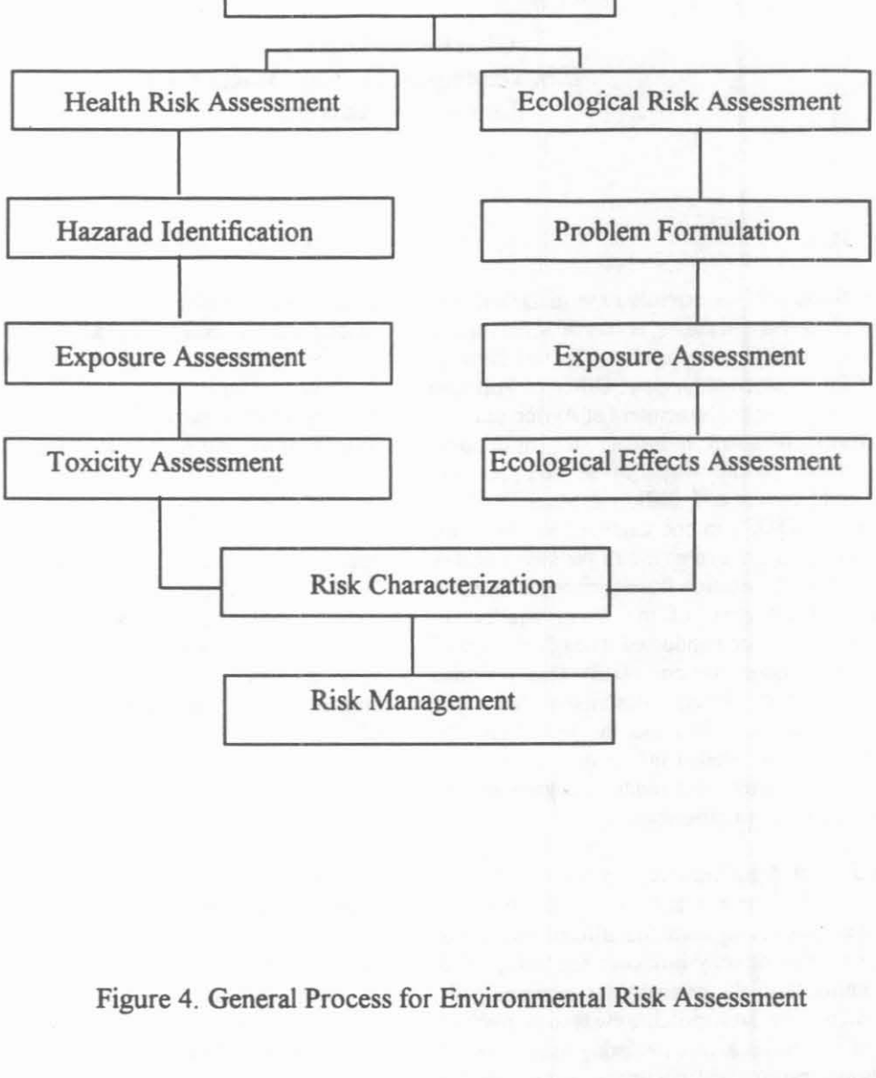

Figure 4. General Process for Environmental Risk Assessment