**Environmental Risk Analysis**

Risk analysis allows us to estimate impacts on the environment and on human health when we have not measured or cannot measure or directly observe those impacts.

In general, a risk factor should meet the following conditions:

• Exposure to the risk factor precedes appearance of the adverse effect.

• The risk factor and the adverse effect are consistently associated. That is, the adverse effect is not usually observed in the absence of the risk factor.

• The more of the risk factor there is, or the greater its intensity, the greater the adverse effect, although the functional relationship need not be linear or monotonic.

The occurrence or magnitude of the adverse effect is statistically significantly greater in the presence of the risk factor than in its absence

**A hazard** is simply a condition or a set of circumstances that present a potential for harm. Hazards are divided into two broad categories:

• Health hazards (cause occupational illnesses)

• Safety Hazards (cause physical harm – injuries)

**Hazard identification** is the process of identifying all hazards in the workplace. There is no set method for grouping agricultural injury and illness hazards.

**Assessment of risk**

Risk assessment is one tool used in risk assessment. It is the process that scientists and government officials use to estimate the increased risk of health problems in people who are exposed to different amounts of toxic substances. Risk assessment is a system of analysis that includes four tasks:

1. Identification of a substance (a toxicant) that may have adverse health effects.

2. Scenarios for exposure to the toxicant.

3. Characterization of health effects.

4. An estimate of the probability (risk) of occurrence of these health effects.

 The decision that the concentration of a certain toxicant in air is acceptable is based on a risk assessment.

 Toxicants are usually identified when an associated adverse health effect is noticed. In most cases, the first intimation that a substance is toxic is its association with an unusual number of deaths. Mortality risk, or risk of death, is easier to determine for populations, especially in the developed countries, than morbidity risk (risk of illness) because all deaths and their apparent causes are reported on death certificates, while recording of disease incidence, which began in the relatively recent past, is done only for a very few diseases.

**Dose-response evaluation**

 Dose-response evaluation is required both in determining exposure scenarios for the pollutant in question and in characterizing a health effect. The response of an organism to a pollutant always depends in some way on the amount or dose of pollutant to the organism. The magnitude of the dose, in turn, depends on the exposure pathway.

Some characteristic features of the dose-response relationship are:

*1. Threshold.* The existence of a threshold in health effects of pollutants has been debated for many years. A threshold dose is the lowest dose at which there is an observable effect.

*2. Total body burden.* An organism, or a person, can be exposed simultaneously to several different sources of a given pollutant.

*3. Physiological half-life.* The physiological half-life of a pollutant in an organism is the time needed for the organism to eliminate half of the internal concentration of the pollutant, through metabolism or other normal physiological functions.

*4. Bioaccumulation and bioconcentration.* Bioaccumulation occurs when a substance is concentrated in one organ or type of tissue of an organism.

*5. Exposure time* and *time vs. dosage.* Most pollutants need time to react; the exposure time is thus as important as the level of exposure.

**Expression of risk**

Risk is defined as the product of probability and consequence, and is expressed as the probability or frequency of occurrence of an undesirable event. It is important to note that *both* probability and consequence must play a role in risk assessment.

The *probability,* or frequency of occurrence, of adverse health effects in a population is written as

$$P=\frac{X}{N}$$

where P = probability, X = number of adverse health effects, N = number of individuals in the population

If the adverse effect is death from cancer, and the cancer occurs after a long latency period, the adverse health effects are called latent cancer fatalities, or LCF. *Relative risk* is the ratio of the probabilities that an adverse effect will occur in two different populations. For example, the relative risk of fatal lung cancer in smokers may be expressed as

$$\frac{P\_{s}}{P\_{n}}= \frac{\left(^{X\_{s}}/\_{N\_{s}}\right)}{\left(^{X\_{n}}/\_{N\_{n}}\right)}$$

where Ps: probability of fatal lung cancer in smokers

Pn: probability of fatal lung cancer in nonsmokers

Xs = fatal lung cancer in smokers and Ns: total number of smokers

Xn: fatal lung cancer in nonsmokers and Nn: total number of nonsmokers

Relative risk of death is also called the *standard mortality ratio* (SMR), which is written as

$$SMR=\frac{D\_{s}}{D\_{n}}= \frac{P\_{s}}{P\_{n}}$$

where Ds: observed lung cancer deaths in a population of habitual smokers, Dn: expected lung cancer deaths in a nonsmoking population of the same size.

In this particular instance, the SMR is approximately 11/1 and is significantly greater than 1.

Risk may be expressed in some ways:

1. Deaths per 100,000 persons
2. Deaths per 1000 deaths

**Example:**A butadiene plastics manufacturing plant is located in Beaverville, and the atmosphere is contaminated by butadiene, a suspected carcinogen. The cancer death rate in the community of 8000 residents is 36 people per year, and the total death rate is 106 people per year. Does Beaverville appear to be a healthy place to live, or is the cancer risk unusually high?

Given: the annual cancer death rate in the United States is 193 deaths/105 persons, and the death rate from all causes is 870 deaths/105 persons. The expected annual death rate in Beaverville from cancer is thus

$$\left(\frac{193 deaths}{100000 persons}\right) \left(8000 persons\right)=15.4 deaths$$

And the expected death rate from all causes is

$$\left(\frac{870 deaths}{100000 persons}\right) \left(8000 persons\right)=69.6 deaths$$

The annual SMR for cancer is thus

$$SMR \left(cancer\right)= \frac{36}{15.4}=2.3$$

For all causes of death, the annual SMR is

$$SMR \left(total\right)= \frac{106}{69.6}=1.5$$

**Ecosystem risk assessment**

Regulation of toxic or hazardous substances often requires an assessment of hazard or risk to some living species other than *homo sapiens,* or assessment of risk to an entire ecosystem. Methods for ecosystem risk assessment are now being developed. Ecosystem risk assessment is done in the same general way as human health risk assessment, except that identification of the species at risk and of the exposure pathway is a far more complex process than in human health risk assessment.