Technical Topics:

Exposure Pathways

What is exposure?

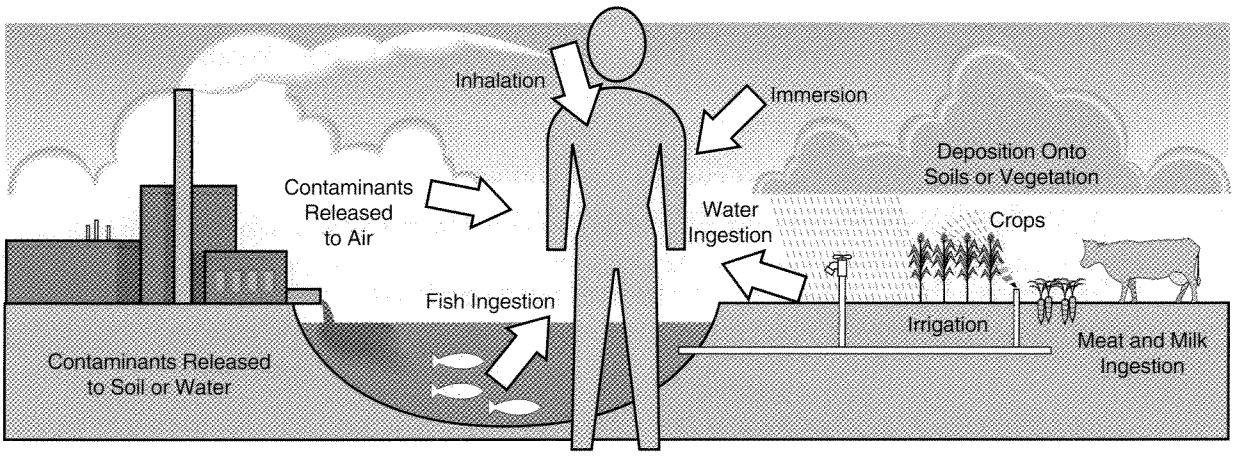
Exposure is defined as "the state of being exposed, especially to the forces of nature;" to expose means "to subject or lay open to something undesirable or injurious" (Webster's II: New Riverside Dictionary, 1988).

What is a pathway?

A pathway, or path, is defined as "the route or course along which something moves" (Webster's II: New Riverside Dictionary, 1988).

What is an exposure pathway?

An exposure pathway is a key element in assessing potential risks to human health. The meaning of the phrase combines the definitions of both words. In a risk assessment, exposure pathways identify how hazardous substances can move through the environment from a source to a point of contact with individuals. Exposure pathways combine two concepts: (1) movement of a substance from the source of contamination through the air, surface water, groundwater and/or soil; and (2) the likelihood that someone might eat contaminated foods,



Technical Topics: This series of papers explains the research design, methods and terminology used in the State of Colorado's health studies related to the Rocky Flats Plant. For information about this ongoing research to identify past contaminant releases from the plant and assess potential health risks, call the Colorado Department of Health at (303) 692-2640 or 692-2652.

COLORADO
DEPARTMENT
OF HEALTH

drink contaminated liquids, breathe contaminated air, come into direct contact with the substance or experience penetration through the skin surface.

What are some examples of exposure pathways?

Exposure pathways can exist under many different circumstances. Toxic substances can be released from a facility or source of contamination during normal, everyday operations or unintentionally through leaks, spills, fires or other accidents. After release, contaminants can move or be transported through the environment by various means.

For example, air emissions from an industrial facility's stack might contain contaminants in the form of gases or small particles. These substances can be carried by the wind and eventually deposited onto vegetation, soils or water surfaces. Air emissions from accidental releases or normal operations have been identified as the primary source of past contaminant releases from the Rocky Flats Plant.

Some facilities discharge treated or untreated liquid wastes into streams, ponds or lakes or into groundwater below the surface. Contaminants can be released directly to the soil and become attached to soil particles or seep into the groundwater. Plants can absorb certain substances directly through their roots from the soil or groundwater or from groundwater used for irrigation. Runoff from rain and snow can carry contaminants into surface water bodies. Wind can lift particles from the ground and carry them from one location to another.

Contaminants can take a combination of routes from their source of release to locations where people can be exposed. Exposure occurs when people breathe contaminants carried in the air (inhalation pathway), eat contaminated fruits or vegetables or drink contaminated water (ingestion). Accidental ingestion of contaminated soil can also occur while working or playing in contaminated areas.

Fish and animals can be exposed in the same ways, and, in turn, people might eat fish or meat that contains toxic substances or drink contaminated milk. People can also be exposed through external contact, such as swimming or washing in contaminated water (dermal contact). Finally, with certain forms of radiation, including solar radiation, X-rays or gamma rays, exposure can occur without direct contact with contaminated materials. This pathway for certain types of radioactivity is called the immersion pathway.

Is it possible to have a contaminant release without exposure occurring?

Yes. Even if a hazard or source of contamination exists, there will be no risk to human health unless exposure is likely to occur. Not all contaminants released to the environment reach points of contact with individuals by all pathways. For example, some chemicals attach or bind tightly to soil particles, which would prevent those chemicals from being washed by precipitation into the underlying groundwater. Individuals using groundwater for drinking or other purposes would not be exposed to those contaminants via this pathway. In this case, the

groundwater exposure pathway is termed "incomplete" and the risk assessor would conclude that it does not contribute to increased health risks. "Complete" pathways are those by which contaminants have reached or are likely to reach points of contact with individuals and are therefore analyzed in depth in a risk assessment.

Why are exposure pathways important in analyzing health risks?

A key step in risk analysis is determining the means and likelihood of exposure. This is done by identifying all complete exposure pathways and evaluating the significance of each pathway as a potential means of human exposure. The risk assessor uses information on sources and amounts of contaminants released and their expected movement in the environment to evaluate exposure pathways. Pathway analysis is essential to estimate the degree of exposure and the potential health risks.

How do scientists analyze exposure pathways?

Scientists consider several factors in evaluating exposure pathways, such as:

a) Source and nature of the contaminant release: the type of substance, how much was released and by what means (air emissions, discharge to water, spills, infiltration through the soil, etc.).

b) Physical and chemical properties of a substance: the form it takes and how it moves in the environment. For example, each substance or chemical compound normally exists in one of three forms: solid, liquid or gas. Some, but not all, compounds can change from one form to another under certain conditions. Some substances dissolve in water while others tend to settle to the bottom. Some contaminants will evaporate when exposed to air; others can be suspended in the air as very small particles. Contaminants in gaseous form can be carried in the air or can move below the ground surface through soil and rock layers.

c) Features of the physical environment: natural pathways or barriers formed by mountains, hills, valleys, streams, lakes, underground rock, groundwater formations, vegetation and different types and layers of soil.

d) Man-made structures such as buildings, roads or underground systems that change the natural environment and can affect contaminant movement: for instance, buildings disrupt air flow; roads can serve as barriers to surface movement; and pumping of water wells can affect the pattern of groundwater movement.

e) Development patterns and land uses: residential, commercial and industrial areas; schools, hospitals, recreational areas and other special facilities; agricultural and grazing lands, etc.

f) Number of people living or working in an area, and their physical characteristics and lifestyle factors that can affect exposure: age, sex, physical condition, occupation, eating habits, etc.

After evaluating exposure pathways, what is the next step in assessing health risks?

Analyzing health risks is a complex process involving several steps. The process begins by identifying a hazard or source of contamination and estimating the releases (source terms). Mathematical modeling is used to reconstruct how the contaminants were dispersed and moved through the environment. After evaluating exposure pathways to determine the likelihood of human exposure, the risk assessor estimates the doses, or quantities of contaminants, that people could have received. Information about the toxic effects of each substance, along with the estimated doses and the means of exposure (inhalation, ingestion, dermal contact or immersion) are then analyzed to determine the potential health risks.

Recycled Paper/Soy-based Inks

10/93