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MULTIMEDIA ASSESSMENT OF HUMAN EXPOSURE

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INTRODUCTION

Exposure assessment is the measurement or estimation of the intensity, frequency and duration of human contact with sources or agents of risk. In this case we consider a special class of risk agents: environmental contaminants. Humans contact contaminants in the environment through the air, water soil and food surrounding them. Commonly exposures are described in terms of exposure routes such as ingestion, inhalation, and dermal absorption, through which physical contact with contaminated media occurs (Fig. 1) (11). The specific method of measuring or modeling exposure, as well as the units and form of expression used, are dictated by the end use to which the exposure assessment will be put. Different approaches to exposure assessment are appropriate depending on the nature of the health endpoint of concern (e.g., cancer, reproductive outcomes, immunological effects), the nature of the decisions to be made (e.g., facility siting, waste site cleanup), and the specific characteristics of the population of concern (e.g., children, the elderly, pregnant women).

MONITORING CONTAMINANT CONCENTRATIONS

Exposure assessments range from those in which the estimates of environmental concentrations are monitored at the point of human contact, to those that focus on characterizing sources of pollutants and using mathematical models to predict environmental transport. In the former case individuals may be outfitted with personal monitors in order to obtain individualized measurements of exposure or pollutant concentrations are monitored at fixed sites, for example in residential areas or on the perimeter of hazardous waste sites and industrial facilities. In the latter case, the flux of contaminants emitted by industrial exhaust stacks, outfall pipes or leaking tanks is monitored. These mass fluxes are then coupled with models requiring information about meteorology, physical/chemical properties of the pollutant, human behavior and activity patterns, and other information to gauge the extent of exposure to individuals and populations of concern.

Monitoring activities range from those intended to collect information about ambient conditions and environmental quality generally to those in which extremely targeted locations and populations are the focus. Sampling may be designed to capture short and long term variations in conditions or to inform exposure assessors about spatial variability (14). In general for ambient sampling, stationary samplers are installed to collect any of a very broad range of pollutants under a variety of conditions. Size and bulkiness of the sampler are usually not an obstacle in this type of monitoring; however, the applicability of the collected data may be complicated since the samplers are generally not positioned in a location where human receptors are always present. Uncertainty about actual human exposures is unavoidable when ambient monitoring supplies the only available data. Personal monitors by contrast must be small, quiet and portable, yet they provide data directly related to the exposure of specific individuals. Personal monitors for air pollutants may be passive samplers such as badges or small tubes worn on the lapel (or another location near the nose and mouth) or active samplers incorporating battery operated pumps directing the air flow through a filter or sample collection medium. Although extremely accurate, personal monitoring is not always feasible, since it may be perceived as inconvenient or intrusive by human subjects. These monitors also may require fairly long sampling periods (up to a week at ambient concentrations) to collect sufficient sample for analysis.

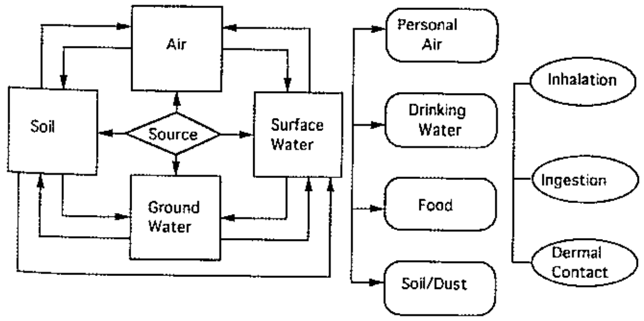

Fig. 1. The progression from contaminant sources through routes of human exposure.

MODELING CONTAMINANT CONCENTRATIONS

When personal monitoring is not feasible and only data from stationary monitoring sites is available, one must resort to mathematical modeling techniques in order to estimate individual human exposures. A variety of fate and transport models is used to describe the distribution and potential transformation of contaminants in the environment, linking concentration measurements from monitors with concentrations at the point of human contact. Contaminants may be transported some distance within a single medium, or may be transported between media many times before human contact occurs. Simple box models assume homogeneous, well-mixed volumes of water, air, soil or biota, with a known mass of pollutant under equilibrium conditions. In cases where complex conditions exist, box models may be replaced by plume models, multicompartment models or others. Since all models are necessarily simplifications of the real world, there is uncertainty associated with their predictions of real world phenomena. Always, the selection of an appropriate model requires a balance between the simplicity of the model and the value of the information provided.

Plume models, also called Gaussian dispersion models, describe the distribution of a pollutant emitted to air (or other medium) in three dimensional space. The most commonly used air dispersion models are the Industrial Source Complex (3) short term (ISCST) and long term (ISCLT) models. The former takes meteorological data in hourly format and calculates average hourly air concentrations across space, while the latter is concerned with annual averages. These models are approved and recommended by EPA for handling complex terrain, building downwash or multiple sources of pollutants and for identifying points of maximum impact due to pollutant sources.