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RISK ASSESSMENT AND THE INDOOR AIR ENVIRONMENT

by

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Introduction

The framework of all environmental research is risk assessment. Results from risk assessment are communicated to policy makers who select one of various options by a process called risk management. Risk assessment is the science component, risk management is the policy component, they combine to reach the desired goal: protection of the public from pollution, disease, and other adverse effects.

The issue at hand is whether risk assessment as practiced conventionally is appropriate and/or sufficient to address concerns of the indoor non-industrial environment. The answer is clearly NO - risk assessment practices do not address comprehensively the needs of indoor air environment. To put it in another way, policy makers will not assure a healthy residence unless they expand the domain of a currently practiced risk assessment.

The need for broadened risk assessment research will be addressed in this paper. An overview of the risk assessment process is presented first, it is followed by the indoor air perspective, which in turn leads to a desiderata set for assuring a healthy residence.

An Overview of Risk Assessment

Four elements combine to assess the risk associated with a pollutant, a mixture of pollutants or a pollution event. The four components of risk assessment are: (1) Hazard Identification; (2) Dose-Response; (3) Exposure Assessment; and (4) Risk Characterization.

Hazardd Identification determines whether exposure to a contaminant causes an adverse health effect. While this step does not seek quantitative results, it does require review of all relevant data including epidemiology, animal-bioassay, physical and chemical structure of the contaminant, and in-vitro research data bases. Hazard identification as practiced today (at least in The United States) focuses primarily on carcinogenicity, it identifies whether exposure to the contaminant under investigation causes cancer. This restriction has a pronounced impact on risk assessment practices and constitutes the nucleus of the difference between risk assessment in general and risk assessment for indoor air concerns.

The data-response element of risk assessment establishes a quantative relationship between the dose administered and response (health impact) caused to humans.

Dose-response studies involve epidemiology data and animal test data. Both result to uncertainties, and require modelling work to extrapolate to lower doses than the experimental ones and to humans from animal data. There is a plethora of methods for such extrapolation models, all do not lead to simil,ar results, some are used more frequently than others, but there is no scientific basis for selecting one model over another. If carcinogenicity is the only concern, dose-response research is applicable to all environments, if, however, the response domain is enhanced to include other adverse effects, then different response concerns enter for the indoor point of view.

Exposure assessment quantitates public exposure to a pollutant and it estimates the impact of changing conditions. Exposure to an air contaminant is the union (product) of pollutant concentration and (multiplied by) the time the public is exposed to that level of concentration. Typically, models are used to estimate pollutant concentrations as a function of emission rates. Concentrations are usually estimated for the outdoor environment or for the workplace (industrial) environment. For such coarse estimates of exposure, time periods of exposure are predetermined at the 24 or 8 hour level. The indoor air requirements may be much more detailed and impose greater demands on all models used to estimate public exposures.

Risk assessment is the synthesis of inputs from information arrived at by the other three elements of risk assessment. It estimates the incidence rate of the adverse health effect associated with the agent under consideration. Furthermore, risk characterization is the communication link transferring information to policy makers, who combine it with other economic, social, and political inputs in order to reach decisions and direct action.

Desiderata for Indoor Air Risk Assessment

The risk assessment process for indoor air will preserve the principal structure of conventional risk studies, but it will enlarge the domain of each ot its four elements.

Present practices of the hazard identification step seek to determine whether exposure to the subject agent causes cancer. In principle a no hazard (i.e., no concern) response leads to a conclusion of no action. This may be justified for the healthy population and indeed for the industrial work force. It is not sufficient for the residental environment where exposures may not be volunteer exposures and where the infirm, the young, and the elderly (i.e., the susceptible) spend most of their time. For indoor air, non-industrial concerns, or in order to achieve a healthy residence, the hazard domain must be expanded to include morbidity, stress, annoyance/odours, and reduction of productivity. This expansion of interest in hazard identification has pronounced impact on the other three elements of risk assessment.

Conventional dose-response efforts focus on translating observed data to levels of relevant data. The concern is exacerbated in the indoor environment where morbidity (not fatal illness), stress, annoyance, and productivity is of equal concern with mortality. The state-of-the-art varies considerably from no work whatsoever on dose and productivity response, to considerable work on stress/ annoyance, and to several well designed studies on morbidity. The major problem of current dose-response practices is extrapolation to low doses and determination of effects, if any, at these low levels. Indoor air adds to this problem by lowering the dose level, broadening the response domain, and focusing on synergistic effects. Realization of indoor air quality demands will lead to dose-stress tests, indoor sensory studies, chamber experiments on productivity, and social surveys that include pollution concerns.

Exposure Assessment is conventionally based on ambient concentrations and on occupational concentrations. Up to 90 % (experts assert up to 98 %) is spent indoors in environments, which are very complex from the point of view of air pollution. Typically exposures are based on ambient concentrations estimated by models using emission rates from a few well-defined major sources. Population data are obtained from small segment of populations and extrapolations to national populations are made on the basis of multiple assumptions. The uncertainties are great and efforts are made to reduce them.

Exposure estimations in indoor environments are more difficult for the following reasons: (1) there are many distinct indoor environments (microenvironments) , which exhibit their own distribution of pollutant concentration, we must identify the optimum number of microenvironments; (2) individuals spent a varying time in each of these microenvironments, therefore, we need polulation activity patterns; (3) indoor air pollution is affected by emissions from any indoor sources, consequently all such sources must be identified, along with pollutants they emit and their "use" pattern; (4) even though observed indoor air pollution concentrations are sufficient to validate indoor air models, these models are complex and depend on emission rates, air exchange rate, and indoor sink rates, the data base for values of these parameters needs additional documentation; and (5) the union of indoor concentrations and time spent in each microenvironment defines exposure, we must optimize the density of relevant time intervals. Presently, it varies from a minute by minute estimate of exposure (CO Denver Study) to weekly or bi-weekly exposures to VOCs. Research is needed to establish the optimum time for risk assessment, this interval may be pollutant dependent.

A typical risk characterization is complex undertaking, which is defined for specific occupational populations and for a specific illness. The task becomes much more complex when one refers to a heterogeneous population (the

national population) and to a very broad domain of adverse effects. The risk is extremely difficult to characterize because: (1) the statistical uncertainties increase markedly; (2) the biologic uncertainties are even larger since the effects have increased for indoor air environments; (3) the source(s) of the effect is not always identifiable, consequently control suggestions may be inefficient; and (4) populations for immediate protection are difficult to specify as are populations that easily exemplify the problem under investigation.

It is the author's contention that risk characterization for indoor environment is a unique assignment, which relates only peripherally to the conventional fourth step of risk assessment. In short, the expert who characterizes the risk of indoor air pollution must first define his trade and then proceed with the synthesis of hazard identification, dose-response, and exposure assessment data.

Acceptable Risk and the Healthy Residence

The goal of risk assessment is to protect the general public (incl. the infirm, young, and elderly), to assure non-hazardous exposures of the public continuously and to provide for reasonable safety of margins from disease associated with indoor air. This qualitative set of requirements when fulfilled lead to the healthy residence. To fulfil this set of requirements we must quantitate them. For a carcinogenic pollutant, a lifetime risk of 10-6 is considered by American authorities insignificant and consequently acceptable. Is such a level reasonable for non-carcinogenic morbidity related risks? For the population of the U.S.A. such a constraint leads to a statistical three excess cases of illness per year per exposure to a pollutant for a lifetime of 74 years. More realistically, estimations lead to 200,000 excess lower respiratory illness per million per year per ug/m^3 of NO_2. The difference is vast and causes a twofold concern: (1) is quantitative risk assessment (the four-step process discussed) and appropriate tool for non-carcinogenic pollutants; and (2) no guidelines exist to perform morbidity risk assessments. The response is clear: risk assessment must not be limited to carcinogenicity, consequently the indoor air quality community must establish guidelines that define acceptable risk, or what is the same, to define "healthy residence"; otherwise members of this technical community may use the same words to mean different concepts. Focus on indoor air environments is required because total elimination of outdoor pollution will not eliminate risks associated with air pollution since the indoor air pollution component of environmental risk is substantial.

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