Assessing the Cancer Risk of Indoor Environments

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The indoor environment is host to many actual and perceived ills including allergies, asthma, headache, fatigue and others. There are also concerns regarding the presence of cancer-causing chemicals that can increase an occupant's risk of contracting cancer. There are various estimates of the percent of cancers that are environmentally-related. These estimates range from a low of 4% to a high of 30%.

In reality, we really do not know exactly what percent of human cancers are caused by exposure to chemical carcinogens. Estimates of environmentally-related cancers assume various levels of chemical exposure in the general population and calculate cancer risk based on these chemical levels. However, the overall levels of exposure to cancer causing chemicals in the in- door environment are not well studied. Cancer generally takes years to develop and the average person is literally exposed to hundreds of hazardous chemicals each day. In addition, the chemical mixture in furnishings, finishes and building materials is constantly changing.

On the other hand, Indoor Air Quality Professionals and public health scientists are some- times called upon to estimate cancer risk from a particular indoor chemical exposure situation. A common situation involves exposure to chemicals leaking into homes from hazardous waste sites. The chemicals may be in the groundwater or they may be migrating into people's homes through soil gas permeation into basements or through other routes.

In evaluating these chemical exposure scenarios, public health professionals and scientists use a risk assessment model to assess the cancer health risk. Risk assessment models have evolved since the early 1960s. The models all make various assumptions in order to estimate cancer risk.

One of the primary assumptions is that cancer incidence rates from animal toxicity testing can be applied to humans. Other assumptions include adjustment of this animal data based on differences between humans and animals including weight, skin surface area, lung volume, breathing rate and so on. Given that we normally do not conduct toxicological experiments on humans, it would appear prudent to use animal data to make risk assessments. However, some will argue that we should not extrapolate animal research data to humans. Unfortunately, they of- fer no other alternative science to estimate health risks from exposure to these chemicals. This is an ongoing debate.

It should be kept in mind that cancer risk assessments are only estimates. They are not absolute and they are not causal relationships. What they are is an indicator that chemical levels in a building might be too high and a prudent person should try to reduce exposure to the identified risk chemicals.

A common unit in risk assessments is a risk of one in a million of cancer death due to exposure over a 70 year lifetime. A risk of one in a million has also been very significant from a legal view point since 1970. The U.S. Supreme Court's ruling on the OSHA benzene exposure standard stated that a risk of cancer of one in a million is not significant. This statement established the benchmark that was applied to all future risk assessments. Basically, if a risk assessment shows a cancer risk of one in a million or less, it is not a significant risk. As a consequence of this Supreme Court ruling, most risk assessment chemical exposure standards are set at a risk level of one in a million. This makes it fairly simple to compare chemical exposure levels to a chemical risk level.

LIFESTYLE CANCER RISKS

Some perspective though needs to be present- ed on these IAQ risk assessments. Life in and of itself is a risky process. Things that we do normally each day have a risk associated with them. In many cases, the risk of these ordinary daily activities can be significantly higher than that of exposure to cancer causing chemicals in the environment.

Back in the 1970s, when risk assessment was in its scientific heyday and science rather than politics was being used to establish regulatory standards, a number of interesting publications appeared quantifying the risks of everyday activities. Natural foods sometimes contain carcinogens. This includes rotten peanuts, sassafras, ethanol, flame cooked meats, to name a few. Ra- don, cosmic radiation and UV radiation are all natural sources of radiation exposure, which also increase the risk of cancers.

One table that was developed from these publications was called the "Mortality Lottery." It shows common everyday activities and their one in a million risk factors for premature death.

However, a very huge factor is missing from a simple comparison of a chemical exposure level to cancer risk level. What we don't know, in most cases, is what is the exposure to these same chemicals in our food, water, occupational setting, hobby activities, etc Another major factor that is missing from a simple risk comparison is the combined effect of exposure to multiple carcinogens.

The effects can be additive or worse, synergistic. What this means is that the risk of environmentally caused cancer based on a comparison of a chemical exposure level to a risk assessment chemical level, will always underestimate the actual risk because of exposure to the same or other cancer causing chemicals from other sources in the man made environment..

CONDUCTING AN ASSESMENT

The first step in performing an indoor air quality cancer risk assessment is to conduct air monitoring for known carcinogenic chemicals. The U.S. EPA and NIOSH have established chemical test methods for targeting these known chemicals. The typical EPA test methods are TO 14 and TO 15. However, there are numerous other test methods.

Each of these methods involves the use of an evacuated stainless steel canister. These canisters come in various sizes depending up the situation to be monitored. Typically for most IAQ situations, a 1 liter canister is used. The canister is placed in the home where the occupants spent most of their time. In most cases, this is the bed- room. On the other hand, in situations where exposure levels in the basement or other intrusion area are greater, one of these areas is selected The control valve on the canister is opened in the area to be evaluated to allow air to enter the canister at a very slow rate. This slow fill rate, allows air monitoring over at least a 24 hour period and sometimes much longer. This long monitoring time allows one to document long-term average exposure levels, rather than the variable conditions that can occur during the day. The evacuated canister is usually supplied by the analysis laboratory. Analysis costs are $150 to $300 per canister depending upon the laboratory and the complexity of the analysis.

Unfortunately, in certain parts of the country, the background level of chemical carcinogens in the air is not zero. What this means is that background levels can be a significant component in daily exposure. These background lev- els will also limit what can be done effectively to reduce exposure levels. Consequently, it is necessary in many situations to sample the out- side air at the same time indoor air is being test- ed to make an accurate assessment of the indoor contribution to chemical exposure levels. Once the air in the cylinder is analyzed, you will get a report showing the chemical concentration in ppb or $\mu g/m^3$. It is good practice to request the results in the latter units, since most risk assessment standards use these international metric units.

USING ESTABLISHED IAQ STANDARDS

A number of indoor air quality risk assessment exposure standards have been established by various states in the United States. Unfortunately, different risk assessment models were used by these states to establish their standards. The reason for the use of differing models by the states is due to the Reagan administration direct- ing the federal EPA to not establish such risk based standards. (See Air Toxics and Risk Assessment by Calabrese and Kenyon.) The states were therefore left to their own means to try to assess whether low level chemical exposures presented a health risk to their citizens.

One very interesting set of risk assessment levels was established by the Santa Clara County Center for Occupational Safety and Health in California in 1995. They developed what they call Health Based Exposure Limits or HBELs. These limits include both chemical carcinogens as well as non-carcinogens.

An HBEL for a carcinogen is a concentration that is estimated to have less than a one in a mil- lion risk of cancer. For example, the HBEL for trichloroethylene is 0.00004 mg/m^3. At this concentration, the risk of an adverse health effect is less than 1/1,000,000. If one measures a concentration of 0.04 mg/m^3 in the indoor air, this is 1,000 times higher than the HBEL. Therefore, the potential health risk related to this exposure level is 1,000 x 1/1,000,000 or 1/1,000. Expressed as a percent, the potential health risk (cancer) is less than a 0.1 of 1% chance over a lifetime of long term exposure at this level.

Some people would disagree with this simplistic of a calculation of risk. These objections typically state that exposures outside of the home are unknown, life style choices are not taken into account, individual susceptibility is not quantified, poor diet, etc. all affect actual risk. Consequently, the actual risk may be lower or higher. These comments obfuscate the risk question. Excessive exposure to a chemical carcinogen is a risk; it is not necessary to quantify this risk with absolute certainty or precision.

RISK ASSESSMENT STANDARDS

Below is a list of some of the governmental agencies in the United States that have established chemical risk assessment exposure concentrations. This information, as well as standards from other countries will be summarized in a new book on International Indoor Air Quality standards due to be released in mid' 2010.

1. **Agency for Toxic Substances Disease Registry (ATSDR)**

The chemical risk exposure levels established by ATSDR are called Minimal Risk Lev- els (MRLs). A listing of MRLs by route of entry and duration of exposure is provided at the fol- lowing website: http://www.atsdr.cdc.gov/mrls/ index.html

2. **California Office of Environmental Health Hazard Assessment (OEHHA) Proposition 65 (Prop 65)**

The chemical risk exposure levels established by OEHHA are called No Significant Risk Lev- els (NSRLs) or No Observable Effect Levels (NOELs). The standards address both cancer and reproductive risk. The list of Prop 65 Chemical is available at the following website: http://www. oehha.ca.gov/prop65/prop65_list/Newlist.html The list of NSRL/NOELs is available at the following website: http://www.oehha.ca.gov/ prop65/getNSRLs.html

3. Federal EPA Integrated Risk Information System (IRIS)

The federal EPA has a database of health effects that may occur from exposure to chemicals found in the everyday environment. he database contains reference concentrations (rfc), reference doses (rfd), and other toxicological information. There are detailed reports on a number of well-known toxic chemicals. The list of IRIS Substances can be found at: http://cfpub.epa.gov/ncea/iris/index. cfm?fuseaction=iris.showSubstanceList IRIS Guidance Documents are available at: http://www.epa.gov/ncea/iris/backgr-d.htm#risk

4. Santa Clara County (California) Center for Occupational Safety And Healh (SCCOSH)

The Santa Clara County HBELs are avail- able from: Santa Clara Center for Occupational Safety and Health, 720 N 1st. St, San Jose, CA 95112.

5. Michigan Department of Environmental Quality

These include the Initial Risk Screening Level (IRSL), which is defined as an increased cancer risk of one in one million (10-6), and the Secondary Risk Screening Level (SRSL), which is an increased cancer risk of one in one hundred thousand (10-5).
They are available at the following website:
http://www.michigan.gov/deq/0,1607,7-135- 3310_4105-11754--,00.html

6. New Jersey Department of Environmental Protection

The NJDEP Air Quality Permitting Program uses unit risk factors and reference concentrations in a risk screening process to evaluate potential health effects from air toxins. This information is available from the NJDEP Air Quality Permitting Program. They include Technical Manual 1003: Guidance on Preparing a Risk Assessment Protocol for Air Contaminant Emissions. The specific chemical risk levels are presented as “Unit Risk Factors for Inhalation” and “Reference Concentrations for Inhalation.” They are available at the following website: http://www.state.nj.us/dep/aqpp/risk.html

7. Texas Voluntary Indoor Air Quality Guidelines for Government Buildings

The current guidelines, while voluntary, went through a required Texas Department of State Health Services rule-making process and are embodied in the Health and Safety Code sections 297.1 – 297.10.
They are available at the following website: http://prestidigitatorialaq/SchoolsGuide. shtm#IAQ_c

REDUCING EXPOSURE LEVELS AND RISKS

Reducing exposure levels in homes and other building can be a significant challenge. Fixes are not absolute and they are often costly. However, some homeowners will want to pursue risk reduction measures.

In cases where soil gases are leaking into a home or building through the basement floor a sub slab depressurization ventilation system can be installed. This is essentially the same as a radon control system. In situations where pesticide residues from wall cavities are leaking into a home, a positive pressurization energy recovery ventilator can be used to slightly pressurize the home. In cases where excessive amounts of chemicals are coming from interior furnishings, such as new carpet or cabinets, additional fresh air needs to be brought into the home.

Evaluating cancer risks in the indoor environment can be a challenging task. However, recommended exposure limits, sampling methods and risk assessment protocols do exist. With proper training and equipment, this expertise can be part of an Indoor Air Quality Professional’s repertoire.