Report from the Euro-CASE workshop in Mainz on 05.03.1999 »Indoor Air Pollution: the Enemy Within"

Organized by H. Greim

1. Introduction

In line with the discussion on the impact of air pollution on human health the quality of indoor air is of great relevance, because indoor air usually contains higher concentrations of chemicals than ambient air and the European population spends most of its time indoors. In general, people spend 50% of their time at home, 20% in other indoor locations, 5% in transit and 20% outdoors. These figures vary according to country, season and time of day.

It is widely recognized that there are diseases due to high exposure of chemicals or biological material. Others, who feel unwell as a result of the indoor environment, are truly sick, although the sickness mostly is psychosomatic. Each of these groups requires medical care but the cause of the diseases have to be carefully evaluated.
The workshop brought together people of different countries and backgrounds to discuss sources of pollution and their regulations, metrology and exposure, health impacts and possible solutions.

2. Metrology

The indoor environment depends on various factors: strength of the sources, human activity, ventilation, climatic conditions, chemical reactions and sinks. Finally, infiltration and ventilation result in a permanent exchange between indoor and outdoor air. Therefore, sampling should take into account ventilation, occupants, temperature, relative humidity, traffic and season. To determine the contribution of ambient air, parallel outdoor measurements are required. Samples should be taken in the vicinity of the building not closer than 1m.
Sampling duration should also consider the nature of the substances under consideration. For example, substances that induce acute effects usually require short-term sampling. Others that induce chronic health effects require long-term sampling.
Sampling duration also depends upon the limits of the analytical method. Substances in ultra trace concentrations like polychlorinated dioxins and furans require appropriate sampling periods.
To determine allergens, it is preferable to use airborne samples. Mite allergens are coupled with larger dust particles. Homes are the primary source but high concentrations are also found in cinemas or hotels.

Thus, determination of indoor air concentrations requires optimal sampling strategies. The German VDI Guideline (Series 4300) includes eight parts: general aspects of sampling strategy; PAH, PCDD/PCDF and PCB; formaldehyde; PCP and lindane; nitrogen dioxide; VOC; ventilation rate; sampling of house dust. International standards are established in ISO TC 146 on Air Quality, which includes a subcommittee on indoor air (SC 6). The recommendations are based on contributions from Germany, SF, the US and the UK.

3. Exposure assessment

While concentration is the amount of substance in the air, exposure of an individual or a population is the product of concentration and time. Since the inhabitants move constantly, individual exposure is the sum of all concentration over a certain time.
Exposure analysis by interviews, questionnaires or diaries may be erroneous because people may lie, underestimate or be unaware of exposure. An indirect method is environmental monitoring by stationary samplers. More costly but objective is the direct survey of the individuals activities including exposure estimation. The most reliable data are obtained using personal samplers or biomonitoring procedures e.g. determining the compound or its metabolites in urine or blood.

Probabilistic Exposure Assessment, also known as the Monte Carlo Technique, attempts to gain a more objective, realistic idea of exposure. It measures concentration at many points within a defined space and takes into account variables such as the height and age of the exposed people. Both have significant influence on respiratory uptake.

There is increasing evidence that bacteria and moulds are hazardous indoor pollutants. A German study on 14 office buildings demonstrated that outdoor levels of bacteria are far lower than indoors. They are similar in normally ventilated buildings and in those with air conditioning. Molds grow particularly in sealed buildings where humidity levels are high. They are higher in ventilated buildings, despite the use of effective filters. Buildings using spray humidification show higher mold levels than those using steam humidification.
Air inlets also influence the level of bacteria and mould. Buildings that use induction and laminar flow bring large amounts of air into the room. This is particularly common in office buildings. European builders increasingly avoid recirculation systems.
The study of moulds requires familiarity with mould development patterns in outdoor air throughout the year. From November to April mould levels are usually low. They rise in May and reach peak levels in August indoors and outdoors.

So far it is not possible to draw firm conclusions unless additional information is required. This must include techniques to better detect viruses in indoor air as well as data on dose-response characteristics of. Methods for detection of bacteria, fungi, endotoxines and chemicals like β-glucane and MVOC must be harmonized. Finally, technology and design of structures and products commonly used indoors must be improved.

4. Health Impact

Generally, all biological and chemical airborne elements pose a threat to human health. Irritation of skin and mucous membranes, respiratory problems, systemic effects and sensory effects are mostly linked to chemical substances. Infections, allergies and genotoxicity usually are of biological origin. The latter are considered far more dangerous because viruses and bacteria cause mortality and morbidity approximately four times as frequently as do allergenic substances, carbon monoxide, household products or formaldehyde.

The most widespread allergic airway disease is asthma. In a population of South Wales the incidence of asthma, eczema and hay fever doubled between 1973 to 1988. The Western lifestyle, characterized by smaller families, industrialization, vaccination programs, increasing consumption of antibiotics, poor ventilation, constant temperature levels, and indoor allergen exposure, was blamed.

Allergic or atopic diseases begin when T-cells respond abnormally to specific elements e.g. mite allergens, pollen allergens, etc. This leads to hay fever or asthma, whereby the lungs become inflamed and hypersensitive. Unspecific stimuli such as cold air or infection provoke more severe reactions than should normally exist.
Asthma or »airway hyper-responsiveness" can be developed by certain risk factors. According to studies carried out in New Zealand and in Germany, the odds of being affected by asthma are twice as high in people who are allergic to household dust or cats. These are the major indoor allergens in Northern Europe and the United States. In house dust the predominant allergen is mite debries and excretes. The household mite lives indoors, preferably in mattresses, where human skin cells and optimal temperatures are available. Exposure to allergens in earlier life more likely results in the development of allergies than exposure later in life. In humid areas, cockroaches and moulds constitute other forms of allergens. In general, clear correlation exist in children between exposure to mite and cat allergens and the families' socio-economic status: those with lower incomes were more likely to present high levels of allergens. High-exposure induces sensitization after shorter time of exposure e.g. to cat hair (1 year) than lower exposed. Sensitization to cats and mites in early life (2^{nd} and 3^{rd} year) more likely leads to symptoms, such as wheezing or bronchial hyper-reactivity than later exposure. Cat hair appear to be more potent than mites and higher exposure results in a higher risk of having asthma. However, genetic predisposition has a major impact because the chances of becoming asthmatic do not necessarily increase when genetic conditions are not conducive to allergies.

These conclusions have a major impact on prevention methods. In families at risk mite allergens, tobacco smoke and pets must be avoided and special guidelines on nutrition should be provided. However, asthma does not only result from indoor exposure so that other reasons must also be considered.

5. Regulations of Indoor Pollution

Standards must be simple in order to be understood, applied and verified. Although many chemicals and biological materials are found indoors only a few are regulated and it is difficult to reach consensus on standards. In Germany it is four primary groups of pollutants: asbestos (1991), polychlorinated biphenyls (1993); pentachlorophenol in buildings (1996); and polycyclic aromatic hydrocarbons (1999). In addition tetrachloroethene concentrations in buildings near dry cleaners are regulated.
This has resulted in significant decreases of indoor air concentrations. Asbestos and PCBs levels have fallen significantly. Being persistent and found in food, blood and mothers' milk, the latter caused particular concern. They have decreased by at least 50% since the mid-80s. Pentachlorophenol levels have also fallen. In the 95th percentile, blood levels decreased from 70 μg/l in the mid-80s to

6 μg/l. Decreasing exposure to polycyclic aromatic hydrocarbons are also considered a consequence of the regulations.
Future regulations require consideration of the actual risks. Whereas the individual lifetime cancer risk from asbestos exposure is about 1 in 100 000, the chances of contracting cancer from passive smoke at home is 1 in 1 000. Despite this, the German Parliament could not agree on a law against environmental tobacco smoke. Even higher are other risks e.g. of lung cancer due to radon exposure or the risk of heart attack due to extended exposure to traffic noise.
Although there is general acceptance that certain indoor situations affect human health, standard proposals repeatedly have failed for various reasons. Even when standards had passed the initial barriers, they are subject to public review and repeatedly became rejected or weakened. Due to its enormous influence the tobacco industry was reported to have interfered with attempts to regulate passive smoke exposure. Abandonment of ASHRAE Standard 62 was the result of controversies over phrases such as »ventilation rates assume a moderate amount of smoking". Smoking lobbies wished to retain this stipulation while their opponents could not accept that smoke be part of a »normal" air environment.

Finally, indoor air quality regulations must take into account the indoor environment (emissions, building products, hobby articles, consumer goods, etc.). So far no legislation had included this aspect, even the new European Framework Legislation.

6. Discussion

The discussions following the different presentations provided further information on several aspects.
Indoor air pollution often can be avoided or reduced by simple measures. Air inlets should be taken from sites with little pollution. Often air inlets are located near parking facilities and even directly adjacent to car exhaust pipes. The ventilation system should be kept as clean as possible, otherwise it becomes one of the dirtiest places in a building: especially the ducts are commonly lined with dust.
Ventilation effectiveness is another important subject and encompasses the way in which the air is introduced into the room. The conventional but unsafe practice is to bring air in from the ceiling.
Moisture control is very important in controlling fungi, particularly in humid zones. It has been generally agreed upon, that in case of effective ventilation pollutants should not pose any threat.

Causes of sensitization and its prevention were another point of discussion.
The frequencies of sensitization by allergens can be different among the countries. In Germany and the UK, mite allergies are predominant, accounting for 70% of airway diseases. In Scandinavia, the major allergen source is pets; in the desert, moulds prevail.
Allergies do not only depend on exposure or age but also on lifestyle. Some researchers believe that increase in sensitivity to allergies is a consequence decreasing exposure to parasites. Since the T-cells are less active, they react to allergens. Inversely, higher incidences of infection would monopolize the T-cells and prevent them to react to allergens.
Moreover frequent consumption of antibiotics might result in increased frequencies of allergies. Anthroposophs, for example, do not allow immunization of their

children, do not use antibiotics and have strict ideas on nutrition and atopic diseases are rare in these populations. In developing countries, severe measles infections seem to lower the incidence of asthma. Consuming pro-inflammatory fats are also said to protect from allergies.
Simple measures to remove allergens from an indoor environment are not available. For example, if one removes pets or mites from a house, the allergens can remain active for years.
Although a completely protected environment can be established, it is almost impossible to entirely avoid contact with the outside world.

7. Participants

The workshop has been attended by 21 scientists of different European countries and background. The scientific presentations have been made by

Dr. David Arnold Feng (UK), Troup Bywaters and Anders;
Dr. Michael Ball (D), ERGO-Forschungsgesellschaft
Dr. Wolfgang Bischof (D), Institut für Arbeits-, Sozial- und Umweltmedizin, Erfurt
Dr. Ursel Heudorf (D), Staat. Gesundheitsamt Frankfurt
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