Indoor Air Quality in the Home

This leaflet was originally prepared by the Institute in 1997. It was produced for DoE (now DETR) as a concise summary of the IEH Assessment *Indoor air quality in the home* (Assessment A2), which is available to order from IEH. See our Web site at http://www.le.ac.uk/ieh for further details.

Much of the information on air quality received by members of the public focuses on outdoor air. However, most people spend the greater part of their lives indoors and are exposed to a variety of chemicals in indoor air. These chemicals come from a wide range of sources including furnishings, cleaning materials, gas cookers, paints, glues and so on.

An assessment based on the available literature on sources, exposures and health effects of a number of indoor air pollutants was produced and published by the Medical Research Council's Institute for Environment and Health[1]. The IEH assessment incorporated information from a report by the Building Research Establishment (BRE) on a study of homes in Avon[2]. The pollutants studied were Nitrogen Dioxide (NO_2), Formaldehyde, Volatile Organic Compounds (VOCs), House Dust Mites and Fungi and Bacteria. The purpose of this document is to present the main findings of the two reports in summary form.

Institute for Environment and Health

UNCERTAINTIES

There are a number of factors, such as social and economic status, eating and drinking habits, whether people smoke or live with a smoker and the presence of other compounds in the air, that complicate any assessment of the health effects of indoor air pollutants. Such confounding factors have to be borne in mind when looking at health risks and attempting to link substances with effects.

Nitrogen Dioxide (NO_2)

About 70% of a person's exposure to NO_2 occurs in the home. Some indoor NO_2 comes from outdoor air, but gas cookers, where present, are the major source of NO_2 indoors. Using a gas oven appears to be more important in increasing NO_2 levels than using gas rings. Studies in the UK have found higher average concentrations in homes with gas cookers (ranging from 25 to 70µg/m^3) than in homes without gas cookers (13 to 40µg/m^3). A maximum one-hour average concentration of 1115µg/m^3 has been recorded in a gas cooker equipped kitchen. Peak exposures are most likely to occur when cooking and standing close to the cooker.

The main target sites for the effects of NO_2 are the airways of the lungs. Studies indicate a potential hazard of respiratory illness in children, perhaps because of increased susceptibility to infection. However, there would seem to be no significant health effect on residents at the levels of NO_2 found in most UK homes. Nevertheless, because NO_2 is only one of a number of potentially hazardous substances produced in gas cooking, it would be sensible to encourage a reduction in exposures by using kitchen extractor hoods or fans, and trying to minimise the time spent in the kitchen when cooking.

Formaldehyde

Important sources of formaldehyde exposure indoors include urea-formaldehyde foam insulation material, particle board and chipboard, water-based paints, fabrics and cleaning agents, as well as cigarette smoke. Vehicle exhaust from outdoor air can also contribute to levels of formaldehyde in indoor air.

Effects of formaldehyde on health can include eye and airway irritation, neuropsychological and behavioural effects, asthma and cancer. However, many of these effects occur only at high exposures and there is no evidence to indicate any adverse health effects at current estimated levels in UK homes. In the BRE study, average formaldehyde concentrations were found to be 0.025mg/m^3. Most, though not all, people would be unable to sense irritation or smell formaldehyde at concentrations of 0.1mg/m^3 or below, averaged over 30 minutes. In most UK homes formaldehyde levels are probably below this.

Recent evidence indicates that newer homes have higher formaldehyde levels than older dwellings. It is important to prevent levels rising and to reduce exposure where possible.

Volatile Organic Compounds (VOCs)

The term VOCs covers a very broad range of substances. There are estimated to be 50 to 300 different compounds that could be classed as VOCs in a typical domestic indoor environment. The main sources of indoor VOCs are building materials, furnishings, furniture and carpet adhesives, cleaning agents, tobacco smoke and infiltration of outdoor air into the home. On average, levels of VOCs in the home are 10 times greater than outdoors. The BRE study found total VOC concentrations averaged 0.415mg/m^3 over a year.

The health effects of VOCs as a group are poorly defined. Whilst there is no evidence to suggest residents are exposed to individual or groups of VOCs at levels posing a threat to health, it is prudent to minimise exposure. Chamber studies show total VOC concentrations of greater than 25mg/m^3 may cause irritation and other effects. Such high concentrations are unlikely to be encountered in the home, except perhaps whilst painting or using other solvent-based products. Concern about exposure to VOCs is primarily directed at these short-term, high exposures. It is therefore advisable to

read and follow the manufacturers' recommendations when using DIY products and for example, to work in a well ventilated area, ideally outside, take frequent breaks away from the work area, and store unused products in a ventilated cupboard or outbuilding.

House Dust Mites

House dust mites are microscopic spiders that inhabit beds, carpets and soft furnishings. They feed on human skin scales and on fungi and bacteria. Exposure to house dust mites represents a potentially very significant hazard to health. This is because the mites produce a protein (allergen) in their droppings to which some people may develop an allergy. Symptoms may include asthma, rhinitis (runny nose) and eczema. However, the relationship between exposure to the protein and the development of an allergic reaction (sensitisation) is not fully understood. A general reduction in mite allergen exposure in homes should be encouraged even though the overall health benefits from such measures remain uncertain.

Outdoor factors (the season, climate, temperature and humidity) and indoor factors (temperature, humidity and ventilation) both affect mite numbers in the home. The major factor controlling mite numbers appears to be humidity, with damp unheated homes usually having higher mite levels. Lower indoor humidity and increased ventilation could contribute to reducing house dust mite numbers and hence allergen exposure. Extended vacuum cleaning may also help to reduce the severity of allergic symptoms by reducing mite numbers. Vacuum cleaners with high efficiency filters are recommended since they trap the fine particles containing the allergen. However, these measures need to be repeated regularly to prevent mite numbers from recovering.

Fungi and Bacteria

Micro-organisms, including fungi and bacteria, are important factors influencing indoor air quality. A wide range of fungal and bacterial species can be isolated from indoor air. The variety of species found alters with nutrient source, water availability and temperature. Outdoor air is thought to be an important source of fungi indoors. The BRE study found Penicillium to be the most frequently isolated fungus in indoor air; the dominant bacteria were *Bacillus, Staphylococcus* and *Micrococcus*. Both fungi and bacteria numbers are seasonally influenced, with higher levels in the summer and autumn than in winter or spring.

Several health effects (other than infections) have been associated with fungal and bacterial species in the indoor environment. These health effects include rhinitis (runny nose), upper respiratory symptoms, asthma and other effects such as allergic skin reactions, tiredness and headaches. There is consistent evidence of an association between damp and mouldy housing and reports of respiratory symptoms in children. However, it is not clear which (if any) specific organisms cause these symptoms. The small number of epidemiological studies looking at relations between airborne fungi and respiratory problems have failed to show any convincing associations. Nevertheless, it is not clear whether these uncertainties are due to limitations of the methods used to assess exposure or to a true absence of a health effect.

Temperature and relative humidity appear to be major factors influencing the levels of fungi and bacteria in the indoor environment. Mould and dampness can be reduced by improved ventilation which may help to reduce any potential health effects of fungi and bacteria indoors.

MEASURES OF EXPOSURE

When discussing gaseous compounds such as NO_2, VOCs and formaldehyde, exposures may be expressed as concentrations on the basis of weight of substance per cubic metre of air, e.g. as mg/m^3 (thousandths of a gram per cubic metre) or $\mu g/m^3$ (millionths of a gram per cubic metre). Alternatively concentrations may be expressed the volume of pollutant in air, for example as parts per million (ppm), i.e. as 1 part in 10^6 or parts per billion (ppb).
For NO_2 1ppb = 1.88 $\mu g/m^3$. For formaldehyde 1ppm = 1.2 mg/m^3

Conclusions

Indoor air quality and its impact on the health of the UK population is a subject of considerable interest and is an important area of public health policy for two main reasons. Firstly, everyone is potentially exposed. Secondly, there is a very broad range of individual susceptibilities within the population.

Based on current evidence of the pollutants considered here NO_2 and house dust mite allergen are the most important in terms of likely health effects following exposure in the home. However, carbon monoxide and environmental tobacco smoke are two other very important pollutants which have recognised health effects, and these are currently being evaluated by the Institute for Environment and Health. The hazard to health resulting from exposure to house dust mite allergen cannot at present be quantified, but a general reduction in levels is recommended. Although there are a number of uncertainties with regard to NO_2, there is some evidence for a link between exposure and respiratory illness, particularly in children. Although the health risk is probably small, measures to reduce exposure to NO_2 are appropriate and should be encouraged.

For the different pollutants considered above, there is a large variation in the amount of available information on levels in the home, degree of confidence in measuring and monitoring techniques and the evaluation of likely health effects. Factors such as age, social class, ethnic group, geographical area and type of dwelling may also influence the likelihood and type of health effects brought about by exposure to these pollutants. While for most people in the UK the risks of adverse health effects are small, the uncertainties and the potential hazard of the pollutants considered make it important to identify and reduce indoor sources and take appropriate measures to minimise exposure.

[1] IEH (1996) IEH Assessment on *Indoor Air Quality in the Home: Nitrogen Dioxide, Formaldehyde, Volatile Organic Compounds, House Dust Mites, Fungi and Bacteria,* (Assessment A2), Leicester, Institute for Environment and Health

[2] Berry, R. W., Brown, V. M., Coward, S. K. D., Crump, D. R., Gavin, M., Grimes, C. P., Higham, D. F., Hull, A. V., Hunter, C. A., Jeffrey, I. G., Lea, R. G., Llewellyn, J. W. & Raw, G. J. (1996). *Indoor Air Quality in Homes. The Building Research Establishment Indoor Environment Study,* London, Construction Research Communications

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The IEH Assessment on Indoor Air Quality in the Home: Nitrogen Dioxide, Formaldehyde, Volatile Organic Compounds, House Dust Mites, Fungi and Bacteria (ISBN 1 899110 05 4) can be obtained from the MRC Institute for Environment and Health, University of Leicester 94 Regent Road, Leicester LE1 7DD. Price £30.00.