MRC Institute for Environment and Health

Fibrous materials in the environment

A review of asbestos and man-made mineral fibres

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1 Executive summary

This report reviews the sources and uses of both natural (asbestos) and man-made inorganic fibrous materials, the levels of exposure to these fibres in the non-workplace environment and the health effects of such exposures. The report provides an overall assessment of the risks to health from exposure to fibres in the environment, together with a range of relevant recommendations.

Asbestos is a natural mineral fibre which is strong, fire resistant and an effective insulation material. These properties resulted in the industrial exploitation of asbestos, and it became incorporated into a wide range of building products. There are three main types of asbestos: chrysotile (white asbestos) and the 'amphibole' forms crocidolite (blue asbestos) and amosite (brown asbestos). Peak use occurred during the 1960s and it was around this time that the health effects associated with workplace exposure to asbestos fibres, in particular the amphiboles began to be recognised. A dramatic decline in asbestos use resulted. Only white asbestos is still used in the UK, most notably in asbestos-cement products. However, many of the asbestos materials that were put into both commercial buildings and homes some thirty or so years ago remain in place today.

The knowledge of the risks posed by exposure to asbestos in the workplace inevitably led to concerns about possible risks to the health of those exposed to asbestos materials in the non-workplace environment. Because asbestos is a naturally occurring mineral, there is a measurable level of background environmental exposure. However, considerably higher exposures can be experienced by those living in, working in or visiting buildings which contain asbestos materials.

Man-made mineral fibres* (MMMF) have been developed as substitutes for asbestos materials in certain applications. However, MMMF also have many uses which are new and unrelated to the uses of asbestos. The most prevalent of these is in insulation wools (including rockwool and glasswool), which provide both thermal and acoustic insulation. Because of some similarities between asbestos and MMMF, the possible risks to health from exposure to MMMF have also been investigated.

Sources, fibre concentrations and human exposure

Asbestos

Asbestos has been used in a wide range of building products, including roofing, cladding, thermal and acoustic insulation and fire resistant internal panelling. Uses of asbestos in the UK have declined to only 6% of the peak in the 1960s. Of the asbestos materials still marketed today, asbestos-cement is the most widely used product. Because the use of asbestos materials has declined so dramatically, the major concern is about products still remaining from past use in buildings, as some of these may release fibres into the indoor environment.

* This report uses 'man-made mineral fibres' (MMMF) to describe all fibres which are man-made rather than naturally occurring. Some authorities prefer the term 'man-made vitreous fibres' (MMVF) to reflect the nature of the majority of fibres in common use; also there is the tendency in some quarters for the word 'mineral' to be associated with 'natural' inorganic materials.

The concentration of airborne fibres in buildings depends on the presence of fibre-containing material within the building, whether there is disturbance, such as maintenance work in progress, and whether the material is in good or poor condition.

Asbestos fibres are found throughout the environment and are derived from both natural and anthropogenic (manufactured) sources. The background outdoor (ambient) levels of respirable asbestos fibres may range from 0.000001 to 0.0001 fibres/ml (f/ml). Assuming a respiratory rate of 8 l/min, this level of exposure would result in a 70 year lifetime exposure to asbestos fibres in the range 295 000 to 29 500 000 for everyone in the UK population.

Most indoor air concentrations of asbestos are below 0.0002 f/ml, which rises to around 0.0005 f/ml in buildings which contain asbestos in good condition. In traditionally built houses and flats some products and materials containing asbestos (mostly chrysotile) may be present. Airborne fibre levels in these buildings are considered unlikely to exceed ambient background levels as the asbestos in general is not in vulnerable locations and has not been extensively used. However, non-traditionally or ‘system-built’ flats constructed between 1945 and 1980 are likely to contain large amounts of amphibole asbestos products, such as sprayed coatings and partitioning, as well as chrysotile materials, in vulnerable positions with high potential for fibre release.

Occupancy of a building containing asbestos in good condition for 12 hours/day, 50 weeks/year over a 30 year period would result in a total exposure of 30 240 000 respirable fibres, which is slightly in excess of the lifetime asbestos fibre exposure at ambient levels.

There is a risk of high concentrations arising inside buildings—notably non-traditionally built flats—from poorly maintained asbestos materials. Where asbestos materials are damaged and clearly releasing fibres, airborne asbestos fibre levels are higher, at around 0.15 f/ml. One week of exposure to damaged asbestos in a non-traditionally built flat would equate to six years of exposure in a similar flat where the asbestos was sound, or 14 years of normal exposure at ambient levels.

Activities such as plumbing and rewiring, which involve asbestos materials, can generate airborne fibre levels of up to 0.04 f/ml. Exposure for one week to levels of asbestos arising from disturbance during maintenance work in a non-traditionally built flat would equate to 40 weeks of normal exposure in the same flat, that is 2.5% of the total exposure over a 30 year period of residence.

Exposure to asbestos during home improvement and maintenance activities carried out by the householder is likely to be episodic, infrequent and short, although high fibre levels may be generated. One hour of exposure to an airborne asbestos fibre level of 1.5 f/ml would be equivalent to 1.7 years of exposure at ambient levels.

Man-made mineral fibres

Loft and cavity wall insulation are the most prevalent current uses of MMMF in the non-workplace environment. As for other airborne fibres, levels in buildings depend on the presence of products containing MMMF and are influenced by disturbance, for example during maintenance work.

Environmental levels of MMMF are generally less than 0.00005 f/ml. Over a 45 year period, that is since MMMF first began to be widely used, a total of 9 500 000 mineral fibres could be inhaled by an individual. This would equate to 14 500 000 fibres over a 70 year lifetime.

Around 15 500 000 homes in the UK have lofts insulated with MMMF. Levels of fibres in buildings containing MMMF insulation are in the region of 0.0005 f/ml. A total of 70 560 000 fibres would be inhaled during a 70 year lifetime for an occupancy of 12 hours/day, 7 days/week and 50 weeks/year. Including background ambient and indoor exposure, approximately 60% to 70% of people in the UK will inhale some 80 000 000 fibres over a 70 year lifetime.

Home improvement and maintenance activities involving MMMF are likely to be episodic and of short duration, with fibre levels in the region of 0.01 to 1.0 f/ml. One hour of such work with MMMF generating airborne levels of 0.1 f/ml is equivalent to 0.06% of the lifetime environmental exposure from both building and background sources.

Health effects of asbestos and man-made mineral fibres

The health consequences of exposure to asbestos have been known for many years. Occupational asbestos exposure has been associated with mesothelioma, lung cancer and pulmonary fibrosis (asbestosis). Amphibole asbestos is established as the most hazardous form, especially with regard to mesothelioma induction. There is no direct human evidence that MMMF are similarly hazardous, although some uncertainties remain. Most agencies classify asbestos as a known carcinogen, and MMMF as possibly carcinogenic. MMMF can also be irritant to the skin, but this is mechanical itching caused by fibres piercing the skin surface rather than a chemically-induced irritant reaction.

There are three important factors to consider when determining the pathenogenicity of fibres, namely dose, dimension and durability. As with any toxic agent, dose is of fundamental importance, although the dose-response relationship for fibrous materials remains mostly undefined. The dimension of the fibre is important with respect to both the likelihood of it reaching the lung and its biological activity at the target site. Increased attention is being given to fibre durability *in vivo*, more properly termed biopersistence, since this determines how long a fibre remains in the lung to exert any potential toxic effect. Fibres of similar size and shape can have quite different toxicities because of differing biopersistence or biosolubility, and this may explain some of the observed differences in the pathenogenicities of asbestos and MMMF. Attention is thus being given to the development of new fibres of low biopersistence.

Risk assessment: Conclusions and recommendations

Given the areas of uncertainty, it is not considered possible to give numerical estimates of risks for low-level exposures to mineral fibres. Since the mechanisms by which fibres produce their health effects are very poorly understood, adopting any particular form of the dose-response curve for low-level extrapolation cannot at present be justified.

There is ubiquitous exposure of humans to low levels of fibres, some of which are of completely natural origin (from rock outcrops), and the small burden of fibres resulting from this background exposure seems to be well tolerated. Exposure to fibres inside most dwellings is not significantly different from background exposure and so should not constitute a health risk. However, where fibrous materials are in poor condition (in the case of asbestos) or are disturbed or actively worked upon, higher fibre levels can be generated and exposures will be greater. Such elevated exposures are unlikely to add markedly to total lifetime 'ambient' exposure and are probably not significant in health terms, although some uncertainty remains with regard to amphibole asbestos and the associated risk of mesothelioma. To avoid the possibility of adverse health effects, high peak exposures, especially to asbestos fibres, should always be avoided.

This assessment leads to the following conclusions.

Asbestos

Existing asbestos in good condition must, where applicable, be managed *in situ*. Where asbestos materials are damaged and fibre release is occurring, removal is justified if this would result in a reduction in exposure. A general policy of asbestos removal would result in more, not less, exposure and this is therefore strongly discouraged. It is recognised that judgement relating to the management of asbestos material must include a consideration of the perception of risk as well as the risk itself.

Interference with asbestos-containing materials by home improvement and maintenance activities can result in significant intense exposures for a short time. Prudence dictates that such exposures should be avoided. However, unlike the exposure of those professionally engaged in working with asbestos, the cumulative exposure from such activities will probably be small, as the frequency of exposure is likely to be far lower.

There is no evidence that fires or natural disasters involving damage to fibre products cause significant human exposures. Although incidents such as those involving asbestos-cement roofs should not usually be a cause for undue concern, arrangements should be in place for proper responses to such incidents. The removal and replacement of the large installed mass of chrysotile asbestos-cement, with resulting fibre release, is not justified by any such low risk of sporadic exposure.

The possibility of increased health risk to smokers (due to synergistic effects) and from childhood exposures to biopersistent fibres such as amphibole asbestos indicates the need for vigilance. Other individual risk factors may be discovered, and the protection of sensitive or susceptible individuals will then need to be considered further.

There is no current justification for any substantive change in the advice previously issued by the UK Government on asbestos.

There is some uncertainty about the risk of mesothelioma from exposure to low levels of asbestos (especially to amphiboles). Identifying the type of asbestos in buildings is very important, and damaged or friable amphibole asbestos may well warrant early removal and replacement. It is most important to provide information for the public about the different types of asbestos and about how to reduce potential exposure to these materials.

Man-made mineral fibres

Most currently available MMMF products do not readily release airborne fibres, few of any fibres which are released will reach the deep lung and those that do will not persist. Thus the bulk of current MMMF products pose little risk. However, vigilance is needed and the properties of new fibres should be monitored.

The production and use of highly respirable fine diameter (<1 µm) fibres should generally be discouraged, especially where this could give rise to environmental exposure.

MMMF have become widespread throughout the industrial and built environment and there is no doubt that their use has resulted in increased thermal efficiency with a consequent increase in energy savings and environmental protection. The presence of a vast installed mass of these fibres, however, means that their deterioration into a more dusty condition could cause some exposure during maintenance or demolition of the existing building stock. This exposure would be to relatively thick fibres so that mechanical irritation to the skin, eye and upper respiratory tract would be the most likely adverse health outcome. In general, the ageing of mineral fibres and the release of dust during building work require further study.

Unnecessary exposure to any fibre should be avoided and exposure events, such as those likely to result from maintenance, installation or removal, should be the subject of further study.

There is no reason to suppose that current levels of exposure to MMMF pose any risk to the public, but prudence clearly dictates that exposures should not be allowed to rise significantly above these current levels. Fibres have been developed that would be less persistent in the lung if inhaled, and the use of these could, over time, reduce the already small burden of fibres in the lungs of both the workforce and the general public. However, there is no justification for widespread replacement of installed MMMF with these newer materials. In some countries, the production of such highly soluble fibres is being actively encouraged, but regarding such fibres as being ‘without concern’ could lead to less control on exposure, which would be inadvisable.