Significance of Environmental Asbestos on Air Pollution in the Eastern Mediterranean Region

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INTRODUCTION

The Centre for Environmental Health Activities (CEHA) of the WHO/ Eastern Mediterranean Region sponsors special studies of regional nature but focusing on the national environmental health (EH) problems through short term consultants in national EH institutions.

This report covers general aspects and significance of environmental asbestos pollution, taking into account the situation in the EMR, where some information was already available together with the collection of additional information based on replies to questionnaires sent to Member States. Based on the conclusions arrived in the study, some recommendations are made for the guidance of Member States, especially the Ministry of Health.

It is hoped that the presented information will also serve as supplemental study material in educational curricula as well as in training programmes for professionals in environmental health departments of Ministries of Health in Member States.
1. SUMMARY

An appraisal of the general aspects regarding asbestos fibers in environmental ambient air has been undertaken, taking account of the situation in the Eastern Mediterranean Region where information was available. This was provided through the preparation of a background document giving the broad situation in the Region together with answers received from a questionnaire sent to the Member States in the Region. Asbestos in environmental air has been considered in outdoor as well as indoor situations in relation to exposure to the general public; the situation regarding occupational exposure related to the workplace was excluded. Much of the asbestos being currently used in the Region would appear to be in the form of chrysotile (white) asbestos often as asbestos-cement products where only minimum release of asbestos fibers is probable; some older different types of product will exist providing for the opportunity for possible somewhat higher exposures to chrysotile but more importantly in some cases, to amphibole forms of asbestos including crocidolite and amosite. It could be that aspects of the control of asbestos in the Region involved in manufacturing, in asbestos removal from buildings and asbestos disposal, are in some instances inadequate regarding the release of potentially undesirable quantities of asbestos fibers contaminating the environmental air. The sources of environmental asbestos, types of asbestos and products made and used, potential asbestos air pollution problems, the fate of airborne asbestos, measurement and concentrations in air, exposure of the public to asbestos and possible health risks, and control aspects have each been addressed. Relatively little detailed information was available regarding the countries in the Region which manufacture asbestos products or the products currently being used there and those used in the past. Where good control is utilized it would appear that any risk of possible health effects resulting from present-day exposure to the small quantities of asbestos in environmental ambient air should be exceedingly low; this conclusion is in accordance with what in general the World Health Organization has reported regarding any risk due to asbestos in environmental air as being 'undetectably low'. Taking account of the currently available information on asbestos in environmental ambient air and some knowledge of the situation in the Eastern Mediterranean Region, it seems most unlikely that there would be any widespread undesirable health effects as a result of the general public inhaling environmental asbestos in
ambient air. There would appear to be a need however (a) to study the aspects of control currently being carried out in the Region in order to identify any areas of inadequate control so as to minimize any undesirable exposures for the general public regarding asbestos in air, as well as, (b) to assess comprehensively the overall asbestos usage situation and its implications. Further efforts for encouraging the safe use, safe handling and safe disposal need to be promulgated to all those in the Region involved with asbestos and products containing it. Based on the findings of this study, various recommendations have been made in this report in regard to environmental asbestos air pollution and its control in the Region.
2. REASON FOR STUDY AND PROCEDURE ADOPTED

WHO has become aware of some concern in certain countries in the Region regarding asbestos fibers being released to the general air; such release could occur during mining, fibre processing, product manufacture, handling, use, removal, and disposal of asbestos and its products. In certain situations it has been considered that a public health threat may exist due to the presence of asbestos in environmental air, especially where significant exposure to the amphibole variety of asbestos occurs in certain parts of the world. It needs to be recognized that past occupational exposure to asbestos has been demonstrated to be a very serious health problem; this was associated with conditions of high workplace exposures with no significant control measures being practiced at that time. Control measures regarding occupational asbestos exposures especially and for asbestos released to the general environmental air, have been improving in many countries. In the Eastern Mediterranean Region relatively little is known about details regarding sources of asbestos, situations of asbestos usage/removal/disposal, levels in environmental air, exposure situations, and any demonstrated health problems which might possibly be associated with exposure to airborne environmental asbestos.

In the first instance, in order to assess the broad situation relevant to environmental asbestos air pollution in the Region, an appraisal of the general aspects was undertaken. The appraisal was provided in the form of an extensive background document where the sources and potential problems related to environmental asbestos air pollution were identified, and where the significance of exposure and health implications were assessed (the background document is included with this Report). Secondly, a questionnaire was devised (see Annex 1) and distributed to all Eastern Mediterranean Member States. The questions were designed to increase the knowledge of the situation in the Region in regard to sources, usage and issues of concern. The significance and control needs and aspects for further investigation were regarded as being of special importance to identify in the procedures used in the study, the findings of which are given in this Report.
3. BACKGROUND DOCUMENT ON GENERAL ASPECTS OF ENVIRONMENTAL ASBESTOS AIR POLLUTION

3.1 INTRODUCTION

The fibrous natural mineral asbestos has been and is likely to continue to be used widely in various products because of its extremely useful and indeed unique properties. In mining, mineral processing, use, handling and ultimately the disposal of asbestos and materials containing it, some asbestos fibers will have been released to the environmental air. Because of the well-known extreme dangers of the now essentially past really high occupational exposures to inhaled asbestos dust, concern has been expressed regarding the effects on the general public of being exposed to environmental ambient levels of asbestos in general air.

Most asbestos fibers will be attached to cement and other particulate material, or 'locked-in' to a plastic, cement, asphalt or resin; however a certain number of fibers in some applications will inevitably be 'free'. Most asbestos fibers released to the environment will be too large to be inhaled, or will be so small in size that they are of little or no health consequence. Nevertheless, a certain number of fibers will be respirable and a sufficiently large quantity of inhaled respirable fibers of a critical size range (longer than 5 microns and less than around 3 microns in thickness) could pose a health risk. Asbestos has probably been one of the most extensively studied single substances in relation to human exposure; numerous reviews and very regular reports are published by international and authoritative bodies including by the World Health Organization; thus it is possible not only to identify the sources and examine the nature of asbestos fibers, but also to assess the significance of their impact including evaluating the relevance of human beings inhaling asbestos.

A great deal of confusion and indeed misunderstanding exists regarding various facets of asbestos production, including product manufacture, asbestos types and forms of asbestos used, sources and extent of contamination, and in particular the precise significance and health impact related to environmental human asbestos exposure.
In relation to the impact of exposure to asbestos in the workplace, it is well known that certain lung diseases resulted from the very heavy exposures to inhaled asbestos dust in various occupational situations in some parts of the world. In the early 1950's, special concern arose regarding occupational exposure to asbestos dust being related to particular diseases, i.e., asbestosis, lung cancer, and mesothelioma. In addition to health problems associated with occupational exposure, some cases of mesothelioma were recorded in the past for example, due to significant exposure to dust brought home on workclothes which affected some housewives. Despite the large differences between exposures inside factories in the past where health effects were clearly detectable, and those in the general environment, considerable but seemingly disproportionate concern has been expressed regarding the health risk for the general public. Such concern would seem to be largely unwarranted; nevertheless in certain countries where control measures may be inadequate, some concern could be justified.

To assist in the evaluation of the health effects of being exposed to asbestos, a considerable amount of animal toxicological testing has been carried out. There is now strong evidence that only fibers greater than 5 microns in length are likely to be fibrogenic and pathogenic, and substantial quantities need to be inhaled (or implanted into animals) to induce effects in animals. It is worth noting in fact that most asbestos fibers in the general environmental air are less than 5 microns in length.

Experience from occupational studies indicates that mesotheliomas have seldom followed exposure to chrysotile asbestos only. Many, but not all cases of mesothelioma have a history of heavy workplace exposure to amphibole asbestos (principally crocidolite but also amosite) either alone or in chrysotile mixtures. There is now very strong evidence that a number of other natural mineral fibers can cause mesothelioma; for example, the mineral called erionite, has caused endemic mesotheliomas in the general public in some localized regions of Turkey. Smoking is associated with a very high risk of lung cancer; research has demonstrated that the combination of occupational asbestos exposure and smoking, substantially increases the risk of this form of cancer. Lung cancer also occurs in the general population resulting from exposure to natural radiation.
It has been estimated that there have been as many as 3000 commercial applications for asbestos, the most prominent including:

* As reinforcement in cement, plastic or rubber,
* As components of brakes and clutches,
* As fibers spun and woven into cloth or rope for insulation purposes,
* In the past, sprayed-on to provide fire resistance coatings in ships and on structural girders and boilers,
* In the past, sprayed-on heat insulation in buildings and ships.

The largest application worldwide, is for asbestos-cement products about 85%. The proportion of asbestos in products varies from as low as 5 to 7.5% for floor tiles and sheets; 10-15% for asbestos-cement; 25-40% for fire resistant boards; 12-100% for insulation products; 15-70% for friction materials; 25-98% for jointing, packing and fillers; 55-70% for moulded plastics; 65-100% for various textile products. Chrysotile asbestos is used in practically all commercial applications or products; small proportions of amosite and/or crocidolite are sometimes incorporated with the chrysotile to improve asbestos-cement production efficiency. At present the world's production and usage of amphibole asbestos (amosite and crocidolite) is less than 3% of the total asbestos produced; amphibole asbestos has been declining in use. Chrysotile asbestos has always been, and will continue to be the main source of asbestos worldwide. These days, most asbestos products being used are non-friable and the release of asbestos fibers to the environment during product transportation, installation and use (including subsequent weathering/abrasion) is low; in the past, the situation was different and the quantities of fibers released to the environment were frequently much higher from certain types of products used then. Certain problems can still exist however, especially in developing countries because control aspects are not adequate.
3.2 SOURCES OF ASBESTOS RELEASED TO AIR

Inevitably some release of asbestos fibers to air, water and soil has arisen as a result of widespread use of asbestos and products containing it. Environmental contamination was greater in the past because of the existence of fewer control measures at the time. In addition to man-made sources, some natural sources of asbestos (weathering of rocks) have significantly contaminated environmental air; water too has been contaminated resulting from contact of the water with natural sources of asbestos-containing rocks. In some cases where contaminated water has become dried up, some asbestos may be then released to the air. It has been stated that 'the total amount of asbestos emitted from natural sources is probably greater than that emitted from industrial sources' (IPCS EHC 53, 1986).

Many potential man-made sources of asbestos have been investigated but in most cases there would seem to be little evidence of significant release of fibers; however, there are certain sources about which some people have expressed some more particular concern, e.g., asbestos brake-linings; asbestos-waste tips; industrial emissions and mining activities; asbestos in buildings; shipyard activities; do-it-yourself activities involving the use of asbestos products; re-entrainment of deposited dust containing asbestos. Although questions have been raised regarding these issues, upon investigation, it can be demonstrated that nowadays so long as good control is maintained, the relatively low emissions to the environment are not considered to be of any undue significance in terms of human health; in the past, some industrial emissions to the environment were unacceptably high. Also some problems will remain in certain parts of the world, particularly in developing countries, where effective control measures are not yet in existence. In relation to most present-day asbestos environmental emission situations, much of the asbestos released to the air will not be inhalable because of the relatively large size of the general dust and other particles to which the fibers are often attached; this is particularly the case once asbestos has become deposited and any dust subsequently re-entrained. Also some asbestos products are coated, making it extremely difficult for any asbestos fibers to be released; the firm binding of asbestos in asbestos-cement products also minimizes fibre-release to the air. Some forms of asbestos, especially chrysotile, will gradually become degraded naturally by
the action of water. At the very high frictional temperatures, where for example asbestos is used for brake linings, much of the asbestos is changed to innocuous amorphous material, and in any case most of the fibers are extremely short as to be of no biological importance. One problem which still remains of importance worldwide is the removal of old asbestos from buildings (especially where amphibole asbestos is concerned) and the demolition of buildings where substantial amounts of old asbestos may be in-situ; it is very important to stress that proper control of these activities should be maintained in order to prevent any undue environmental contamination.

During the mining of asbestos ore which these days is often carried out in open-pit operations, some release of asbestos to the environment can result. Release of fibers to the air can occur during drilling, blasting, loading broken rock and transporting of ore to the mill. In many cases, the environmental impact is insignificant since the mining is often carried out remote away where people live, and also because much of the asbestos is released in the form of coarse dust which settles out fairly readily. In contrast, during milling which is largely confined to a mill building, very little emission to the general air arises these days because of the existence of normally good operational controls there; within the mill building, the exposure to the workers should nowadays be at a low level, although years ago the conditions during milling were often exceedingly dusty. The asbestos products being currently manufactured are such that the release of fibers is generally at acceptably low levels so far as workers are concerned and this in turn reflects very low process-emissions to the general ambient outdoor air. This is largely because of improved working practices over the years and the existence of proper regulations being applied in various countries. Most manufacturing processes are nowadays carried out as 'wet' procedures thereby minimizing asbestos fibre release to the air. Special attention needs to be given to dust control in asbestos textile production where more hazardous fibers seem to be emitted probably due to large fiber lengths.
3.3 TYPES OF ASBESTOS PRESENT IN AIR

Asbestos exists as a class of naturally occurring fibrous silicates. Asbestos deposits are found in many parts of the world. Russia and Canada mine considerable quantities but South Africa, Zimbabwe, China, Brazil, India, Kazakhstan, Swaziland and Australia have also been noted for their production. Small deposits often in quantities quite uneconomical to mine, will be found in many countries. Asbestos or products containing it are manufactured or imported by practically all countries.

There are two main groups of asbestos: the serpentine and the amphiboles, comprising a total of six main types of fibre (i) Serpentine group:- chrysotile asbestos (‘white’ asbestos); (ii) Amphibole group:- amosite, crocidolite (‘blue’ asbestos), anthophyllite, tremolite, actinolite.

Different asbestos types as mined may be contaminated with other minerals including fibrous ones; some of these minerals may be removed in processing raw asbestos. Also, different types may exist together; for example, chrysotile is not uncommonly associated with small quantities of an amphibole asbestos, tremolite (1-3%). The properties of the different fibers vary. Chrysotile is rather different from the amphibole group; it tends to be attacked by acids whereas the amphiboles are more resistant to such attack. Because of the different properties of the various fibers they are used for a variety of purposes. The consumption of asbestos greatly increased during this century. The world’s production of asbestos (1987 data) was estimated to be about 4.2 million tonnes, nearly two thirds of which originated from the USSR, and about one-sixth from North America. In 1992 the world’s production was about 3.1 million tonnes. The world’s production reached a peak in the mid-seventies. Approximately 97% of all asbestos now produced is chrysotile; the remainder consists mainly of amosite and crocidolite. In recent years the use of amosite and crocidolite has significantly declined.

All forms of asbestos can be detected in environmental ambient air; the commonest form found is chrysotile but amosite, crocidolite and tremolite are often detected. In some situations, essentially only chrysotile will be found, but there are also certain situations where the predominant fibers detected will be the amphibole forms of asbestos, for example where old insulation products have been used.
3.4 ASBESTOS AIR POLLUTION POTENTIAL PROBLEM SITUATIONS

3.4.1 Outdoor weathering of asbestos sheeting and roofing tiles, etc

Some asbestos fibers will be released during natural weathering processes of a variety of different asbestos containing products utilized for external use. Such materials have been used extensively in the construction of various buildings; they are still used widely in various parts of the world. Studies have been made of the release of fibers from such products, and in general the contribution they make to the general outdoor environmental levels of asbestos from other sources is relatively small. The acidity of rain and levels of air pollutants such as sulphur dioxide govern the release. In general about 20% of any fibers released can be dispersed in the air, the remainder are washed out by rainwater and essentially do not find their way to the atmosphere.

3.4.2 Asbestos in the home and other buildings

There is a wide range of potential sources within homes and other buildings, e.g. asbestos flue pipes, electric Toasters, electric heaters and hair-dryers, ironing board pads, oven gloves, cooker and boiler seals, cooker simmer pads, ceiling and floor tiles, some clothes dryers, packing materials, boarding, lagging and for some other insulation purposes (in the past especially sprayed-on insulation). One common misconception is that the different products containing asbestos all readily release fibers. Many asbestos products consist of asbestos fibers which are locked into cementitious or other binding materials which makes it very difficult (if not impossible in some cases) for fibers to become released to the air. One rather different situation however exists where asbestos has been used in the past where it was sprayed on to surfaces for insulation purposes; the practice has now been abandoned. Probably this practice has provided one of the more notable sources of asbestos being released to the air inside buildings. If the surface of any asbestos-containing article becomes significantly damaged, then this creates a potential for asbestos fibre release to the air. A number of studies have been carried out to measure the levels of asbestos fibers in indoor air but in general the concentrations found have been relatively low; nevertheless a great deal of work has been involved in asbestos removal in many buildings but the
general view now is that this work was often unnecessary. It should be pointed out that where remedial work needs to be carried out, to minimize any possible problems, special tools and control procedures for installation and repairs of asbestos-containing materials are used; generally these procedures involve wetting the materials or using vacuum equipped or hand tools. Other remedial measures include coating with special paints, and enclosure or encapsulation of damaged or friable materials. If asbestos-removal is deemed absolutely necessary, great care needs to be exercised, and trained and experienced contractors are essential, both for protecting the maintenance workers and the general public in the vicinity of the work.

3.4.3 Shipyard activities

Some asbestos emissions to the air occur during ship maintenance and ship-breaking activities. Elevated levels of fibre-release may have occurred in the past; however these days, the possibilities for significant fibre-release are expected to be more remote. Nevertheless in parts of the world where cheap labour exists and where ship maintenance/breaking activities occur, these activities may be poorly controlled leading perhaps in some cases to undesirable quantities of asbestos released to the general air.

3.4.4 Release of asbestos to the air from brake linings containing asbestos during braking

Brake linings gradually wear away releasing particles to the air. Very high local temperatures are associated with frictional processes which occur in braking and they are sufficient to cause physical and chemical degradation of the asbestos. At high temperatures, forsterite can be produced from the chrysotile asbestos incorporated into brake linings. Forsterite and other amorphous forms of substances produced seem to be biologically inert. Various studies have shown that only a very small fraction of the total brake debris is in the form of identifiable asbestos. The relatively small quantities of asbestos fibers which are released are often the short fibers of little or no biological significance. There is now considerable evidence regarding the small quantities of any potentially dangerous inhalable asbestos which can be released during braking in that it is known that the concentrations which they contribute to the environmental ambient air is low (ICS/89.34. Geneva, 1989).
3.4.5 Asbestos waste disposal

Because considerable experience has now been acquired in disposal practices, it is now possible (in properly trained hands) to carry this out very satisfactorily. Particular care needs to exercised with certain types of waste, particularly from sprayed-on asbestos or old lagging which can both be physically friable. Generally speaking, this particular type of waste should be disposed of in sealed containers (heavy gauge plastic bags or metal drums) appropriately labelled as asbestos waste. Asbestos-cement products are much less of a problem because significant quantities of inhalable fibers are not normally readily released. In the transportation of friable asbestos to waste tips, general care must be exercised to avoid release of fibers. In general, asbestos waste is covered with sand or soil, etc. or is kept wet in settling ponds. For properly controlled waste sites, significant quantities of inhalable asbestos are not released. Ideally, deep and properly contained (covered) pits in areas remote from the general public should be used; indiscriminate open dumping should not be carried out (ICS/89.34. Geneva, 1989).

3.4.6 Asbestos released during intense fires

A number of building-fires have been reported in recent years where asbestos has been released to the environmental air typically from asbestos-cement roofing sheeting heated to high temperatures. Flakes of combusted material are frequently raised to enormous heights during fires and provide some local and some area fallout. Many particles from fires will be very large and are not capable of being inhaled. In general it is considered that the health significance of airborne fibers released in this way is not of special concern partly because of the alteration of asbestos to forsterite or related glassy material. (Proceedings of a Symposium, Atlantic City, 1987).

3.4.7 Re-entrainment of asbestos to the air

There is a definite possibility of re-entrainment to the air of quantities of asbestos deposited on ground surfaces, either in continuously dry areas or in situations where surfaces (including riverbeds) which become dry after being wet. From a health standpoint, a very high proportion of re-entrained dust is non-
inhalable. In the case of asbestos fibers of potentially inhalable size, a large proportion will become attached and intermingled with general dust to render them non-inhalable.

3.4.8 Asbestos release from road surfaces made of asphalt (or bitumen)/asbestos materials

Asbestos makes a very satisfactory binding material for asphalts or bitumens for use as pavements or road surfaces. The asbestos fibers are extremely well bound in the matrix making it very difficult for any fibre-release during application or afterwards. In several studies, no significant differences could be detected between asbestos in air levels near road surfaces containing asbestos bonded into asphalt or bitumen and those where it was absent.

3.4.9 Do-it-yourself activities involving asbestos products

This is a potential source of exposure for the general public. These days, recommended procedures are suggested to be used to minimize exposure. Unless care is taken this source may perhaps represent a substantial source of exposure for members of the general public. Particular care needs to be exercised when sanding, cutting, drilling, sawing of products containing asbestos.

3.4.10 Industrial emissions and mining activities, including mining tailing dumps

In the past these represented significant contributors to the levels of asbestos in the general air. Fortunately much better controls are now used and normally any potential significant problems can be avoided. Often such activities are remote from where the general public are living. In addition, it has been demonstrated that the concentration falls off rapidly as the distance of the source increases. Concentrations decreased inversely as the square of the distance from the emission source; at 100m and 500m from the source, concentrations have been found to be over one-hundredth and over one-thousandth of those close to the source. Transportation of asbestos these days should not be a
significant source of asbestos since the material ought to be conveyed in adequate packing and in enclosed vehicles.

3.5 FATE OF AIRBORNE ASBESTOS

According to their size and the asbestos sources from which they arise, the fibers will disperse into the environment in various ways and remain there to become diluted for longer or shorter periods depending on their properties.

Amphibole forms of asbestos (only a fraction of the total asbestos used is of this amphibole variety) are more resistant to attack by natural and man-made factors.

Asbestos fibers released to the air will disperse according to:

(#) their aerodynamic properties, the latter being primarily a function of fibre size and shape and what extraneous material and how it is attached to the fibers, and
(#) various meteorological factors, especially those related to wind and rainfall.

Some fibers will readily fall out from the air and deposit onto surfaces in the ambient environment (this process being related primarily to those fibers which are large and in general non-inhalable). Some will attach themselves to surfaces (e.g. walls) due to certain adhesive properties related to particle-charge effects. Some fibers will be washed out by rain; this is one of the most effective mechanisms for particle removal of all types whatever their composition. Finally, some (mainly the very finest particles containing inhalable asbestos) will be dispersed into the air as a result of wind and thermal currents to become gradually diluted in the atmosphere; they will then be scavenged from the air by various processes as indicated above. Although the airborne lifetime of asbestos particles is variable, usually most will disperse and be well-diluted in air fairly rapidly.

Many particles whether they contain asbestos or not, will ultimately be washed out by rain to drains, sewers, ditches, streams, etc. or to the soil. In
many parts of the world, any asbestos which might be washed out by rain may then enter rivers, and subsequently find its way to the oceans. Some asbestos fibers may be absorbed into soil but in most cases it would be very difficult for them to become readily detached again.

3.6 MEASUREMENT OF ASBESTOS IN ENVIRONMENTAL AIR

The sampling and analysis of asbestos fibers in the occupational field have become standardized. In contrast, as yet no internationally accepted standard method for measuring asbestos in environmental ambient air has been published. The standardized occupational methods are based on phase-contrast optical microscopic examination of specially collected filter samples; relevant 'respirable' particles (ie. those of potential health significance which are not less than 5 microns long and are less than 3 microns thick, and having a length to width ratio greater than 3:1) are recorded. This method although not capable of distinguishing between different types of mineral fibers or different forms of asbestos fibre, is nevertheless quite adequate for examining the occupational workplace where asbestos is used, since the predominant fibers will be asbestos of a known type. For measuring asbestos fibers in environmental ambient air, this method is totally inappropriate because numerous non-asbestos fibers will always be present; typically, only 10% or less of the total fibers present will be asbestos. It is necessary to use electron microscopy for determining asbestos fibers in environmental ambient air. Either transmission microscopy (a complex and expensive method) or scanning electron microscopy (a somewhat cheaper and usually faster method) can usually be used. The resolution of scanning electron microscopy however is not adequate to detect the finest asbestos fibers present; only those 5 microns in length or longer are of health significance and this method will generally detect at least 90% of 'respirable' fibers of health significance. For research purposes, the transmission electron microscope is an essential requirement; in certain situations where there is uncertainty in regard to the distribution of particle size of asbestos and other mineral fibre types, it can be necessary to use transmission electron microscopy. Usually, many more fibers will be detectable by transmission electron microscopy but most of these are irrelevant with respect
to their health implications when inhaled. Perhaps typically, only a few percent of the total asbestos fibers are longer than 5 microns; close to factories and mining activities, the proportion may be higher.

There were a variety of procedures used in the past to measure asbestos in environmental ambient air; only the more recently made measurements are reliable however and only those are referred to here. What is essential in the analysis of asbestos fibers is the need to use special detecting instrumental attachments coupled to the electron microscope; these are known as Selected Area Electron Diffraction and/or Energy Dispersive X-ray Diffraction analysers. These instrumental attachments will confirm that a detected fibre is really asbestos or not; this is important since perhaps as many as 90% of fibers could be non-asbestos in the environmental ambient air. For analysis, special sampling equipment is needed to collect samples; the samples are collected on special membrane filters which need to be treated by standardized procedures before being inserted into the electron microscope for analysis. Electron microscopic analysers and the needed attachments are very expensive instruments; they need to be used by fully trained personnel and the availability of certain consumables, spare parts and local service facilities is an important requirement which needs to be borne in mind.

3.7 CONCENTRATIONS OF ASBESTOS IN AIR

Measurements of airborne asbestos have been expressed in mass terms and/or fibre concentration terms. It is difficult to convert from one measurement unit to the other unless the fibre-type and fibre-size distribution is known precisely. Typical conversion factors range from between 0.00002 and 0.0004 fibers/ml air per nanogram/cubic metre air.

Fibre dimensions for environmental air vary over a wide range. The finest fibre of asbestos might be only 0.01 micrometres diameter and 0.2 microns long (having a mass of only 4 times 10 to the power minus seventeen of a gram). A typical asbestos fibre in air might be somewhat less than 0.1 micrometer diameter and about 1 micrometre long; most fibers in environmental ambient air are less than 1 micrometre long. In this document only, the concentrations in air
of regulated 'respirable' fibers, i.e. those more than 5 micrometres long and having a length to thickness ratio of at least 3:1 are considered.

Reliable outdoor air measurements covering a wide range of circumstances in urban and rural areas of the world have provided median values in the range of 0.0007 to 0.007 microgrammes per cubic metre air; and 0.0001 fibers per ml to 0.001 fibers per ml air. A typical very long-term exposure is around 0.0005 fibers per ml air or lower for the outdoor environment; nearly all of the asbestos is in the form of chrysotile (white) asbestos with only a small proportion of amosite, crocidolite, tremolite or other forms of amphibole asbestos.

Reliable indoor air measurements covering a wide range of situations inside buildings have provided figures which are typically in the range 0.001 to around 0.1 microgrammes per cubic metre air; and 0.0002 to 0.002 fibers per ml air. A typical very long-term indoor air exposure is around 0.0005 fibers per ml air, or lower; this is not dissimilar to that for many outdoor situations. For indoor air, nearly all the asbestos is normally in the form of chrysotile asbestos (white asbestos) with usually only a small proportion of amosite, crocidolite, tremolite and other forms of amphibole asbestos. In some special situations in the indoor environment, e.g. where asbestos insulation materials have been used and perhaps have become seriously damaged, concentrations higher than 0.001 fibers per ml have been recorded.

3.8 EXPOSURE TO AIRBORNE ENVIRONMENTAL ASBESTOS

Asbestos, whether it comes from natural sources or whether it occurs as a result of human activities can frequently be of a particle size such that some of it can be inhaled. In general, only very fine fibers can penetrate to the depths of the lung; many of the extremely fine fibers however are immediately exhaled again. Very large fibers on the other hand, if they are capable of being inhaled at all, may simply be trapped in the human nose or mouth. Certain asbestos fibers are capable of being deposited in the bronchial regions of the pulmonary system. In addition to exposure via the pulmonary tract, some airborne fibers may enter the body via the mouth to become directly swallowed. Also, many of the fibers
deposited, i.e. those deposited in the bronchial regions ('finer' fibers) and the upper respiratory tract ('coarser' fibers) will be cleared by mucociliary clearance and become swallowed. These swallowed fibers will enter the gastro-intestinal tract.

In order to assess the significance of the exposure to asbestos in environmental ambient air, it is necessary to understand the situation regarding occupational exposure. Occupational exposures in the past were often exceedingly high and this partly accounts for the high incidence of a number of diseases which resulted from such heavy exposures; nowadays in many countries, exposures to workers are well-controlled with dramatically reduced workplace airborne concentrations which are continuing to be lowered with time as more effective control measures are introduced. Taking account of various studies it appears likely that certain dusty workplace atmospheres in the past were commonly averaging hundreds of fibers per ml air (fibers greater than 5 micrometre long). To interpret exposures meaningfully, only concentrations in air expressed in fibre-number terms can be used, as opposed to those on a mass basis.

Exposure to individuals in certain situations in the past will have been higher; for example (i) those exposed to factory dust brought to their homes by asbestos factory workers living there, (ii) those living near some (uncontrolled) mining activities years ago, (iii) those perhaps living extremely close to some activity where considerable quantities of asbestos dust may have been released, e.g. some shipyards or certain factories.

Although fibers covering a fairly wide range of sizes are capable of being inhaled, the geometry of the lower respiratory tract is such that only minute particles of geometric diameter less than about 3 micrometres (roughly one-third thousandth of a centimetre) can normally penetrate to the lower pulmonary region. Because fibers can travel longitudinally in an air stream, it would not be uncommon to find particles perhaps 25-40 micrometres long entering the depths of the lung. Analysis of lung tissue in post-mortem samples has been used as some indication of the possible asbestos fibre exposure; several orders of magnitude higher asbestos levels were detected in some heavily exposed occupational asbestos workers compared with 'non-exposed' groups. The
quantities of fibers in lung tissue are not necessarily wholly suitable in terms of an index of exposure and potential effects however; this is partly because the rates of deposition and absorption of inhaled asbestos vary. For example, chrysotile asbestos is much more quickly removed from the lung than the more stable amphibole forms (eg. amosite or crocidolite). Some amphibole fibers could remain in the lung for a human lifetime; in comparison, chrysotile fibers can be eliminated in a matter of months.

Deposited fibers less than about 5-10 micrometres long may often be engulfed and digested by a single lung macrophage. Fibres longer than 5-10 micrometres are incompletely engulfed by one macrophage, although several macrophages may sometimes act together to inactivate such fibers. Long thin fibers would seem to be capable of being trapped in the depths of the lung and this has been confirmed in animal experiments demonstrating that these fibers are the most biologically active ones. Some of the longer fibers can be eliminated by mucociliary mechanisms to become expectorated or swallowed.

3.9 HEALTH RISKS OF EXPOSURE TO AIRBORNE ASBESTOS

In order to evaluate fully the implications of the health effects of being exposed to airborne asbestos it is necessary to consider the health effects associated with occupational exposure of fibers and to take account of animal toxicological data together with the findings regarding environmental asbestos exposures. Both the effects of asbestos fibers on the respiratory system and elsewhere in the body need to be considered since when any particular material such as asbestos is inhaled (some of it is also ingested and as well) fibers which become deposited in the respiratory system may ultimately be translocated elsewhere in the human body.

Associated with heavy prolonged exposure to inhaled asbestos have been three undisputed well-defined and serious diseases, (i) fibrosis (asbestosis), (ii) lung cancer (bronchogenic cancer), and (iii) mesothelioma (cancer of the pleura and of the peritoneum). In addition, there have been suggestions that certain other cancers, eg. gastro-intestinal, kidney, ovarian and laryngeal, could be
associated with heavy prolonged exposure; however these cancers have not been firmly and definitely established to be due to asbestos exposure per se. Finally, asbestos fibers can produce pleural plaques and pleural calcification (shown by X-ray examination); such an effect per se is not generally regarded to be disabling to an exposed asbestos worker. Lifetime risk values for selected situations is presented in Annex 2.

3.9.1 Animal Studies

A very considerable amount of work has been carried out on animals exposed to asbestos; these tests consisted of inhalation, ingestion, and implantation studies. Depending on the route of administration, fibrosis, lung and other tumours including mesotheliomas, have been observed in animals.

Although general animal testing using asbestos has been used for the evaluation and assessing the significance of possible effects which could relate to human exposure, it is recognized that animal experiments are only of limited value when the results are quantitatively (in particular) but also qualitatively, extrapolated to humans. Thus for the purposes of establishing the human health implications regarding asbestos exposure, the results of animal experiments can only be part of the overall process of drawing general conclusions as far as human exposure is concerned; additional data from human epidemiological studies, certain toxicological data and risk assessment applications need also to be taken into account.

Implantation tests in animals have clearly shown that mesothelioma is only associated with long fibers; i.e. fibers more than 5 micrometres long. The maximum carcinogenic potential appears to be associated with those fibers longer than 8 micrometres and less than or equal to 0.25 micrometres thickness; other non-asbestos fibers may also have carcinogenic potential such as erionite.

Inhalation tests on animals using asbestos have demonstrated fibrosis, lung cancer and mesothelioma (using long fibers).

Only fibers longer than 5-10 micrometres are capable of causing cancer. The carcinogenicity depends on the durability of fibers. Chrysotile is far less durable
than the amphibole forms of asbestos and this is seen in terms of the amphibole forms having a higher potential to induce tumours in comparison with chrysotile. The precise mechanisms which involve certain forms of asbestos (and other mineral fibers) acting as carcinogens when inhaled (or implanted) are not fully understood. The mechanism might involve the fibers acting as carcinogenic initiators (i.e. acting as a genotoxic carcinogen). In the case of bronchial cancer it is well documented that smoking and asbestos exposure act synergistically in heavy occupationally exposed workers and in this case the asbestos seems to act as a promoter; the absorption by asbestos of carcinogens like benzo(a)pyrene enhancing tumour development (animal tests show this) confirms the promoter hypothesis.

Recent studies suggest that there may be a threshold exposure level below which chrysotile is not expected to induce lung cancer. Some doubts have been expressed whether the exposure of this type of asbestos alone is likely to cause mesotheliomas, although some disagree with this hypothesis. Heavy exposure to amphibole asbestos (particularly amosite and crocidolite) seems to be associated with the development of this disease.

Ingestion experiments are essentially negative in terms of their outcome. Despite a series of studies involving huge numbers of animals fed massive doses of various forms of asbestos, no significant carcinogenic response has been observed. This could at least partly be explained by the fact that at most, very few (if indeed any) fibers are capable of passing through the gastrointestinal tract wall; also stomach acidity can chemically degrade certain forms of asbestos like chrysotile, gradually rendering them non-pathogenic (IPCS CHC 53, WHO. Geneva, 1986).

3.9.2 Human Studies

The studies on humans exposed to asbestos fibers have been essentially part of numerous epidemiological surveys carried out on groups of industrially exposed workers together with some investigations related to the general population. Epidemiological surveys are often fraught with difficulties in terms of inadequate exposure data, limited population data, limited population size studied and precise details of mortality and morbidity information, and the fact
that numerous confounding variables exist, eg. smoking, dietary habits, exposure to different occupational carcinogens, race, social factors, population density/mobility, etc. However, taking account of the results of various epidemiological studies together with toxicological and other data, some reasonable conclusions can be drawn. In order to evaluate the relationship between asbestos exposure in the general environmental air, it is necessary to take account of occupational exposure data; the occupational situation needs to be considered first, followed by examination of the environmental situation.

3.9.3 Occupational exposure situations

Health effects of inhaling asbestos have been usually associated with prolonged exposures to very high concentrations of fibers in the workplace air. In many cases, the development of the diseases relate to exposure 25-35 or more years ago; thus diseases being detected today usually relate to the high exposure situations of the past. The following diseases asbestosis, lung cancer, and mesothelioma) can result from excessive exposure to asbestos:

3.9.3.1 asbestosis

This seems only to be produced when the exposure has been prolonged and high; below certain exposure thresholds clinically defined asbestosis is most unlikely to develop. As far as exposure to asbestos in general environmental air is concerned, the risk of contracting this disease is essentially nil.

3.9.3.2 lung cancer

This seems to occur in heavily exposed asbestos workers; it has been hypothesized that it occurs only where the exposure has been so high as to produce asbestosis; thus a definable threshold exposure would seem probable. The incidence of the disease is very significantly enhanced where the workers were heavy smokers. For example the risk of lung cancer for asbestos workers (compared with non-asbestos workers) is around 8 to 9 times; where they smoked, the reported risk dramatically increased approximately 10 fold higher still. Lung cancer is also caused by exposure to various industrial occupational
3.9.3.3 mesothelioma

This is a relatively rare form of cancer which is known to be produced by high occupational exposures to asbestos. Malignant mesothelioma of the pleura (the pleura is a membrane surrounding the lung), and malignant mesothelioma of the peritoneum (the peritoneum is a membrane which lines the cavity of the abdomen), have both been associated with occupational asbestos dust exposure; the latter being normally less frequently found than the former. Crocidolite and amosite (amphibole forms of asbestos) are much more hazardous than chrysotile in relation to occupational exposures to asbestos and the development of mesothelioma. It has been hypothesized that mesotheliomas in fact have seldom followed exposure to chrysotile asbestos only; in seems that for amphibole asbestos, mesothelioma appears at a much lower fibre burden in comparison with chrysotile (it is reckoned that the fibre types appear to differ by at least two orders of magnitude in their potential to induce mesothelioma). This human finding however is inconsistent with the results of animal experiments but could be explained partly by the dustier nature of crocidolite and amosite in occupational situations. Also chrysotile asbestos becomes removed from lung tissue (by dissolution) at a significant rate compared with amphibole forms of asbestos which is an important finding since tumour development is a function of a species lifetime, eg. for rats it is around 2 years during which little opportunity for dissolution would arise compared with the lifetime in humans. It seems likely that the relatively greater dissolution of chrysotile compared with amphibole asbestos would dramatically reduce the possibility for inhaled carcinogenic levels of this fibre in the general environmental air from accumulating in the human lung. There have been some suggestions that pure chrysotile itself may not be responsible for occupationally induced mesotheliomas and perhaps the presence of traces of tremolite (commonly naturally occurring with chrysotile deposits) could account for some cases of mesothelioma in the absence of any occupational crocidolite and/or amosite exposure. Taking account the occupational exposure in males and the incidence of mesothelioma being consistent with the disease developing 30-40 years after exposure and the para occupational exposure in females (ie. for dust brought home on the workclothes of male workers living there), it has been reasoned that there appears little room left for cases of mesothelioma.
attributable to general non-occupational environmental exposure.

At one time it was thought that mesothelioma was exclusively related to asbestos exposure, but there are now many examples of other factors including exposure to other environmental contaminants which can cause mesotheliomas. Natural erionite fibers (this a non-asbestos fibre) have been responsible for a number of cases of mesotheliomas in some villagers exposed to the fibre in two remote areas of Turkey; factors such as exposure to certain viruses, exposure to some forms of radiation and specific chemicals are also regarded as important in mesothelioma development in some situations.

Although statistical correlations have been observed relating for example gastro-intestinal cancers (oesophageal, stomach, colon, and rectal), and laryngeal, kidney and ovarian cancers to the inhalation of asbestos dust in occupational situations, the general evidence for a causal relationship is neither consistent nor firm.

3.9.4 Ambient Environmental Exposure Situations

Firstly, it needs to be recognized that the exposure to asbestos fibers in general environmental air is generally many orders of magnitude lower than that experienced in occupational situations where many cases of disease were recorded as being associated with the not infrequently found enormously high dust exposures of years ago. At least 100 to even 10,000 times lower, has been suggested for the general environment. Two main diseases are considered here which have been suggested to be possibly related to being exposed to asbestos in the general environment, (a) lung cancer, and (b) mesothelioma; as far as fibrosis (ie. asbestosis) is concerned, this is considered to be of essentially zero significance for the general population because the exposures are very low. There is thought to be threshold level of exposure below which asbestosis does not occur; it was assessed that the risk of this disease in the general population is virtually zero. As far as lung cancer and mesothelioma are concerned, it has been evaluated that the risk in the general population attributable to present-day asbestos exposure is undetectably low (IPCS, EHC 53, 1986).
3.9.4.1 general environmental exposure studies

A range of different studies have been were carried out including:

* A study of the incidence of cancers in regions where asbestos can be found naturally; no statistically significant differences between test and control (i.e. for non-asbestos regions) were found.

* An asbestos mining district in Austria; no significant differences in lung cancer rates were found which could be attributed to asbestos exposure.

* Two mining townships in Canada with very heavy pollution; 'snow-like' films of dust being common there some 25 years ago. Results of the study were compatible with no excess risk being attributable to asbestos in the air, even though the air pollution levels were some hundred times greater than some control towns in America and Europe.

* An amosite factory in the USA in the vicinity of where people lived; no excess mortality was detected compared with a control region. None of these studies demonstrated any undesirable health effects including cancer from inhaling asbestos in the general community air.

3.9.4.2 neighbourhood studies:

A number of cases of mesothelioma in non-occupationally exposed people have been detected in different places close to where asbestos activities were ongoing. For example, in London, Hamburg, and in some regions in Cape Province in South Africa. In these areas there would have been excess asbestos air pollution, although no firm information was available on the levels of exposure. Thus there is an association of mesothelioma incidence and certain neighbourhood exposures, although an important factor to consider is that some of the so called neighbourhood exposures may have been 'household contact' exposures (see below) which were undoubtedly the cause of some cases of mesothelioma.
3.9.4.3 household-contact studies

Studies in the USA, UK and Australia, have shown that special instances of household contact to asbestos resulted in some cases of mesothelioma. These seem to be related to housewives being regularly exposed to asbestos dust brought home on the workclothes of men employed at asbestos factories or mining activities. No reliable representative figures are available for the concentrations of asbestos dust in the air to which people were exposed at home. However in view of the very dusty nature of asbestos attached to clothing, the exposure may well have been substantial; also once the dust has been brought home it could be difficult to remove it, and fine asbestos fibers could be re-entrained and released again and again to the indoor air. Home exposure is also significant in the fact that it continues for the whole time one is at home and in the case of some people like housewives, it can represent a high proportion of their time each day. A number of non-occupationally exposed housewives have unfortunately developed mesothelioma.

3.9.4.4 other exposure situations

Concern has been expressed regarding general indoor air exposure to asbestos with special concern considered for children. However a number of reliable studies have now confirmed that the release of asbestos to the air as a result of the use of asbestos products in the home, schools, office buildings, etc. provides normally only slightly above normal exposures; asbestos products which have been considered were those related to asbestos panels, asbestos ceiling tiles, sprayed-on asbestos materials. It is important to acknowledge that no confirmed cases of disease have been reported which could definitely be attributed to indoor asbestos exposure other than the household-contact exposures referred to above where dust was transferred from the dusty workclothes worn during asbestos occupational exposure, to the home by working relatives, etc.

Although some pleural plaques have been detected (seen by X-ray examination) including in certain regions of the world where asbestos occurs naturally, these plaques are not reported to have significant health implications.
for the general population.

Other than mesothelioma and suggestions of lung cancer in the general population which could be related to environmental asbestos exposure, certain other cancers have also been studied, eg. gastro-intestinal, ovarian, laryngeal and kidney cancers; as far as these latter cancers is concerned, the evidence for occupationally exposed workers is weak, and thus for the general population having much lower exposures, it can be concluded that evidence for it being significant is weaker still. In relation to gastro-intestinal cancer specifically, it should be pointed out that where asbestos is inhaled, some of the fibers will subsequently be ingested. Any evidence of gastro-intestinal cancer in the general population is extremely weak and this is of relevance to the ingestion of drinking water where it is conveyed through asbestos-cement pipes; the ingestion of asbestos in drinking water is not considered to be a significant health problem (Water Quality Guidelines, WHO, Geneva, 1993).

It seems that as a result of various community studies, no firm evidence of a health risk from environmental asbestos seems to exist nowadays (various controls have been adopted and changes in usage of some asbestos products made), but risk estimates based on mathematical predictions have been considered; these are considered below.

3.9.4.5 estimates of possible health risks associated with inhaling asbestos in environmental air

Since there is definite and indeed a sizeable health risk associated with past occupational exposures where high levels of asbestos were inhaled by workers at that time, it is not inconceivable that perhaps a small risk might possibly exist for the general population where the latter inhale very much lower concentrations of asbestos.

Since asbestosis (see above) is considered to be too improbable in relation to the general public's exposure, only the risk estimates for possible lung cancer and mesothelioma need to be considered.

The extent of any possible general environmental health risk has been carefully considered by a number of specialists in recent years. By making
comparisons and extrapolations with data related to the past heavy industrial exposures and related health effects, it has become possible to estimate the health risk for present-day environmental levels of asbestos in ambient air (primarily the exposure is to chrysotile asbestos nowadays).

Based on a long-term exposure of 0.0005 fibers per ml. air (fibers more than 5 micrometres long), which seems typical of the situation even for people who may have been exposed to a somewhat higher level say at school for some years, a risk level can be estimated. The calculations using the occupational health/exposure data involve the use of a linear model for lung cancer and a power model for mesothelioma. For a variety of reasons, including the fact that many past occupational figures underestimated the true exposure situation for different types and mixtures of asbestos, and because the model assumes that possible effects could occur even for extremely low exposures (i.e. model neglects a 'threshold' level below which no effects could occur), the risk values will be conservative. The cancer risk (if any) from being exposed to present-day levels of around 0.0005 fibers per ml. air (fibers of more than 5 micrometres long) appears to be at most equivalent to a 'rare-event extremely low level risk' which for example, is perhaps equivalent to the very low risk of being killed by lightning, of getting cancer from eating some charcoal-broiled meat, or getting cancer from the increased cosmic radiation by flying across the Atlantic say once a year: see table 1 for more details. The true level of risk could well be even lower because the public's present-day exposure is predominantly to chrysotile asbestos which has a much lower potential risk in comparison with amphibole forms of asbestos.

The estimated level of lifetime risk of cancer being exposed at the typical environmental level of 0.0005 fibers per ml. air appears at most to be around one in 100,000, which is at a figure where informed society would seem not to consider further controls to be warranted. The Water Quality Guidelines of WHO accept a lifetime risk level of 1 in 100,000 as 'acceptable'; there is no reason why this would also not apply to environmental ambient air exposures. To give some additional appreciation of the degree of such an estimated risk level, it has been estimated that for example in Britain if 20% of the 50 million or so population there experience the typical environmental exposure for 20 years, then so low is the anticipated risk that at most only one death per year would be caused by the asbestos in air; this is said to correspond to a predicted average loss of life of
only 15 minutes.

3.10 CONTROL OF ENVIRONMENTAL ASBESTOS

Because of the extremely low predicted level of environmental risk associated with the present-day usage of asbestos products where the proper controls are being utilized, there would appear to be no special general need to introduce ultra stringent control measures or to curtail the usage of asbestos. However, if adequate control measures are not being taken as may occur in some parts of the world as can arise in some developing country situations, then well-recognized approved control approaches would need to be adopted to ensure that the concentrations of asbestos in the general environmental air are at acceptable levels.

Although overall control is very important, there are three particular situations which often require special vigilance in terms of a requirement of ensuring effective control; these are (i) old friable asbestos in buildings, etc., and its removal, (ii) demolition of buildings where substantial quantities of asbestos are present, (iii) asbestos-waste disposal; particular attention in each case needs to be given to amphibole asbestos.

Because of the known relatively high occupational risk of being exposed to amphibole forms of asbestos compared with chrysotile, these forms (crocidolite and amosite) are being phased out. Certain types of consumer product, including the use of loose asbestos fibers; and the spraying of asbestos are now discouraged and banned in some countries.

3.10.1 Asbestos control in mining and milling of asbestos

Special control measures have been developed and adopted for these processes since mining and milling are both potentially very dusty operations. By means of the provision of copious quantities of water, good control can often be achieved in many mining activities. The modern processes of milling of asbestos ore can be effectively controlled to provide the minimum of fibre-release to the general environmental air; electrostatic precipitators, cyclones and bag house filter systems are often effectively employed.
3.10.2 Asbestos control in product manufacture

Because of some of the forms of asbestos used and certain types of products used in the past, it was very difficult to control the emissions of fibers to acceptable levels during manufacturing processes. Now with advanced technology and the extensive use of wet processes, it is relatively easy to control the release of asbestos fibers to an acceptable degree both for worker protection as well as in relation to potential contamination of the general environmental air. Various regulations exist in different countries, limiting direct emissions of asbestos into the general atmosphere. These days, careful control has been introduced to ensure that workers take a shower before leaving their workplace as well as ensuring that they travel home after work wearing clothing uncontaminated with asbestos dust.

3.10.3 Asbestos control in construction activities using asbestos products

For the present-day manufactured asbestos products where preformed materials are usually supplied to the construction industry, any possible problems of environmental contamination are minimized. Most construction materials nowadays consist of a product where the asbestos is firmly bound to a matrix (e.g. asbestos-cement) and in cases where the material needs to be shaped on site, special highly effective cutting tools (including those into which water is injected) are available. Codes of practice relating to the use of present-day asbestos products should be adopted and by the working personnel involved.

3.10.4 Asbestos control in buildings

In general, the predicted possible risk from asbestos exposure in buildings has been shown to be extremely low. In some specific cases however the past usage of asbestos in a building has created a possible potential risk to the occupants where some people might have become exposed to substantial amounts of fibers over a period of time. This can be because of serious
deterioration or damage of certain types of asbestos materials, including the presence of sprayed-on friable asbestos; in such cases either remedial measures such as sealing, encapsulation or even removal, may be warranted. In the case of removal, there have been many reported cases where elevated environmental levels have been created due to inappropriate (or no) control measures having been used. It is essential to use proper control measures for this purpose; the appropriate procedures are now well-documented. Many people now are of the opinion that the wholesale removal of asbestos from buildings is in fact unnecessary and indeed unwise because, (i) the removal workers may be needlessly subjected to elevated levels of exposure, (ii) there are many examples of where (owing to malpractices and accidents) significant release of asbestos to the environment has occurred, (iii) apart from the cost being often very high, the subsequent health risk is generally extremely and acceptably low when simple sealing of damaged/friable asbestos is performed; this latter practice being often very easy and cheap to carry out.

3.10.5 Asbestos control in building demolition

If a substantial quantity of friable old asbestos, especially amphibole asbestos including amosite and crocidolite, is present in a building, then it may be prudent to remove the relevant material where possible, prior to demolition; the procedures for doing this are well documented. In contrast, most present-day asbestos products would create very minimal difficulties when a building is demolished.

3.10.6 Asbestos control in waste disposal

Good control is important, both in the handling, packaging, transportation, and disposal to landfill. The procedures for doing this are now fairly well-standardized and also fairly well-documented. With proper control measures which are usually readily achievable, a satisfactory minimal release of any asbestos to the environment can be maintained where asbestos waste needs to be disposed of. In the case of factory wastes containing asbestos, these are usually readily handled and controlled because in many situations the material is wet; these days, many industries are recycling waste materials as an economic and effective control measure.
4. EVALUATION OF REPLIES TO QUESTIONNAIRES SENT TO EMR MEMBER STATES

A copy of the questionnaire used is given in Annex 1. Replies to the questionnaire were received from Bahrain, Cyprus, Egypt, Djibouti, Iraq, Jordan, Oman, Pakistan, Sudan, and Syria. Since replies were not received from all the Member States in the Region, a complete assessment of the situation in the Region is not possible; however based on some general background knowledge of the Region it was felt that the replies received would be expected to be fairly representative of many aspects of the sources and uses of asbestos which could contribute to environmental asbestos air pollution related to the Region as a whole. Taking account of the answers received, the following conclusions could be drawn:

(1) Environmental asbestos exposure in the Region is regarded as ranging from a 'small' to a 'large' problem depending on the country; mainly it is described as a 'small' to 'moderate' problem.

(2) Mining of asbestos occurs in a few countries; where it is mined, it is also processed in the country.

(3) Some manufacturing of asbestos products is currently being carried out in most Member States.

(4) Many Member States are importing asbestos/products from abroad.

(5) In most Member States the asbestos/products are mainly for outdoor usage; in a few Member States, the asbestos is predominantly for indoor usage.

(6) Where asbestos has been used for insulation purposes, it has been for the purpose of heat insulation, hot water and steam pipe thermal insulation, roofing, sheeting and for false ceilings.

(7) In general, the extent of usage of asbestos/products is 'rather small' to 'fairly extensive'; in one country the usage was described as 'extensive'.

(8) In most Member States the asbestos product used is mainly as asbestos-cement materials.
(9) Only in two countries had any formalized studies related to asbestos in general environmental air been carried out.

(10) In most Member States, no consideration is normally given to removing asbestos/products first prior to demolishing buildings/structures; only in one country was the asbestos stated to be usually removed first.

(11) 'No' or 'very little' in the way of health education and awareness programmes have been carried out regarding environmental exposure to asbestos in the general air in individual countries in the Region.

(12) In terms of the extent of actual physical controls being adopted regarding the release of asbestos to the general environmental air, Member States practiced either, none or at most the control measures were described as being carried out to a 'little extent only'.

(13) In relation to the anticipated sources/situations where asbestos could be released to the general air, Member States regarded the most important to be:- Manufacturing (factories making roofing sheets, panelling, pipes, car brakes, heat insulation products), Waste Dumps and Waste Disposal Practices (industrial wastes), Construction Activities (cutting sheets, pipes, installation work), Release to air from in situ products (roofing, panelling, insulation products), Vehicle Brakes (road vehicles, trains), Asbestos Removal and Building Demolition where asbestos was present.

(14) The greatest concerns were expressed regarding asbestos release to the general environmental air coming from factories making asbestos products, from outside usage situations (roofs, panels in situ), arising from construction work, and due to asbestos waste disposal operations. Problems/concern were also expressed related to the release of asbestos during transportation of asbestos-containing materials and asbestos removal operations. Some problems and concern were considered to relate to the release of asbestos from mining/milling of mined asbestos in some Member States, and from usage of asbestos/products inside offices/schools and homes in some cases.
5 CONCLUSIONS

These conclusions relate to the general situation regarding environmental asbestos air pollution taking account of the situation in the Eastern Mediterranean Region where information was available.

5.1 General Conclusions

Relatively little is known about the details of asbestos usage, of asbestos released to the air and levels of asbestos in the general environmental air, and the specific problems in the Member States of the Eastern Mediterranean Region. What is known however is that many of the uses, sources and potential air pollution situations in the Eastern Mediterranean Region are in principle not dissimilar to those in a number of other parts of the world about which more is known.

It is very likely that many of the different usages of asbestos common to other countries will have occurred in a number of Eastern Mediterranean Region Member States. A World Health Organization publication [Asbestos and Other Natural Mineral Fibres, Geneva, 1986] refers to the production of asbestos in three countries in the Region:- Afghanistan, 4000 tonnes produced in 1979; Cyprus, 35,472 tonnes produced in 1979 declining to 17,288 tonnes in 1983; Egypt 238 tonnes in 1979 increasing to 325 tonnes in 1983. The production in Cyprus was 14585 tonnes in 1988 and that of Egypt 450 tonnes in 1992. The Middle East is considered a growth area regarding asbestos-cement production. Production facilities exist in Saudi Arabia, Kuwait, Iran, Iraq, Oman, United Arab Emirates, Lebanon and Syria; Morocco, Tunisia, Libya and Egypt also have production capabilities. As far as importation figures of products containing asbestos for specific countries in the Region, the information is sparse.

What is to be expected is that the environmental control of asbestos in certain Eastern Mediterranean Region Member States would not have been as good as for some more developed countries in the world; known examples exist of poor asbestos waste disposal in the Region.

Effort is needed to assess the extent of asbestos usage in the Region in relation to any significant release of asbestos fibers to the ambient environmental air.
An increased awareness of the need for adequate control needs to be promoted. Training in the use of control measures is important.

The collection and assessment of any data in the Region regarding environmental asbestos air pollution and its dissemination to all Member States in the Region, would be highly desirable. Effort needs to be encouraged for improvements in safe handling, safe use, proper emission-control in asbestos product manufacture and usage, and safe disposal of asbestos and products containing it.

5.2 Specific Conclusions

(1) Airborne contamination by asbestos fibers is common, although environmental exposure levels are normally low; most fibers in environmental ambient air are short, i.e. less than 5 micrometres long.

(2) Most of the asbestos in environmental ambient air is chrysotile (white) asbestos with lower proportions of crocidolite (blue) and amosite (brown) amphibole forms of asbestos.

(3) Both natural and man-made sources of environmental asbestos contribute to levels in ambient air.

(4) In the Region, a wide range of asbestos products seems to exist used for outdoor and indoor use. Modern products such as asbestos-cement (roofing, panels, piping, etc) release relatively little in the way of fibers; where they exist, old insulation materials and sprayed on asbestos can more readily release fibers.

(5) Few products used today contain amphibole asbestos. Older products may contain some amphibole asbestos; old insulation materials often contained a high proportion of amosite and/or crocidolite.

(6) The carcinogenic potential of asbestos increases with fibre length. Fibres less than 5 micrometres long are not considered to be carcinogenic. Based on the experience of heavy occupational exposures years ago, amphibole forms of asbestos (eg, crocidolite and amosite) are more carcinogenic than chrysotile asbestos. Diseases such as asbestosis, lung cancer and mesothelioma have been reported to be associated with heavy occupational exposures to all forms of asbestos.
(7) Both mesothelioma and lung cancer in the general public may perhaps possibly have resulted where people happened to be exposed for prolonged periods to elevated levels of environmental asbestos in air; lung cancer however appears to be rather less likely in that this seems to be associated with occupational exposures where asbestosis also occurs (this latter disease occurs only as a result of exposure to very high levels of asbestos). In the past some cases of mesothelioma were reported in the general population in certain parts of the world due to situations of specially high exposure to crocidolite and/or amosite. It has been reported that any risk of disease in the general population due to present-day asbestos exposure is undetectably low (IPCS, EHC 53).

(8) In most situations, the risk to the general public would appear to be so low as to be considered negligible, i.e., acceptably low. At most, the risk would normally appear to be less than certain extremely low 'rare-event' risks such as being killed by lightning. In situations of poor control, as does occur especially in some developing countries, the risk may perhaps in some situations be higher.

(9) Of somewhat more concern, is exposure to loose or friable asbestos material especially where it is non-bonded; asbestos-cement products where fibers are essentially 'locked-in' is of little concern, unless subjected to rough mechanical treatment such as sanding, grinding or cutting.

(10) There is concern regarding the repair or removal of asbestos in-situ in buildings (including situations of building demolition with considerable quantities of certain forms of asbestos present). The wholesale removal of asbestos from existing buildings is no longer considered appropriate; however, removal may be needed in some cases where highly friable asbestos exists particularly where loose amphibole asbestos is present in substantial amounts. Where achievable however, the well-tried process of sealing/encapsulation should be used.

(11) There is some concern regarding asbestos-waste transportation and disposal to landfill because of the danger of spreading asbestos to the environmental air in situations where poor control exists.

(12) As far as mining, manufacture, use and disposal of asbestos in the Eastern Mediterranean Region, any concern would relate more especially to
situations where poor control could exist. Some cases of poor control have been reported in some Member States. It is important that manufacturers and users become fully aware of the potential dangers of asbestos and that the appropriate control methods (provided in certain available codes of practice) are consistently adopted and followed.

Some conclusions which were drawn specifically taking account of replies to questionnaires distributed to Member States are given in section 4, 'EVALUATION OF REPLIES TO QUESTIONNAIRES SENT TO EASTERN MEDITERRANEAN REGION MEMBER STATES'.
6. RECOMMENDATIONS

6.1 General recommendations

Where significant problems are thought to occur (eg. where poor control measures exist) particular attention could need to be given to potential asbestos emissions to environmental ambient air and aspects of improvements in control related to:

(1) Manufacturing processes (factories making roofing sheets, paneling, pipes, car brakes and thermal, insulation products)
(2) Waste dumps and waste disposal practices (primarily industrial wastes)
(3) Constructional activities (cutting of sheets, and pipes, installation of various products)
(4) Release of asbestos fibers to air from usage of products such as roofing, paneling, insulation products
(5) Specifying of and following of defined asbestos removal criteria, including where building demolition is involved
(6) Asbestos/products being transported
(7) Mining and milling (in countries where this is carried out)
(8) Inside usage for offices, schools and homes
(9) Asbestos and asbestos product usage including type of asbestos (ie. specifying and labelling of chrysotile or amphibole forms)

NB. Special attention should be given to health education and awareness programmes for the general public.

6.2 Specific Recommendations

(1) The Ministry of Health in individual Member States to consider preparing and issuing guidance leaflets describing the impact for the general public regarding asbestos release to environmental air (the guidance should stress that any impact is minimal where good controls are practiced in
order to encourage the safe use of asbestos/products and the adoption of proper controls).

(2) The Ministry of Health (in conjunction with appropriate Industrial Bodies) in individual Member States to consider preparing and issuing guidelines (including the formulation of written codes of practice) related to the safe use of asbestos and control of any asbestos-release to the general environmental air. These should be directed to all manufacturers and users of asbestos/products (the guidelines to refer to factory emissions, waste dumps and waste disposal practices, construction industry, asbestos removal activities, mining and milling of asbestos).

(3) Studies to be carried out of the mining and manufacturing (where these apply), usage and disposal related to asbestos activities in individual Member States.

6.3 Suggested follow-up action for WHO to consider in relation to Asbestos in Environmental Ambient Air in the EMR

(1) WHO to distribute to all Member States the prepared documentation on the significance of environmental asbestos air pollution which includes reference to health implications of being exposed to asbestos fibers from the various sources and aspects of control.

(2) WHO to undertake missions to selected Member States in order to evaluate existing situations in regard to asbestos in environmental air taking account issues and specific problems, pointing the way for Member States to consider and to study these including providing local advice on health aspects, safe usage, and approaches for control (including the preparation of written codes of practice). Particular attention to be given to (a) general asbestos type and product usage, (b) factory emissions, (c) waste dumps and waste disposal practices, (d) constructional work, (e) criteria for and asbestos removal, (f) mining and milling, (g) asbestos/products being transported, (h) asbestos in indoor air of offices, schools, homes, etc.

(3) WHO to draw up guidelines for health educational and awareness programmes including control aspects.

(4) WHO to hold Regional Seminar on subject of Asbestos in the Environment and its Control for EMR Member States.
SELECTED BIBLIOGRAPHY


(4) Harvard University, Energy and Environmental Policy Centre: Proceedings Symposium on Health Aspects of Exposure to Asbestos in Buildings, Harvard, USA, 1989


Annex 1

INDOOR AIR POLLUTION QUESTIONNAIRE

RELATED TO YOUR COUNTRY PLEASE COMPLETE FOLLOWING QUESTIONNAIRE:- (NB. For the purposes of this questionnaire "Indoor Air Pollution" covers all sources except the exposure to industrial pollutants at the workplace).

A. Tick appropriate box (only one tick per question is required)

1. Is exposure to Indoor Air Pollution considered to be important?
   - Large problem □
   - Moderate problem □
   - Small problem □

2. What are considered to be the main sources of indoor air pollution problems?
   - Mainly combustion products (heating/cooking) □
   - Mainly natural pollution (dusts/pollens, etc) □
   - Mainly other sources (PLEASE SPECIFY) □
   - Similar problems each for combustion, natural and "other" sources □

3. Where are the greatest problems considered to exist?
   - Mainly rural areas □
   - Mainly urban areas □
   - Similar problems for rural and urban areas □

4. Does air temperature seem to affect the severity of the problem?
   - Problems mainly when colder □
   - Problem mainly when hotter □
   - Problem not significantly affected by temperature □

5. What are considered to be main combustion fuels causing problems?
   - Fuels combusted mainly for heating □
   - Fuels combusted mainly for cooking □
   - Similar problems for both heating and cooking □

6. Generally, are combustion fumes vented to outside air?
   - Nearly always □
   - Fairly often □
   - Very rarely □

7. What typically is considered to be the exposure time for elevated levels of indoor air pollution?
   - Only very brief periods per day □
   - Around 1/2 to 2 hours per day □
   - Many hours a day □

8. What typically are the populations exposed to elevated levels of indoor air pollution?
   - Mainly females □
   - Mainly males □
   - Similar exposures for men & women □

9. What age group has the anticipated greatest exposure problem?
   - Children □
   - Adults □
   - Similar for all □

10. Have formalized actual studies of indoor air pollution been carried out?
    - Yes □
    - No □
    - (If answer is "Yes" please provide brief outline information on a separate sheet, indicating type and number of studies, where they were carried out,
extent and type of problems found; plus (where available) outline of air pollutant concentrations found and nature and extent of health effects and populations affected.

11. How important a problem is indoor air pollution by tobacco smoke considered to be?
   Very important [ ] Moderate importance [ ] Minor problem [ ]

12. What is the coverage for Health Education and Awareness Programmes regarding indoor air pollution?
   Extensive [ ] Some [ ] Very little [ ] None [ ]

13. What is the extent of actual physical control activities for indoor air pollution?
   Extensive [ ] Some [ ] Very little [ ] None [ ]

B. Please answer/complete the following:

1. List all anticipated sources of indoor air pollution
   (commence with most important first)

2. List actual indoor air pollutants regarded to be of national concern
   (commence with most important first)

3. List types of heating and cooking fuels being used
   (commence with commonest fuel used)

4. Indicate situations where indoor air pollution problems exist (insert in boxes in priority sequence, number 1-6; 1 being greatest problem, 6 the least).
   Homes ( )
   Offices ( )
   Restaurants/Bars ( )
   Shops ( )
   Entertainment establishments ( )
   Other ( ) (PLEASE SPECIFY "Other")
### Annex 2

**LIFETIME RISK VALUES FOR SELECTED SITUATIONS**

Selected risk situations; mainly U.S. data:

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Activity</th>
<th>Lifetime risk per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra High Risk</td>
<td>Smoking (all causes of death)</td>
<td>21,000</td>
</tr>
<tr>
<td></td>
<td>Smoking (cancer only)</td>
<td>8,800</td>
</tr>
<tr>
<td>High Risk</td>
<td>Motor vehicle</td>
<td>1,600</td>
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<tr>
<td>Elevated Risk</td>
<td>Frequent airline passenger (deaths)</td>
<td>730</td>
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<tr>
<td></td>
<td>Cirrhosis of liver, moderate drinker (deaths)</td>
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<tr>
<td></td>
<td>Motor accidents, pedestrians (deaths)</td>
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<tr>
<td>Moderate risk</td>
<td>Light drinker, one beer per day (cancer)</td>
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<tr>
<td></td>
<td>Drowning deaths: all recreational causes</td>
<td>140</td>
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<td></td>
<td>Air pollution, U.S., benzo(a)pyrene (cancer)</td>
<td>110</td>
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<tr>
<td></td>
<td>Natural background radiation, sea level (cancer)</td>
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</tr>
<tr>
<td></td>
<td>Frequent airline passenger, cosmic rays (cancer)</td>
<td>110</td>
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<tr>
<td>Low Risk</td>
<td>Home accidents (deaths)</td>
<td>88</td>
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<tr>
<td></td>
<td>Person sharing room with smoker (cancer)</td>
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<tr>
<td></td>
<td>Diagnostic X-rays, (cancer)</td>
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<tr>
<td></td>
<td>(Risk level where few would commit their own resources to reduce risk; Royal Society, London)</td>
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<tr>
<td>Very Low Risk</td>
<td>Living in brick building, natural radiation (cancer)</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Vaccination for small pox, per occasion (death)</td>
<td>22</td>
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<tr>
<td></td>
<td>One transcontinental air flight per year (death)</td>
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<tr>
<td></td>
<td>Saccharin, average U.S. consumption (cancer)</td>
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<td></td>
<td>Consuming Miami or New Orleans drinking water (cancer)</td>
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<tr>
<td></td>
<td>(Risk level where few would consider action necessary, unless clear causal links with consumer products, Royal Society, London)</td>
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<tr>
<td>Extremely Low 'Rare-Event' Risk</td>
<td>One transcontinental flight per year, natural radiation (cancer)</td>
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<tr>
<td></td>
<td>Lightning (deaths)</td>
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<tr>
<td></td>
<td>Hurricane (deaths)</td>
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<tr>
<td></td>
<td>Charcoal broiled steak, one per week (cancer)</td>
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<td>ENVIRONMENTAL ASBESTOS RISK (cancer), (around one per 100,000 or lower)</td>
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<td>('Acceptable' risk, WHO, drinking water (cancer))</td>
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<td>(Further control not justified, Royal Society, UK)</td>
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