PLAINTIFF'S
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GF-2238

BIOLOGICAL EFFECTS OF ASBESTOS

LYON, October 2-5, 1972

Paper 38

Asbestos in the Environment

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ASBESTOS IN THE ENVIRONMENT

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SUMMARY

Chrysotile asbestos has been found to be present at concentrations of nanograms per cubic meter in the air of major U.S.A. metropolitan centers. Similarly, water sampling demonstrates the presence of chrysotile at concentrations of micrograms per gallon in two eastern U.S.A. river systems. The sources of these environmental levels have not been determined, but they could be the result of both man's activities and natural sources.

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This paper will discuss the sources from which asbestos may enter the air and water of our environment. Methods of measuring small quantities of asbestos which may exist in the environment will be described, and data on the quantities which have been found in the atmosphere and in rivers will be presented. Throughout the discussion, the term "asbestos" will be used to refer in a non-specific way to the family of fibrous inorganic minerals typified by chrysotile, crocidolite, amosite, anthophyllite, actinolite and tremolite.

SOURCES

There are two general sources from which asbestos fibers may be freed in a form to enter our environment: (1) the activities of man; and (2) the activities of nature. Man's activities encompass the mining and milling of asbestos, or of other materials that contain some asbestos; the fabrication of asbestos-containing products; the application and use of these products; and the disposal of the waste or residue from these activities. The natural sources of asbestos in our environment are the weathering and erosion by wind and water of rock masses that contain asbestos.

The mining of asbestos is carried out in both open-pit and underground mining operations. The potential sources of asbestos in the environment are open blasting of ore, transportation of the ore to the milling site, drying the

ore, freeing the fiber from the host rock, and disposal of the waste or tailings from the milling process. In addition to the mining of asbestos ores, other mining operations, which involve materials that may contain asbestos as a minor impurity, are potential sources of asbestos. Examples would be the mining of certain talc deposits which contain tremolite asbestos as an impurity, and the quarrying of serpentine rock which may contain asbestos. Although the quarry grade serpentine rock may not contain any visible asbestos fibers, examination of a number of serpentine rock samples from many different geographical sources has shown that many of them contain electron microscopic-size asbestos fibers.

Manufacturing operations which incorporate asbestos into the many products in which it is used are potential sources of asbestos in the environment unless all air and water effluents from the manufacturing activities are efficiently and effectively filtered. In addition, the solid asbestos-containing waste from manufacturing is a source of asbestos unless it is properly transported and covered in a suitable waste disposal area.

On a world-wide basis, the major use of asbestos in manufacturing is, by far, in combination with cement to form a variety of asbestos-cement products such as pipes, flat and corrugated sheets, shingles, and molded articles. Well over half of all the asbestos produced annually is incorpor-

ated into asbestos-cement products of this type. Other significant uses of asbestos are in asphalt and vinyl-based flooring, in insulating products for pipes and boilers and shipboard walls, in roofing felts and shingles, in specialty textiles, in friction materials and packings, in gypsum joint cements, in spray composition fireproofing products and in electrical insulations. There are literally hundreds of applications beyond those just listed, but many of them constitute relatively minor uses insofar as the total quantity of asbestos used annually is concerned.

Once an asbestos-containing product has been manufactured, whether or not it may constitute a source of asbestos in the environment will depend to a great extent on whether or not the asbestos is firmly "locked-in" the product with a binder, saturant, coating or bonding agent such that normal handling, application and use does not release asbestos. Asbestos-cement products are a good example of "locked-in" products which probably do not constitute a significant source of asbestos to the environment under normal conditions of use once they have been manufactured. On the other hand, the use of asbestos in spray-on fireproofing compounds is an example of a nonlocked-in use. The major source of environmental contamination in this use is the application of the spray itself and subsequent dissemination of airborne asbestos fiber from the application site. This problem is serious enough that this use of asbestos has been banned in a number of cities in

the United States.

Another potential source of asbestos in the environment may be from brake linings. Brake linings contain about 50 per cent asbestos by weight. Studies have shown that under average braking conditions 98 per cent or more of the asbestos in the linings is destroyed by the heat of friction. Nevertheless, it has been speculated that the small quantities of asbestos released from the linings may be a source of part of the background level of electron-microscope-size fibers in the ambient air. More definitive work needs to be done to establish the actual quantity of asbestos fiber released from brake linings in a state which permits it to become airborne and remain airborne.

The demolition of structures which contain asbestos-bearing products can be a source of fiber in the air unless precautions are taken to wet down the asbestos-containing products. This would be particularly true for relatively low-density products such as pipe and boiler insulation and for buildings which had been fireproofed with an asbestos-containing spray-on fireproofing.

Construction excavations and road building activities can be potential sources of asbestos in the environment if they are in areas of serpentine rock. Since most serpentine rock contains E.M.-size asbestos fibers, the open blasting associated with road building and excavations has the potential to put E.M.-size fiber into the air.

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The natural weathering of asbestos-bearing serpentine

rock is another potential source of E.M.-size fiber in the ambient air and in water. Serpentine is a relatively common type of rock in many areas of the world where it occurs at or near the surface. Although it is reasonable to assume that the weathering of these rock masses may release some E.M.-size fiber to the environment, it is difficult to determine how much this source may contribute to the environmental background of asbestos.

SAMPLING AND ANALYSIS TECHNIQUES

In the analysis of ambient air samples for asbestos, the presence of other organic and inorganic material presents significant problems. Typical urban air may contain 100 $\mu g/m^3$ of "suspended particulates". Such material is generally of respirable size and may include 25 per cent to 50 per cent of inorganic matter. In contrast, typical urban asbestos concentrations range from about 0.1 ng/m^3 to perhaps 100 ng/m^3. Thus, asbestos may constitute only 0.001 per cent to 0.1 per cent of the particulate matter present in a given air sample. Moreover, the asbestos found in the ambient air includes both micron-size fibers and numerous individual fibrils, having diameters of from 200 angstroms to 400 angstroms and lengths of perhaps 1000 angstroms. In many cases these fibers and fibrils may be agglomerated with a variety of other material present in the air sample.

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These considerations preclude the possibility of quantitative analysis of such ambient air samples by light micros-

To prepare a sample for electron microscopic analysis, a portion of the sample, mounted on a microscope slide, was ashed in a low temperature activated oxygen asher for 20 minutes to 1 hour. This served to remove the membrane filter material, all organic material in the collected sample, soot, and other carbonaceous material. The residue, consisting mostly of fly ash and mineral matter, was dispersed on the microscope slide by grinding the sample with a watch glass in a solution of one per cent nitrocellulose in amyl acetate for 5 to 10 minutes. The sample was dispersed fairly uniformly over part of two microscope slides by placing another glass microscope slide over the ground sample, and drawing the microscope slides apart. Upon evaporation of the amyl acetate, the dispersal was scanned for uniformity by optical microscopy and representative areas chosen for transfer to electron microscope grids for scanning. Alternatively, techniques have been used in which the sample was dispersed by ultrasonic energy while suspended in a detergent solution (Aerosol OT). By thus breaking up and dispersing the mineral matter, the asbestos fibers which had agglomerated on other particles are made visible. However, this procedure destroys any information of the fiber size distribution of the asbestos; only knowledge of the mass of asbestos in a sample can be obtained.

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In the above "rubout" procedure, all the material from an ashed sample (usually that on 1-3 cm^2 of the filter) is dispersed over a prescribed area of a microscope slide. If

no losses occurred during the ashing and rubout, the amount of fiber in the sample could be determined by multiplying the amount of fiber measured on the area observed in the electron microscope by the ratio of this area to the total area of sample on both microscope slides. In practice, losses occur in both the ashing procedure and rubout. These have been determined by periodic checks with doped samples and found to be in the range of 40 to 70 per cent. In addition to the problem of using an "average loss correction" there is an additional unknown error introduced by the non-uniformity of the material deposit over the total slide area.

An alternative procedure is to ash a larger portion or all of the sample in a crucible and disperse an aliquot during the rubout. Here, it has been found useful to mix some radioactive Au^{198} with the ashed residue. The fraction of the initial sample dispersed on an electron microscope grid can then be determined from the relative count rates of the grid and the full sample.

The samples thus prepared were scanned either directly or on photomicrographs at a magnification of approximately 40,000X. Identification of chrysotile took advantage of its unique tubular structure and in our analyses was the only asbestiform mineral quantitated. Typically, four to eight 100 micron x 100 micron squares of separate grids from each sample were scanned and the mass of chrysotile fibers determined by sizing each individual fiber. The fibers ob-

served per square ranged from a few fibrils to over 100. Background contamination levels averaged less than 2 fibrils per square. This level was maintained, however, only by adherence to strict clean room procedures, as normal room air provided a ready source of contamination. While random statistical variations occurred in the number of fibers counted per square, greater variations arose from the highly variable volume of an asbestos fibril. An additional source of variation between measurements on samples prepared from different portions of the same filter is the random presence of groups of fibrils from large fibers that were incompletely dispersed during the rubout.

During the course of this work, sixteen samples were analyzed in duplicate. The samples were mostly those for which an unusually high or low value was found on the initial analysis. Thus, differences in replicate analyses would reflect the large fluctuations present both in samples having only a few fibers present on a grid square and in those with large fibers that may have been improperly dispersed. The average per cent deviation from the mean of all samples analyzed in duplicate was 43 per cent. In view of these calibration studies and duplicate analyses, we feel confident that a single analysis is accurate within a factor of two. Averaging over several samples thus provides a very good representation of the chrysotile asbestos content of urban air.

RESULTS OF SAMPLING AND ANALYSIS OF AIR

One hundred eighty-seven (187) samples from 49 United States cities,collected by the National Air Pollution Control Administration from their air sampling network during 1969 and 1970, were analyzed. Biweekly samples in various 3-month periods were composited and analyzed using the microscope slide ashing procedure. Table I gives the ranges of values obtained. Table II lists the results obtained from a series of single samples collected in New York City by the Department of Air Resources at 12 sites of their sampling network.

All of the above samples were collected during periods when the procedure of fireproofing high-rise buildings by spraying asbestos-containing materials was permitted. While no sampling station was known to have been located adjacent to such sites, unusually high levels could have resulted from these procedures.

To verify that construction sites were, indeed, a significant source of asbestos fiber, sampling was conducted in lower Manhattan about construction sites where extensive spraying of asbestos-containing fireproofing material was taking place. Table III shows the results of this sampling and demonstrates that spray fireproofing can contribute significantly to asbestos air pollution. In some instances, chrysotile asbestos levels approximately 100 times "background" are observed.

RESULTS OF SAMPLING AND ANALYSIS OF RIVER WATER

In the period March 1971 through March 1972 regular monthly water samples were taken from a series of stations located on the Juniata River in Pennsylvania and the Connecticut River which flows through the New England states. The stations on each river ranged from the upper to the lower reaches of the river. The purpose of the study was to establish the general levels of asbestos fiber which might be encountered in river waters in the eastern U.S.A., and to determine if there were any significant seasonal variations in those levels.

The results of the study are shown in Table IV. In all the samples in which chrysotile asbestos was found, the fibers were electron-microscopic in size, and probably many of them were suspended in the water as individual fibrils. Insofar as this study is concerned, there was no statistically significant seasonal variation in the amount of fiber found in the rivers. The numerical concentration values reported in Table IV should be considered as indicative of the order of magnitude of fiber in the water rather than as exact values. The extremely small quantity of fiber observed in the samples (e.g., 1 microgram/gallon is equivalent to less than 1 part per billion) makes quantitative analysis very difficult. The source of the fiber in the river water could have been from both man's activity and natural sources. In any case, the amount found is relatively small even though the lower reaches of these rivers have passed through industrial areas of activity

TABLE I

CHRYSOTILE CONTENT OF AMBIENT AIR - SAMPLES COLLECTED BY NAPCO

Fiber range in nanograms/cm^3	No. of samples in range
0.1 - 0.9	61
1.0 - 4.9	102
5.0 - 9.9	12
10.0 - 19	9
20 - 49	2
50+	1
Total samples	187

TABLE II

CHRYSOTILE CONTENT OF AMBIENT AIR IN NEW YORK CITY BY BOROUGH

Sampling Locations	Number of Samples	Asbestos air level in 10^{-9} grams/m^3 Range	Average
Manhattan	7	8-65	30
Brooklyn	3	6-39	19
Bronx	4	2-25	12
Queens	4	3-18	9
Staten Island	4	5-14	8

TABLE III

CHRYSOTILE AIR LEVELS NEAR SPRAY FIREPROOFING SITES

Sampling Location	Number of Samples	Asbestos Air Level in 10^{-9} g/m^3 Range	Average
1/8 - 1/4 mile	11	9 - 375	60
1/4 - 1/2 mile	6	8 - 54	25
1/2 - 1 mile	5	3.5 - 36	18

TABLE IV

CHRYSOTILE CONTENT OF EASTERN U.S.A. RIVER WATER

Sample Source	Number of Samples	Range in Micrograms per Gallon	Average in Micrograms per Gallon
Juniata River			
Breezewood, PA	13	0 - 9.2	2.2
Newton-Hamilton, PA	13	0 - 6.2	2.2
Lewistown, PA	10	0 - 15.0	4.7
Amity Hall, PA	10	0 - 14.8	3.5
Connecticut River			
Canaan, VT	13	0 - 13.9	2.6
Littleton, NH	13	0 - 13.8	2.6
Lebanon, NH	13	0 - 2.6	1.3
Greenfield, MA	13	0 - 23.5	5.1
Middletown, CT	12	0 - 14.5	5.9