Environmental Health Perspectives
Vol. 9, pp. 161–163, 1974

Chrysotile in Water

by Sidney Speil*

The problems of quantitating chrysotile in water by fiber count techniques are reviewed briefly and the use of mass quantitation is suggested as a preferable measure.

Chrysotile fiber has been found in almost every sample of natural water examined, but generally transmission electron miscroscopy (TEM) is required because of the small diameters involved. The extreme extrapolation required in mathematically converting a few fibers or fiber fragments under the TEM to the fiber content of a liquid sample casts considerable doubt on the validity of numbers used to compare chrysotile contents of different liquids.

Chrysotile accounts for approximately 95% of the asbestos fiber used commercially and occurring naturally in rock formations. Therefore, it is much more common than amphibole in the waters of the United States and, presumably, of the world. I would like to consider for a few moments the occurrence of chrysotile in various water samples and attempt to present a better perspective of the problems involved in quantitation of the fiber content in these waters.

The best way to detect and evaluate the amount of fibers is by a direct transfer technique from the collecting membrane or filter. In this way we can look directly at the original fibers, measure them, count them, integrate them in whatever form or method we wish by numbers, mass, etc. But when we are evaluating a tremendous number of samples, as we have done at the Johns-Manville Research and Development Center, and where we are attempting to quantitate a fiber which is really not an individual fiber, but merely an assemblage or bundle of fibers, we have a special problem. Each chrysotile fiber is a bundle of fibrils varying in diameter from 250 to 400 μm, depending on the amount of work that has been put into the fiber, these fiber bundles are splayed, partially opened, and in many cases, divided into subfibers, each of which again contains an assemblage of fibrils. Do we call such partially opened fibers a single fiber or a hundred million fibrils? In time, the fiber is liable to become mostly fibrils.

In the case of normal river waters, we find the situation different from that in Lake Superior where experimenters have found a fairly large percentage of the total material can be classed as fibers by the conventional NIOSH definition of a 3:1 aspect ratio. In river waters we find the percentage of chrysotile fiber in the filtered residue varying from as low as 0.001% to possibly 0.5% of the total matter on a weight basis. Because of these problems, we have adopted a mass system rather than a fiber number system.

The procedure we have adopted is relatively straightforward. The suspended solids are collected on some form of membrane filter, usually a Millipore filter, although a Nuclepore filter could be used just as well. We have determined that a 0.8 μm pore size filter effectively removes all fibrillar matter from the water. A large part of the material in river waters is organic in nature, which would normally interfere with quantitation by often masking the presence of fibers. We, therefore, ash the sample at 800°F to remove most of this organic

*Research and Development Center, Johns-Manville, Denver, Colorado 80217.

matter without significantly damaging the chrysotile structure. The residual material is rubbed out on microscopic slides to disperse the fibers and obtain a uniform field for transmission electron microscopy. By this technique we do not observe the fibers in their original form so that numerical fiber rating is meaningless, but mass measurement is easily done by counting all the chrysotile fibrils which are readily recognized.

An appropriate number of electron microscope pictures are taken at approximately 4000× magnification, and each fiber is measured for length and diameter. Masses are computed by an appropriate technique using a statistical system for specifying the probable number of fibrils for any measured diameter. The integrated mass of all fibrils in the pictures is then translated to a total mass for the entire sample by using either an area multiplication factor or by using a radioactive gold tracer to determine the percentage of the total mass for the entire sample by using either an area multiplication factor or by using a radioactive gold tracer to determine the percentage of the total sample that is on a microscopic grid. Few fibers are present in any sample. Chrysotile fibrils are readily recognizable by their form in this type of analysis. We have studied all kinds of water—potable water samples as well as normal river samples—and every sample of natural water that we have examined has had some small amount of chrysotile. In the water supply of ten cities that we studied, the chrysotile content varied from as little as 0.005 to as high as 6.0 μg/gal. This higher amount of chrysotile in the water is approaching the lower limits of the amount of fibrous material indicated *(1)* as being present in Lake Superior water samples.

Incidentally, we have not been able to identify chrysotile fiber in any of our potable water samples with optical microscopic observation alone; all the chrysotile fiber observed was submicron in size. In our normal evaluation process, each sample of filtered residue was scanned with an optical microscope at 500× magnification before being subjected to the normal rub-out technique.

While we talk about specific amounts of chrysotile fiber in the water, it should be recognized that by the techniques that are currently being used to evaluate the amount of chrysotile in water, we are fortunate if we find a variation of two to three times in the amount reported by different operators or even by replicate examinations by the same operator. Comparison between different laboratories often shows a variation of five times to as high as ten times in the amount reported. We, therefore, do not normally consider a variation of this magnitude between different waters to be significant unless a sufficient number of samples are taken to improve the statistics.

We have examined a wide variety of samples from river systems. In one study we compared two rivers. The Connecticut River, which starts in Vermont in the serpentine belt, was sampled for approximately one year at various points along its path. The other river, the Juniata River, flows through an area of the United States which does not contain any serpentine rocks and should not pick up any chrysotile from the rocks through which it flows. We confined our studies to the determination of chrysotile content and did not consider or measure amphibole fiber content.

After taking samples for one year at monthly intervals, we could observe no statistically significant difference for the average over the entire year in the amount of fiber in these two rivers. The variation from monthly sample to monthly sample and from place to place along the river was tremendous; these variations were particularly dependent on spring thaws, summer droughts, and other seasonal variations. But on an average basis, there was very little difference between the two rivers. Let's consider one additional point here as a point of reference. The average content of chrysotile fiber we found in potable water was approximately 1 μg/gal. Assuming a person drinks 2 l./day over a 70-year lifetime, he will consume a total of 50,000 l. The total lifetime fiber consumption is 0.05 g. For the maximum fiber concentration we found of 6 μg/gal, the lifetime consumption would be 0.3 g.

The truth is that everybody is exposed to some, relatively insignificant, amount of chrysotile fiber in the water they are drinking. They have been exposed to fiber in drinking water for over their entire lifespan.

Several years ago in England there was much

publicity devoted to the fact that chrysotile fiber was present in beer. This fiber was attributed specifically to the fact that many beers were filtered through asbestos-containing pads to improve the quality of the beer and remove residual proteins. Without delving deeply into this specific subject, as a result of the publicity we evaluated 30 different brands of beer. The specific sample of beer that had the most chrysotile in it had never been filtered through a chrysotile-containing pad, but it was made from water which came from a sparkling clear spring well in the mountains of Pennsylvania. These mountains are primarily serpentine rock which contain large amounts of ultramicroscopic chrysotile fibrils. Again, to bring things into proper perspective, various presentations today have referred to tremendous numbers of fibers. For example, a typical sample might contain 5×10^6 fibers/l. These fibers are extremely small, and if we assume an average fiber to be 0.15 μm in diameter with an aspect ratio of 10:1 or 1.5 μm long, then 1×10^6 fibers with the density of a typical amphibole would weigh approximately 0.085 μg; thus 12×10^6 fibers/l. is equivalent to μg/l.

We talk of these extremely large numbers of fibers as if they are precise numbers—3 million fibers or 5 million fibers. What we often forget is that in the method that is used in determining these fibers tremendous multiplication factors are involved. For example, in one of the more common methods of quantitating the number of fibers, a count of 5×10^6 fibers/l. is based on counting a total of approximately 20 fibers of extremely small dimensions in approximately 160 to 200 transmission electron microscope fields. The 20 fibers are then multiplied by a factor of 250,000. Going further, some attempts have been made to subdivide this into a specific number of amosite fibers or tremolite fibers or chrysotile fibers in the water using as a basis a total of only 20 fibers observed for the entire sample. I think you can have some compassion for the microscopist who does the actual microscopic observation and some reservation concerning the validity of the quantitative mineralogical data.

REFERENCE

1. Nicholson, W. J. Analysis of amphibole asbestiform fibers in municipal water supplies. Environ. Health Perspect. 165 **9**: (1974).