Dust-Fiber Relationships in the Quebec Chrysotile Industry

Graham William Gibbs, MSc, PhD, Maurice LaChance, Eng, Montreal

Epidemiological studies of Quebec chrysotile miners and millers have related various indices of health to dust exposure, as measured with the midget impinger. The interpretation of these relationships in terms of fiber necessitates the conversion of midget impinger (particle + fiber) counts to membrane filter (fiber) equivalents. An investigation in which 87 side-by-side midget impinger-membrane filter samples were taken at five mines and mills showed that the correlation was poor and no single conversion factor was justified. Until more detailed information on the relationships between midget impinger and membrane filter counts can be obtained, it is recommended that safety standards, at least in this industry, should continue to be based on dust counts, for which there is considerable epidemiological support, rather than on fiber counts, for which there is no direct evidence.

In Canada and the United States, for many years routine measurements of airborne concentrations of asbestos have been made by the midget impinger method. In consequence, the few epidemiological studies that have related health of asbestos workers to dust exposure have, of necessity, been forced to use concentrations measured by this technique. This has been true of surveys in Quebec of mortality, roentgenographic appearance, respiratory function and symptoms in chrysotile miners and millers,[1-5] and also of surveys of production workers in the United States.[6,7]

Because of its relatively low efficiency for the collection of fibers, the midget impinger is not ideal for the determination of airborne asbestos fiber concentrations.[8] This limitation and the belief that fiber is the essential cause of disease have led to the recommendation that standards for exposure should be based on fiber counts derived from the membrane filter technique.[9,10] In North America, there are no asbestos standards based on gravimetric or other methods.

Unfortunately, safety standards have little validity unless based on epidemiological evidence and, as has been stated, this evidence has of necessity been related to midget impinger counts. There might be no serious difficulty in converting dust counts to fiber counts if some reasonable constant relationship were found to exist between the two types of measurement. Ayer et al[11] measured the ratio between the membrane filter count and the midget impinger counts for textile plants, and found that ratios differed for different operations in the same plants and for similar operations in different plants. This report describes a preliminary investigation of this problem in the Quebec mining and milling industry.

Methods

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Surveys in August 1971 and 1972 were conducted at up to nine selected sites in each of five mines and mills of the Quebec chrysotile mining and milling industry. A total of 87 pairs of membrane filter samples and midget impinger samples were collected side-by-side at each location with sampling rates of 2 liters per minute and

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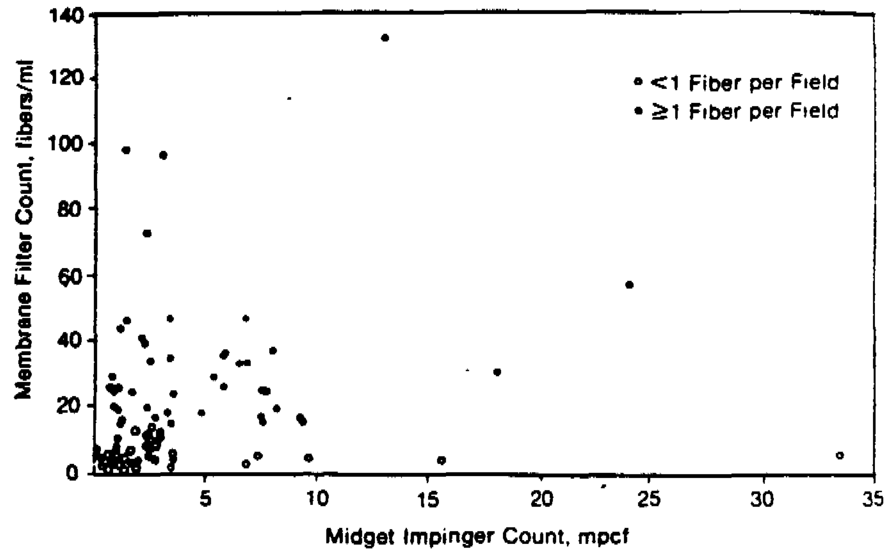
From the Department of Epidemiology and Health, McGill University, Montreal (Dr. Gibbs) and the Quebec Asbestos Mining Association, Thetford Mines, Quebec (Mr. LaChance).

Reprint requests to Department of Epidemiology and Health, McGill University, 3775 University St, Montreal H3A 2B4 (Dr. Gibbs).

2.8 liters per minute, respectively. The filter and impinger inlets were both at approximately 1.5 meters above the floor. Sampling times ranged from 5 to 30 minutes, and were the same for both methods. The membrane filters were 37-mm plain white (pore size, 0.8μ), and the samples were taken with the entire filter exposed. These samples were fixed, mounted with use of the British method,[12] and counted at 500× magnification with a Zeiss standard binocular WL microscope with phase contrast optics. One observer counted all samples; 20 random fields, of area 0.0055 sq mm, were observed, and all fibers greater than 5μ in length were counted. A fiber was defined as any particle with a length-to-breadth ratio greater than 3:1. The midget impinger method, essentially that approved by the Asbestos Textile Institute,[11] used isopropyl alcohol, and particles were counted at 100× magnification with light-field illumination. These samples were counted by two observers. One observer (M.L.), who had made all previous routine midget impinger surveys of the Quebec mining and milling industry,[3] counted 51 of the total number of samples, and the other observer (trained by M.L.) counted the remainder. Counts made on the same samples by the two observers were within 15%.



A plot of membrane filter and midget impinger counts; mpcf represents millions of particles per cubic foot.

Results

A plot of all 87 membrane filter and midget impinger counts is shown in the Figure. As membrane filter samples were collected over the same sampling period as the midget impinger samples, the fiber concentrations on the filter were not always optimal (2 to 6 fibers per field). This was owing to the low ratio of fiber to other particulates in certain processes and the time limit imposed by evaporation of isopropyl alcohol from the impinger. The linear correlation coefficient for 56 samples with more than 1 fiber per field was 0.32, and, after a logarithmic transformation of both variables, the correlation was increased to 0.45. For 31 samples with less than 1 fiber per field, the linear correlation was very close to zero (−0.03), and the correlation of logarithmically transformed data was 0.25. The highest correlation obtained for these data (0.45) demonstrated an association between the results obtained by the two methods. However these correlations suggest that for all mines the regression lines are unsatisfactory for the prediction of fiber counts from impinger counts, as the improvement in prediction for the best correlation (0.45) is only 13% better than a conversion obtained at random. A 50% improvement of prediction would require a correlation coefficient of 0.87.

If membrane filter and midget impinger counts were considered by work area (Table), it was clear that the ratios of the two in some mines were of a different order from those in others where the same process was

Ratios of Membrane Filter Counts to Midget Impinger Counts*

			Open Pit		Dryer and Crusher		Mill			
Mine	Overall Mean	Underground	Drill	Shovel	Dryer	Crusher	Rock Screening	Fiber Screening	Bagging	Storage
A	4.5 (28)	1.7 (1)	8.0 (2)	5.4 (2)	3.2 (2)	2.5 (6)	4.9 (5)	3.5 (5)	8.1 (3)	3.3 (2)
B	11.4 (18)	...	9.1 (2)	2.4 (2)	29.8 (2)	3.7 (4)	29.8 (2)	8.5 (2)	6.1 (2)	2.0 (2)
C	21.9 (18)	...	5.2 (2)	7.9 (2)	15.9 (2)	12.5 (4)	32.6 (2)	47.4 (2)	31.1 (2)	22.8 (2)
D	5.9 (11)	...	...	...	2.0 (3)	8.8 (1)	10.4 (2)	4.3 (2)	3.8 (3)	
E	1.7 (12)	...	0.6 (1)	0.5 (1)	0.4 (2)	1.1 (2)	0.3 (1)	5.3 (3)	4.5 (1)	0.8 (1)
All mines		1.7 (1)	5.3 (7)	4.6 (7)	9.5 (11)	5.3 (17)	14.2 (12)	11.0 (14)	10.4 (11)	8.1 (7)

* Membrane filter counts were measured in fibers per milliliter; midget impinger counts in millions of particles per cubic foot. Numbers in parentheses are numbers of membrane filter-midget impinger pairs.

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employed. In addition, ratios varied with stage of production within the same mine and mill.

Conclusions

Although only 87 pairs of samples were collected in this pilot investigation, these were sufficient to demonstrate that no single conversion factor could be applied to all mines or to all work areas within a mine. This result coincides with the findings of Ayer et al[11] in textile plants.

Thus, the conversion of dust-disease relationships for the Quebec mining and milling industry to fiber-disease relationships does not seem possible at the present time. Further information on the relationships of the two methods at each site within each plant is required. With adequate counts of pairs of samples at selected sites, and with assumptions as to the effects that dust control and changes in ore have had on impinger-filter counts, dose-response relationships based on fiber exposures could be examined, and it is possible that safety standards based rationally on fiber counts could then be established. Without this, there is no way of estimating with any accuracy the total fiber exposure of persons in the Quebec asbestos mining and milling industry, or indeed of deciding whether the dose-response relationships would be better or worse than those obtained from particle counts. Until satisfactory conversion factors are derived, it would seem best to base standards, at least for mines and mills, on particle counts, for which there now exists a reasonable body of evidence. A similar argument probably applies equally to all epidemiological studies of asbestos workers in North America in which exposure has been considered.

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H. Hui, BSc, and A. Corsillo carried out the field surveys and performed the midget impinger and membrane filter counts.

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