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Project Summary

Evaluation of Turbidimetric Methods for Monitoring of Asbestos Fibers in Water

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A rapid and inexpensive technique is needed for the routine monitoring of drinking water and other water supplies to reveal asbestos fibers. To this end, the use of turbidity measurements obtained with a commercially available but modified turbidimeter was investigated in a 1-year study.

The modified turbidimetric technique, which uses magnetic separation for the prior concentration of fibers, allowed monitoring of high-iron amphiboles at the one-million-fiber-per-liter level. Additional instrument modification and improvements in the methodology are needed to permit monitoring of low-iron amphiboles and chrysotile at environmentally significant concentrations.

This Project Summary was developed by EPA's Environmental Research Laboratory, Athens, GA, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The analytical method for determination of asbestos in water samples has been progressively improved since the Preliminary Interim Method was issued in 1976 by the U.S. Environmental Protection Agency's (EPA's) Environmental Research Laboratory in Athens, GA. The method is based on filtration of the water sample through a submicrometer pore diameter membrane filter, followed by preparation of the filter for examination in a transmission electron microscope (TEM). Individual fibers are then identified, measured, and counted.

Asbestos analyses using the TEM method are time-consuming and expensive because each sample requires examination in an analytical electron microscope for at least 3 hours, during which every fiber is separately classified and measured. Satisfactory analyses require that the microscope operators have a high degree of skill and experience.

The high cost and the long turnaround time of analyses made by electron microscopy have prompted investigations into whether more rapid analytical procedures could be developed, even if these were not capable of comparable specificity and sensitivity. Several potential technical approaches based on optical scattering by fibers have been investigated recently. These instrumental techniques, however, are at the prototype stage. Accordingly, there is interest in the concept of using established instrumental techniques, perhaps with minor modifications, to monitor asbestos fiber concentrations in water.

Turbidimetry is a sensitive technique that has been applied by several investigators to the problem of measurement of asbestos in drinking water. In these investigations, however, it appears that the following two apparently contradictory conclusions were reached:

- Turbidity readings can be used as an indicator of fiber removal efficiency in a filtration plant.
- No definite correlation between fiber concentration and turbidity was found.

The situation is complicated further by the fact that most of the fiber concentration values reported in these studies of turbidity would now be considered questionable because of the new methods used in the preparation of specimens for the TEM evaluations.

Clearly, there is no reason why the asbestos fiber concentration should be related to the turbidity measurement, unless the asbestos is the principal particle species that gives rise to the turbidity in the particular water sample. This is unlikely to be the case in most water systems. Nevertheless, turbidity measurements may be useful in monitoring asbestos fiber concentrations in two ways: first, if the fibers could be concentrated selectively so that they form the major contribution to the turbidity measurement; and secondly, if the turbidity of the sample could be reduced so that the residual value corresponds to a fiber concentration below some level of concern. There also would be an advantage if the turbidity measurement itself could discriminate between the contributions made by fibrous and equant particles. In the study reported here, all of these aspects were investigated to determine whether measurement of turbidity could provide a realistic method for monitoring asbestos fiber concentrations in drinking water, with TEM reserved for more specific characterization.

Conclusions and Recommendations

The experiments showed that the Sigrist L65 turbidimeter was capable of detecting a turbidity increment of 0.002 nephelometric turbidity unit (NTU) above the value for non-boiling still water. Other turbidimeters were not able to achieve this detection level.

Relationships between turbidity and asbestos fiber concentration were obtained for UICC crocidolite, UICC amosite, and Union Carbide refined Calidria chrysotile. These indicated that a contribution of 0.004 NTU to the total turbidity corresponded to asbestos fiber concentrations of 5 million fibers per liter (MFL), 2 MFL, and 1000 MFL for UICC crocidolite, UICC amosite, and Union Carbide chrysotile, respectively. These corresponded to mass concentrations of about 1.3 μg/L, 1.3 μg/L, and 6.0 μg/L, respectively, for the three varieties of asbestos.

A modification was made to the turbidimeter that allowed the sample to be placed between the poles of an electromagnet. The magnetic field caused the fibers to become oriented, and it was possible to observe a change in the turbidity reading when the field was applied.

A change of 0.004 NTU in the turbidity reading corresponded to fiber concentrations of 3.5 MFL, 12 MFL, and 20,000 MFL for UICC crocidolite, UICC amosite, and Union Carbide chrysotile, respectively. These corresponded to mass concentrations of 0.8 μg/L, 7.5 μg/L, and 100 μg/L, respectively, for the three varieties of asbestos.

In the modified turbidimeter, with application of the magnetic field, fibers that adopted an orientation parallel with the field (p-fibers) caused an increase in the turbidity reading; fibers that adopted orientations normal to the field (n-fibers) caused a reduction in the turbidity reading. Increases in the turbidity readings were obtained using crocidolite, amosite, chrysotile, anthophyllite, and cummingtonite. Decreases were observed using tremolite and actinolite. In the case of amosite, the signals from the two alignment modes of fiber partially canceled each other, and different magnitudes of effect were obtained with two different varieties of amosite. Theoretically, some fibrous minerals or mixtures could exist in which the effects from the two alignment modes of fiber could completely cancel each other, leading to an incorrect conclusion that no fibers are present.

The detection levels of the modified turbidimeter system could be improved by use of more sophisticated time-averaging and read-out techniques.

Magnetic separation was an effective procedure for concentration of crocidolite from water samples. Starting with 4-liter water samples, the amphibole fibers could be separated and transferred to a 65 mL water sample for the turbidimeter. The numerical fiber recovery was variable for some reason, between 14% and 43%, although the mass recovery was constant at about 65%, indicating that the larger fibers were recovered more reproducibly. Concentration of the fibers by factors of between 8.7 and 26.9 were achieved, equivalent to a factor of 40 in terms of mass concentration. Magnetic separation cannot be used for concentration of chrysotile and low-iron amphiboles, and other methods must be used.

To improve detection limits, techniques were investigated to reduce the turbidity of the water sample while retaining the majority of the asbestos fibers. Filtration of the sample through large pore diameter Nuclepore filters was studied as a means of separating the asbestos fibers from other particulate material on the basis of differences in their size distributions. For a typical size distribution of waterborne chrysotile fibers, Nuclepore filters of pore diameters exceeding 0.8 μm allowed most of the chrysotile asbestos fibers of an artificial dispersion to pass through. This was demonstrated using 0.8 μm, 2.0 μm, and 3.0 μm pore diameter filters. After such a filtration, the turbidities of typical drinking water samples were significantly reduced, usually by a factor of about 10 when 0.8 μm pore diameter filters were used.

The technique was more effective for samples of drinking water if the organic materials were oxidized prior to this selective filtration step, indicating that many of the fibers were associated with organic materials in the original drinking water sample. Using a 2.0 μm pore diameter filter, 78% of the fibers in an artificial dispersion prepared using a drinking water sample were found to pass through the filtrate, and, at the same time, the turbidity was reduced from 0.109 NTU to 0.0165 NTU. Therefore, this procedure would achieve an improvement of about a factor of 5 in the detection limit.

The turbidity measurement made by the modified instrument, with prior concentration of the fibers by magnetic separation, would allow fiber-specific monitoring of high-iron amphiboles at the 1 MFL level. The utility of the instrument for low-iron amphiboles depends on the extent to which the detection level can be improved by signal averaging and on the effectiveness of the selective filtration technique for amphibole fibers. Additional modification of the instrument would be required before it could be used to monitor chrysotile at realistic concentrations.

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The complete report, entitled "Evaluation of Turbidimetric Methods for Monitoring of Asbestos Fibers in Water," (Order No. PB 84-232 511; Cost: $11.50, subject to change) will be available only from:
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