

## **Assessment of Asbestos in Drinking Water in Alexandria, Egypt**

**Gihan Hosny\* and Mekkawy Akel\*\***

\* *Environmental Health and Molecular Carcinogenesis Division, Department of Environmental Studies, Institute of Graduate Studies and Research, University of Alexandria, Alexandria, Egypt.*

\*\* *Department of Environmental Health, High Institute of Public Health, University of Alexandria, Alexandria, Egypt.*

### **ABSTRACT**

Over the past several years, the presence of fibrous asbestos particulates has been observed in a number of municipal water supplies throughout the USA, Canada, and several other regions all over the world. The possible health hazards which these fibers present have spurred a great deal of interest in the problems of detection and removal of the submicroscopic particulates in water. Asbestos is a group of fibrous metamorphic silicate minerals that is ubiquitous in the environment as a result of its extensive industrial use and the dissemination of fibers from natural sources. The health hazards associated with inhalation of asbestos in the occupational environment have long been recognized including asbestosis, bronchial carcinoma, malignant mesothelioma of the pleura and peritoneum, and possibly cancers of the gastrointestinal tract and larynx. It is introduced into water by the dissolution of asbestos-containing minerals and ores, and from industrial effluents, atmospheric pollution and erosion of asbestos-cement (A/C) pipes in the distribution systems of drinking water. In Alexandria, most of the pipes in the distribution systems of drinking water are asbestos-cement (A/C) pipe system. Drinking water samples (1 liter each) were collected in glass containers from different regions in Alexandria and filtered in cellulose filters (mixed cellulose ester type filters of pore size 0.2  $\mu\text{m}$ ) within less than 48 hours. Filters were allowed to dry, gold plated and scanned microscopically. Asbestos fibers were detected in all water samples collected from regions having A/C pipe drainage

---

Correspondence to:

Gihan Hosny

Environmental studies Department,  
Institute of Graduate Studies and Research  
Alexandria University

E-mail: Gihan\_hosny@yahoo.com

system. No fibers detected in regions, where the pipe distribution system was poly vinyl pipe system or changed from A/C pipe to cast iron pipe system. The determination of asbestos fibers in drinking water of Alexandria should have particular concern because of the health hazards that might be associated with their presence.

*Key words: Drinking water, Asbestos, Asbestos fibers, Alexandria, Egypt.*

## **INTRODUCTION**

Asbestos is a broad term for a group of naturally occurring fibrous mineral silicates of magnesium and iron. Asbestos-containing rock is mined, crushed and milled to obtain fibrous material, processed further into finer fibers. Asbestos fibers are categorized into 2 groups: amphiboles (straight fibers: e.g. amosite, anthophyllite, crocidolite, tremolite, actinolite) and serpentines (Chrysotile). The crystalline structure and the chemical nature of natural resistance to heat and acid, high tensile strength, remarkable thermal, electrical and sound insulating properties, durability and flexibility, have resulted in thousands of commercial applications, including floor tiles, boiler and pipe insulation, roofing materials, brake linings, and cement pipes.<sup>(1)</sup>

It has been well documented that inhalation of asbestos fibers by humans causes asbestosis (a model of one of the chronic dust diseases causing pulmonary fibrosis), lung cancer, and mesothelioma (cancer of the pleura and peritoneum).<sup>(2-4)</sup> Fibers provoke the accumulation of macrophages in alveolar ducts and peribronchial regions, which become thickened. This fibrotic process progresses, leading to a stiffened, smaller lung with diminished capacity for gas exchange. Progression can occur after exposure has ceased, due to the retention of fibers in the lung and persistent inflammatory response. Inhalation of asbestos in the workplace has also been associated with an increase in

the incidence of gastrointestinal cancers.<sup>(2-4)</sup> Furthermore, there had been concern that ingested asbestos may cause an increase in cancer incidence in exposed populations. Probable sources of asbestos in drinking water include the dissolution of asbestos-containing minerals and ores, industrial effluents, atmospheric pollution, asbestos cement (A/C) pipe in water distribution system, dumping of asbestos-containing materials into sources of drinking water, and the natural leaching process into the ground and surface watershed.<sup>(1,2)</sup> The amount of asbestos can vary widely depending on the location and area's geological composition.<sup>(2)</sup> The contribution of A/C pipe to the asbestos content of water varies as a function of pH, alkalinity and water hardness. In a national survey of 71 locations across Canada, erosion of A/C pipe appeared to contribute measurably to the asbestos content of water supplies at only two locations. It was reported that A/C pipes do not release significant amounts of asbestos unless they are cut, broken, or repaired.<sup>(5)</sup>

Many studies had attempted to discover if there is a relationship between exposure to asbestos and gastrointestinal carcinoma.<sup>(6-10)</sup> One study compared the incidence of gastrointestinal cancer of asbestos workers with general population, an increased incidence of stomach and colon-rectum cancer was found.<sup>(6)</sup> Other studies had compared the cancer incidence in areas serviced by water of high asbestos content with areas using water of low asbestos content and concluded that there was no consistent pattern of statistically significant differences observed.<sup>(8,9)</sup> It was postulated that insufficient time had passed for excess cancers to develop (20 or more years might be required between exposure and cancer development).<sup>(9)</sup> Furthermore, evidence that only a small fraction of those fibers contained in ingested water is eliminated in urine was provided.<sup>(7)</sup> A number of human studies have reported that

occupational exposure to asbestos has been linked to adverse effects on kidney with increased risk of renal cell carcinoma.<sup>(11-13)</sup>

Because of the health hazards that might be correlated with the exposure to asbestos, the present study was performed in order to assess the presence of asbestos in drinking water of Alexandria, Egypt.

## **MATERIALS & METHODS**

### **Sample collection:**

In Alexandria, most of the pipes in the distribution systems of drinking water are asbestos-cement (A/C) pipe system, as acquainted from the General Municipal Water Company of Alexandria. Drinking water samples (1 liter each) were collected in glass containers from different regions in Alexandria and filtered under vacuum in cellulose filters (mixed cellulose ester type filters of pore size 0.2 µm, Sartorius AG, Geottingen, Germany) within less than 48 hours, as previously described.<sup>(14)</sup> Filters were allowed to dry, gold plated (JEOL, JFC-1100E ion sputtering device "Fine Coater for Gold Plating"), scanned microscopically (JEOL, JSM-5300 scanning microscope) and photographed, as described.<sup>(15)</sup> Reference samples were prepared by dissolving 0.5 µg asbestos (Laboratory chemicals; May & Baker LTD., Dagenham, England) in 1 liter distilled water and then filtered. Reference and blank (membrane filter paper) samples were scanned microscopically with the studied samples. Drinking water samples were collected randomly from different regions in Alexandria, from garages or coffee shops to ensure that water supply is coming from the common municipal water supply and not from water-tanks over the building. Water was allowed to run for few seconds before sample collection to be representative of the general municipal water. Regions involved in this

study were Elshatby, Sidi Gaber, Elmanshia, Moharam Bek, El-Anfoshy, El-Maamora, Rushdi, San Stifano, Saba Basha, Loran, Somoha, Stanly, Gleem, King Maryot, Elamrya, Wady Elkamer, Elmax, Mostafa Kamel, Bakkos, Sidi Beshr, Abou Celiman, Ghobrial, Abou Kir, Elmandara, and Ellassafra.

## **RESULTS**

Samples of drinking water in Alexandria were examined for the presence or absence of asbestos fibers using scanning electron microscope. Figures from 1 to 5 illustrate the photomicrographs of the scanned samples having asbestos in their water. Figure 1 shows the photomicrographs for the gold-plated membrane filters of blank and reference samples, as well as from Somoha drinking water. Figure 2 shows the photomicrographs for the gold-plated membrane filters of the filtered drinking water samples from Somoha, Stanly and Loran; note the presence of asbestos fibers  $<5 \mu\text{m}$  in samples collected from Somoha region (Figures 1 & 2). Figure 3 illustrates the presence of asbestos fibers in the filtered drinking water samples from King Maryot, Elamrya, Elmax and Wady Elkamer, as shown in the photomicrographs for their gold-plated membrane filters. Figure 4 presents the photomicrographs for the membrane filters from Bakkos, Abou Kir, Elmandara and Ellassafra. Figure 5 shows the photomicrographs for the membrane filters from Ghobrial, Abou Celiman, Mostafa Kamel, and Sidi Beshr.

Regions, that were free of asbestos fibers in their water samples, are: regions from Elshatby to Sidi Gaber, Elmanshia, Moharam Bek, El-Anfoshy, El-Maamora, Rushdi, San Stifano, Saba Basha, Loran & Stanly (some parts), and Gleem. The distribution system of these regions were changed to either cast iron or poly vinyl pipe lines, as referred to from the General Municipal Water Company of Alexandria.

**Figure 1. Photomicrographs for the Gold-plated Membrane Filters of Blank and Reference Samples, as well as from Somoha Drinking Water. Note the Presence of Asbestos Fibers <5  $\mu\text{m}$  in Samples Collected from Somoha Region.**

**Figure 2.** Photomicrographs for the Gold-plated Membrane Filters of the Filtered Drinking Water Samples from Stanly, Somoha, and Loran; Note the Presence of Asbestos Fibers <5 µm in Samples Collected from Somoha Region.

**Figure 3.** Photomicrographs for the Gold-plated Membrane Filters of the Filtered Drinking Water Samples from King Maryote, Elamrya, Elmax and Wady Elkamer.

**Figure 4.** Photomicrographs for the Gold-plated Membrane Filters of the Filtered Drinking Water Samples from Bakkos, Abou Kir, Elmandara and Ellassafra.

**Figure 5.** Photomicrographs for the Gold-plated Membrane Filters of the Filtered Drinking Water Samples from Ghobrial, Abou Celiman, Mostafa Kamel and Sidi Beshr.

Regions, that had asbestos fibers in their water samples, are: Loran & Stanly (some parts), King Maryot, Elamrya, Wady Elkamer, Elmax, Mostafa Kamel, Bakkos, Sidi Beshr, Abou Celiman, Ghobrial, Abou Kir, Elmandara, and Ellassafra. Fibers <5  $\mu\text{m}$  were only detected in Somoha region.

## **DISCUSSION**

In the present study, samples of drinking water in Alexandria were examined microscopically for the presence of asbestos. Asbestos was detected on the cellulose membrane filters used for the filtrations of drinking water samples obtained from Loran & Stanly (some parts), King Maryot, Elamrya, Wady Elkamer, Elmax, Mostafa Kamel, Bakkos, Sidi Beshr, Abou Celiman, Ghobrial, Abou Kir, Elmandara and Ellassafra. Asbestos is one of the most publicized carcinogens in our environment, yet the problems associated with it are complex and not fully understood because of the multi factors that may be intervened together, related to the pathogenesis, mechanisms of disease, relative importance of fiber size ..etc.<sup>(15,16)</sup> Smaller fibers are active in the promotion of tumor growth.<sup>(15)</sup> Fibers <5  $\mu\text{m}$  were only detected in Somoha region. The method of choice for the determination of asbestos in ambient air and water is transmission electron microscope (TEM), with identification by energy-dispersive x-ray analysis and selected-area electron diffraction, and results can be reported in terms of fiber numbers or mass concentrations, depending upon the method of sample preparation.<sup>(14)</sup> The scanning electron microscope (SEM) offers a versatile approach to asbestos monitoring, with energy-dispersive x-ray analysis to further characterize the fibers.<sup>(15)</sup> However, the only available technique in the current study to detect the presence of asbestos in drinking water was SEM.

The health hazards associated with inhalation of asbestos in the occupational environment have long been recognized starting from asbestosis and ending with lung cancer and mesothelioma and possibly cancers of gastrointestinal tract and larynx.<sup>(2-4)</sup> In contrast, there has been little evidence for the carcinogenicity of ingested asbestos in toxicological and epidemiological studies conducted to date.<sup>(2,17)</sup> In epidemiological studies of population in the United States and Canada examined for the association between drinking water supplies containing asbestos and cancer mortality.<sup>(8,9,18-24)</sup> It was reported that there had no consistent evidence of an association between cancer mortality or incidence and ingestion of asbestos in drinking water, although increases were observed in leukemia and in the following site-specific neoplasms: esophagus, stomach, small intestine, colon, rectum, gallbladder, pancreas, peritoneum, lungs, pleura, prostate, kidneys, brain and thyroid. However, one ecological epidemiological studies in San Francisco Bay area provided evidence for association between area cancer rates and ingested asbestos.<sup>(25,26)</sup> The studies had attempted to relate area average ambient asbestos pollution levels found in drinking water to area average cancer mortality rates but not the exposure of specific individuals to their cancer risks. Furthermore, a case-control study reported by Polissar et al.,<sup>(27,28)</sup> did not demonstrate any definitive excess of cancer mortality associated with asbestos pollution of drinking water. Thus, it was reported that since none of the epidemiologic studies provided useful information concerning a dose-response relationship, they do not form an adequate basis to perform a quantitative risk assessment.<sup>(2,17)</sup> It was, also, not clear, in occupational epidemiologic studies, if the observed increases in gastrointestinal cancer found among occupationally exposed workers are due to the swallowing of fibers previously inhaled and then expelled from the lung.<sup>(2,29)</sup>

There was also no conclusive evidence from studies in animals that ingested asbestos was carcinogenic.<sup>(30)</sup> The most extensive animal studies conducted were those of the U.S. National Toxicology Program involving treatment groups of 250 animals of each sex.<sup>(31-33)</sup> No increases in tumor incidence related to treatment were observed in Syrian golden hamsters fed 1% amosite or short-range or intermediate-range chrysotile in the diet over their lifetime. Similarly, no treatment-related effects were observed in Fischer-344 rats fed 1% tremolite or amosite in the diet over their lifetime. The incidence of colon lesions and benign epithelial neoplasms in the gastrointestinal tract in male Fischer-344 rats fed 1% intermediate-range chrysotile (65% longer than 10  $\mu\text{m}$ ) was significantly increased in comparison to control rats. However, the increase was not statistically significant and was limited to one sex. Moreover, no increase in tumor incidence was observed in Fischer-344 rats ingesting short-range chrysotile (98% shorter than 10  $\mu\text{m}$ ) that was composed of fiber sizes more similar to those found in drinking water. However, Condie<sup>(34)</sup> reported that these studies had many deficiencies in their design and/or conduct. Most were not lifetime studies and used an insufficient number of test animals and controls. Also, the time from first exposure to asbestos to the sacrifice of the animals was often too short regarding the long latency period known for asbestos-related cancers.<sup>(34)</sup>

Elevated concentrations of asbestos in the drinking water supply (up to 10 billion fibers/L) were detected in Woodstock, NY, and were attributed to severely deteriorating A/C pipes.<sup>(35)</sup> Another report<sup>(36)</sup> on water transported via A/C pipe described concentrations of asbestos as high as 38 million fibers/L in Florida, 47 million fibers/L in Kentucky and 480 million fibers/L in Massachusetts. It was reported that the extent of shedding asbestos from A/C pipe was dependant on the characteristics of the pipe (e.g. coated or uncoated), the water's pH.<sup>(36)</sup>

Thus, the maximum contaminant level goals (MCLG, the safe levels based solely on possible health risks and exposure) had been set for asbestos at 7 million fibers/L of water and it was believed that this level would not cause any of the potential health problems.<sup>(37)</sup> Furthermore, the use of asbestos filters in food processing and manufacturing of soft drinks and drugs had resulted in contamination of these life-stuffs.<sup>(38)</sup> The extent of asbestos contamination of solid foodstuffs had not been well studied because of the lack of a simple, reliable analytical method. Concentrations of  $0.151 \times 10^6$  fibers/L had been found in some English beers.<sup>(39)</sup> Concentrations of 4.3 to  $6.6 \times 10^6$  fibers/L have been recorded in Canadian beers, and between 1.7 and  $12.2 \times 10^6$  fibers/L in soft drinks.<sup>(40)</sup>

Finally, we conclude that sufficient direct evidence for the association between asbestos ingestion and cancer risk is not available and extensive toxicological and epidemiologic studies are still required to examine such a relation. However, we believe in preventive public health policy that recommends the elimination of the possible source that may contribute to the incidence of the disease. Thus, replacement of the A/C pipe in the distribution system of drinking water in Alexandria is highly recommended.

#### **ACKNOWLEDGEMENT**

We would like to acknowledge the cooperation of personnel in the General Municipal Water Company of Alexandria.

## REFERENCES

1. Suta BE, Levine RJ. Non-occupational asbestos emissions and exposure. In: Micheals L and Chissick SS editors. Asbestos: Properties, applications and hazards. Vol. 1. Chichester: John Wiley & Sons; 1979. p.1-113.
2. DHHS Committee. Report on cancer risks associated with the ingestion of asbestos. Environ Health Perspect. 1987; 72: 253-65.
3. Royal Society Report. A review of the INSERM report on the health effects of exposure to asbestos, 1996.
4. Lemen RA, Lloyd JW, Groth DH, Kang HK, Dement JM, Jennings RL, *et al.* Workplace exposure to asbestos: Review and recommendations. Washington, DC: US Government Printing Office; 1980. DHHS (NIOSH) Publication No. 81: p. 103.
5. Chatfield EJ, Dillon MJ. A national survey for asbestos fibers in Canadian drinking water supplies. Ottawa: Department of National Health and Welfare; 1979. Environmental Health Directorate Report 79-EHD-34.
6. U.S. Environmental Protection Agency. Ambient Water Criteria for Asbestos. Washington, DC: EPA; 1980. Report EPA-440/5-80-022.
7. Cook PM, Olson GF. Ingested mineral fibers: elimination in human urine. Science. 1979; 204(4389): 195-203.
8. Levy BS, Sigurdson E, Mandel J, Laudon E, Pearson J. Investigating possible effects of asbestos in city water: Surveillance of gastrointestinal cancer incidence in Duluth, Minnesota. Ann J Epidemiol. 1976; 103(4): 362-8.
9. Wigle DJ. Cancer mortality in relation to asbestos in municipal water supplies. Arch Environ Health. 1977; 32: 185-9.
10. National Research Council. Drinking water and health. Washington, DC: National Academy of Sciences; 1977.
11. Mattioli S, Truffelli D, Baldasseroni A, *et al.* Occupational risk factors for renal cell carcinoma: a case-control study in Northern Italy. J Occup Environ Med. 2002; 44(11): 1028-36.

12. Pesch B, Haerting J, Ranft U, Klimpel A, Oelschlagel B, Schill W. Occupational risk factors for renal cell carcinoma: agent-specific results from a case-control study in Germany. MURC study Group, Multicenter urothelial and renal cancer study. *Int J Epidemiol.* 2000; 29(6): 1014-24.
13. Van Poppel H, Nilsson S, Algaba F, Bergerheim U, *et al.* Precancerous lesions in the kidney. *Scand J Urol Nephrol (Suppl.)* 2000; 205: 136-65.
14. Beard ME, Rook HL. Advances in environmental measurement methods for asbestos. ASTM Stock Number, STP1342. ASTM. West Conshohocken, USA: American Society for Testing and Materials; 2000. p. 227-297.
15. Quinby-Hunt MS, McLaughliu RD, Quintanilha AT. Instrumentation for environmental monitoring. Lawrence Berkeley Laboratory Environmental Instrumentation Survey. Volume 2, Water, 2<sup>nd</sup> edition. New York: John Wiley & Sons; 1985. p. 660-684.
16. Finkelstein MM. Silica, silicosis, and lung cancers: a risk assessment. *Am J Ind Med.* 2000; 38: 8-18.
17. California Environmental Protection Agency. Public Health Goal for asbestos in drinking water. Responses to major comments on technical support document, Pesticide and Environmental Toxicology Section, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency; September 2003.
18. Marsh GM. Critical review of epidemiologic studies related to ingested asbestos. *Environ Health Perspect.* 1983; 53: 49-56.
19. Mason TJ, McKay EW, Miller RW. Asbestos-like fibers in Duluth water supply: relation to cancer mortality. *J Am Med Assoc.* 1974; 228: 1019-20.
20. Sigurdson EE, Levy BS, Mandel J, McHugh R, Michienzi LJ, Jagger H, *et al.* Cancer morbidity investigations: lessons for the Duluth study of possible effects of asbestos in drinking water. *Environ Res.* 1981; 25: 50-61.
21. Toft P, Wigle DT, Meranger JC, Mao Y. Asbestos and drinking water in Canada. *Sci Total Environ.* 1981; 18: 77-89.

22. Harrington JM, Craun GF, Meigs JW, Landrigan PJ, Flannery JT, Woodhull RS. An investigation of the use of asbestos cement pipe for public water supply and the incidence of gastrointestinal cancer in Connecticut 1935-1973. *Am J Epidemiol.* 1978; 107: 96-103.
23. Meigs JW, Walter SD, Heston JF, Millette JR, Craun GF, Woodhull RS, *et al.* Asbestos cement pipe and cancer in Connecticut 1955-1974. *Environ Res.* 1980; 42: 187-97.
24. Millette JR, Craun GF, Stober JA, Draemer DF, Tousignant HG, Hildago E, *et al.* Epidemiology study of the use of asbestos-cement pipe for the distribution of drinking water in Escambia County, Florida. *Environ Health Perspect.* 1983; 53: 91-8.
25. Kanarek MS, Conforti PM, Jackson LA, Cooper RC, Murchio JC. Asbestos in drinking water and cancer incidence in the San Francisco Bay area. *Am J Epidemiol.* 1980; 112: 54-72.
26. Conforti PM, Kanarek MS, Jackson LA, Cooper RC, Murchio JC. Asbestos in drinking water and cancer in the San Francisco Bay area: 1969-1974 incidence. *J Chron Dis.* 1981; 34: 211-24.
27. Polissar L, Severson RK, Boatman ES. A case-control study of asbestos in drinking water and cancer risk. *Am J Epidemiol.* 1984; 119: 456-71.
28. Polissar L, Severson RK, Boatman ES, Thomas DB. Cancer incidence in relation to asbestos in drinking water in the Puget Sound Region. *Am J Epidemiol.* 1982; 116: 314-28.
29. National Academy of Sciences. *Asbestiform Fibers: Non-occupational Health Risks.* Washington, DC: NAS; 1984.
30. Toft P, Meek ME, Wigle DT, Meranger JC. Asbestos in drinking water. *CRC Crit Rev Environ Control.* 1984; 14(2): 151-97.
31. McConnell EE, Shefner AM, Rust JH, Moore JA. Chronic effects of dietary exposure to amosite and chrysotile asbestos in Syrian golden hamsters. *Environ Health Perspect.* 1983; 53: 11-26.

32. McConnell EE, Rutter HA, Ulland BM, Moore JA. Chronic effects of dietary exposure to amosite asbestos and tremolite in F344 rats. *Environ Health Perspect.* 1983; 53: 27-44.
33. National Toxicology Program (NTP). Toxicology and carcinogenesis studies of chrysotile asbestos in F344 rats. National Institutes of Health, Public Health Service, U.S. Department of Health and Human Services; 1985. Publication No. 86-2551, Technical Report No. 295.
34. Condie LW. Review of published studies of orally administered asbestos. *Environ Health Perspect.* 1983; 53: 3-9.
35. Meranger JC, Reid WW, Davey ABC. The transfer of asbestos from water to air via a portable drum-type home humidifier. *Can J Public Health.* 1979; 70: 276-82.
36. Millette JR. Analyzing for asbestos in drinking water. *News of Environmental Research.* Cincinnati: U.S. Environmental Protection Agency; 1976.
37. Safe Drinking Water Committee, National Research Council, National Academy of Sciences. *Drinking Water and Health.* Washington, DC: National Academy of Sciences. 1977. p. 160-163.
38. Food and Drug Administration. *Federal Register.* 1973; 38: 27076-81.
39. Biles B, Emerson TR. Examination of fibers in beer. *Nature* 1968; 219: 93.
40. Cunningham HM, Pontefract RD. Asbestos fibers in beverages and drinking water. *Nature.* 1971; 232: 332.